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Preface

The education industry has obviously been influenced by the Internet revolution. Teaching and learning methods have changed significantly since the coming of the Web and it is very likely they will keep evolving many years to come thanks to it. A good example of this changing reality is the spectacular development of e-Learning.

In a more particular way, the Web 2.0 has offered to the teaching industry a set of tools and practices that are modifying the learning systems and knowledge transmission methods. Teachers and students can use these tools in a variety of ways aimed to the general purpose of promoting collaborative work.

In these 27 chapters, we survey many of all those disciplines that help the educative community to achieve real Advanced Learning. This book is organized in seven sections: the first one (chapters 1 to 5) deals with matters concerning Computer-Supported Collaborative Learning (CSCL), collaborative authoring tools and adaptive environments; in the second section (chapters 6 to 10) subjects such as mobile learning, ubiquitous devices and games are considered; the third section (chapters 11 to 15) studies the semantic web and semantic tools; section four (chapters 16 to 19), looks into web 2.0, online communities and social software; in section five (chapters 20 to 23) standardization in e-Learning is discussed; in the continuing section, number six (chapters 24 and 25) robotics and bioelectronics are approached; finally, section seven (chapters 26 and 27) presents the organization of educational material.

The editor would like to thank the authors, who have committed so much effort to the publication of this work. She is sure that this volume will certainly be of great help for students, teachers and researchers. This was, at least, the main aim of the authors.

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Contents

Enhancing on-line Blended Learning Systems using a new Human-Computer Interaction Educational Methodology

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1. Introduction

The Internet has given rise to one of the latest revolutions in Education. While in the past, students learned primarily passively, by attending lectures given by human teachers, today the student can become an active agent in the learning process through the use of web-based educational systems.

This revolution has also affected the assessment of courses (Peat & Franklin, 2002). Traditionally, assessment focused on paper & pencil written exams. Web-based educational systems on the other hand have favoured the introduction of different types of summative and formative assessment, in which formative assessment is used to teach and not only to score the student's work.

However, the use of web-based learning and assessment in isolation from traditional teaching has been shown to present problems, such as the loss of the student-teacher relationship (Chung & O'Neill, 1997). Therefore, Blended Learning has appeared, proposing the combination of traditional teaching methods with the use of computers for education (Graham, 2006). Following this approach, the student-teacher relationship is not lost, but the roles change: the teacher becomes a guide who facilitates learning and the student is in charge of his/her own learning process.

The use of Blended Learning systems has not become as widespread as it could become. We believe that one reason for the slow uptake is that many Blended Learning systems are designed by Computer Science teachers for Computer Science students, and because the designer is aware that the intended users have reasonable technical skills, they do not put much attention into the user-friendliness of the system.

We believe that current systems could be much improved if they were designed according to Human-Computer Interaction (HCI) principles. Taking such an approach, Blended Learning systems would be more accessible for everyone, and not only for those with Computer Science training.

Here, in this chapter, we present one solution to this problem: a methodology for the management of human-computer interaction within Blended Learning systems.

This chapter is structured as follows: firstly we survey the existing work in the relevant fields (Blended Learning, Computer Assisted Assessment, and Human-Computer Interaction). Then we describe our proposed HCI Educational Methodology, and provide two case studies to illustrate the methodology. Finally, we present our conclusions drawn from the results achieved in the case studies and some lines of future work.

2. Related work

Given the multidisciplinary nature of the work presented in this chapter, no single field can be highlighted as most relevant to our work. Therefore, in this section, an introduction to the fields of Blended Learning, Computer Assisted Assessment and Human-Computer Interaction is provided.

2.1 Blended Learning

Blended Learning systems combine traditional teaching methods with the application of the new Information and Communication Technologies (ICTs) for education (Graham, 2006). Combining these approaches, students continue to learn from lectures with their teachers, while, outside of class, they can gain additional training from on-line courses, running on any computer connected to the Internet.

In recent years, e-learning systems have been adopting the Blended Learning approach because Blended Learning systems have the advantages of e-learning (flexibility in time and location, adaption to particular user needs, etc.), without its disadvantages (teacher-student relationship broken, isolation feeling in front of the computer, etc.)

However, the use of Blended Learning systems has still not spread to all educational institutions, largely because of issues of its own (Garrison & Kanuka, 2004). It is not just that teachers and students need to adapt to new computer technology. The introduction of Blended Learning systems into an educational institution requires the involvement at all levels, including administration and support services: the development of policies for the integration of computers as an educational resource; the provision of funding for the development and management of different Blended Learning programs for different areas of knowledge, and the systematic evaluation of the degree of user satisfaction of the Blended Learning program among students and teachers to test its success.

The use of Blended Learning program might be rejected simply because of technological challenges, if not all teachers and students can be assumed to have necessary technological skills to use the software (Kim, 2007). This could be why the uptake of Blended Learning systems has been strongest in Computer Science departments (Howard et al., 2006; Kim, 2007; Fong, 2008).

Our contribution to this field is to provide a methodology detailing how to design Blended Learning systems so that they are easy to use for people without any technical training, and thus to lessen the rejection of Blended Learning programs for this reason.

In particular, our focus is on formative assessment, as we believe that a Blended Learning program can operate effectively with the content of the course being delivered by teachers through lectures, while the online component is used by the student to review the content after class.

2.2 Computer Assisted Assessment

The increasing use of computers for educational assessment had led to the creation of the field of Computer Assisted Assessment (CAA) (Mcgrath, 2003; Mitchell et al., 2003; Palmer & Richardson, 2003). CAA can be defined as the field that studies how computers can effectively be used to assess students' learning progress. Originally, CAA was limited to just Multiple Choice Questions (MCQs) and fill-in-the-blank exercises, despite the general opinion in the field that these types of assessment are not enough by themselves to measure higher cognitive skills (Birenbaum et al., 1992; Sigel, 1999; Mitchell et al., 2003).

Therefore, new and more sophisticated types of assessment were created, such as simulation exercises or assessment of students' free-text answers or essays (Valenti *et al.*, 2003). However, many argued that these types of assessment were too complex and sophisticated to be performed by computers (Hearst, 2000).

In particular, there have always been detractors dismissing the idea that a computer could grade human essays. There are still today researchers who do not consider that automatic grading is possible. These researchers claim that computers do not have common sense and thus are not able to understand the students' answers. However, the advances in other research fields such as Natural Language Processing (NLP) have provided the means of overcoming this limitation up to certain point (Valenti *et al*., 2003).

Currently, there are more than thirty different free-text CAA systems working in academic institutions and companies. They are based on the use of different NLP techniques such as Latent Semantic Analysis, Information Extraction, or statistical techniques (Deerwester et al., 1990; Mitchell et al., 2003; Mitkov, 2003).

It would be pleasing to have one standard metric to measure the goodness of the automatic evaluation of students' free-text answers, and to be able to highlight one of these free-text CAA systems as the best one. However, there is no consensus among free-text CAA researchers, and thus we can only say that if we choose as a possible metric the correlation between the automatic scores and the scores marked by a human to the same set of questions, the state-of-the-art results range from 0.3 up to 0.95 (Pérez-Marín, 2007).

Our past work in this area made two contributions. Firstly, as we believe that free-text CAA systems should keep a model of each student so that the system can adapt the assessment to the needs of the particular student, we proposed the use of free-text Adaptive Computer Assisted Assessment (ACAA) systems. Free-text ACAA systems can be defined as free-text CAA systems able to assess students' free-text answers to non-ambiguous open-ended questions in an automatic and adaptive way (Pérez-Marín *et al*., 2006a).

Furthermore, free-text ACAA systems can also keep track of the students' conceptual evolution to generate Open Learner Models, that is, models that can be shown both to teachers and students, with information about which concepts should be reviewed, and which concepts have already been assimilated by the students (Pérez-Marín et al., 2007a).

Our second contribution has been to provide the ability to combine free-text assessment with self-assessment (Pascual-Nieto et al., 2008). This combination is beneficial to the free-text CAA field as automatic assessment is still not perfect, and whenever the system makes a mistake, the self-assessment allows the students to correct it.

2.3 Human-Computer Interaction

There have been many definitions of Human-Computer Interaction (HCI). For instance, Tufte (1989) defines HCI as follows: "*Human-Computer Interaction can be understood as two* *potent information processors (a human and a computer) trying to communicate with each other using a highly restricted interface*". Also, Preece (1994) offers an alternative definition: "*Human-Computer Interaction is the discipline of designing, evaluating and implementing interactive computer systems to be used by humans*".

Nevertheless, the great majority of these definitions share the same key idea: computer applications should be designed using principles that adapt their interface to make it easier for humans to use them (Berge, 1999). It has been claimed that even if a computer system is perfect from a technical point of view, the system could be regarded as a failure if users do not understand how to interact with it. Furthermore, the relevance of HCI and of making usable computer applications can also be seen in the fact that at least 48% of the code of computer applications is devoted to the interface (Myers, 1998).

Shneiderman (2002) stated that, while in the past Computer Science was more oriented to what computers could do, now Computer Science should be more oriented to what users can do with computers. This means that researchers not only from Computer Science, but also from Psychology, Sociology and other areas of knowledge should devise a set of principles to help designers to make computer applications user-friendly. Some of these principles are gathered below (Dumas & Redish, 1999; Holzinger, 2005; Thimbleby, 2007):

- A different interface should be provided for novice than for expert users.
- It is important to keep all interfaces of a program consistent in their terminology, format and procedures.
- Users should be assisted with dialogue boxes whenever the task to be accomplished is complex. Moreover, if the task is composed of several subtasks, a flow diagram should be shown to indicate all the subtasks, and which subtask is currently being done.
- The messages provided to the users should be meaningful.
- The application should have on-line help.
- Users should be provided the same information in different representation formats to improve the accessibility of the application (e.g. a written message could also be read aloud to help blind people).
- The answer time of the application should be reasonable. Where tasks take a long time, a progress bar should indicate the amount of work done, and the amount of work to be done. In all cases, the user should receive confirmation to his or her actions (e.g. with a written message and/or a sound).
- If the computer application has a complex navigation structure, a site map or some kind of structure should be shown to help the user orientate himself or herself through the application.
- Cognitive aspects should be taken into account, such as the importance of color (e.g. avoid using aggressive combinations such as yellow/black or red/black) and the limited short-term memory of users (e.g. messages of previous screens should be repeated if they are going to be needed in the future).

These principles should be applied in the design of any computer application. In particular, our interest in this work is the application of HCI principles for educational applications, in which the users are teachers and students who may not have any computer training.

Some researchers are already aware of the importance of correctly managing HCI in educational applications (Borsook & Higginbotham-Wheat, 1991; Drave, 2000; Rovai & Barnum, 2003; Chou, 2003; Anderson, 2004). Their research has provided some results: the recipes of Borsook & Higginbotham-Wheat (1991), which aim to make web-based learning

applications more interactive; the framework of Chou (2003), intended to simplify the design of interactive web-based learning applications; or the distance education interactivity theory of Anderson (2004).
However, to our knowledge, there have been no proposals of a formal methodology to aide designers of web-based learning applications, and in particular for Blended Learning applications and their particularities. Our contribution in this chapter tries to fill that gap, by proposing a Human-Computer Interaction Educational Methodology for on-line Blended Learning systems, as we will describe in the next section.

3. Human-Computer Interaction Educational Methodology for on-line Blended Learning systems

The proposed HCI Educational Methodology presented here will be called M-I2P5. This methodology defines a set of methods or strategies to manage the interaction in a Blended Learning system between the teachers, students and the content of the system.
The definition of M-I2P5 starts with the identification of the entities (i.e. agents of the methodology), the data model, the interactions and the computational processes (i.e. actions performed by a computational layer o middleware to achieve an interaction goal), which are the target of the methods or strategies that will serve to manage the interaction in on-line Blended Learning systems. Figure 1 shows an interaction scenario with these elements.

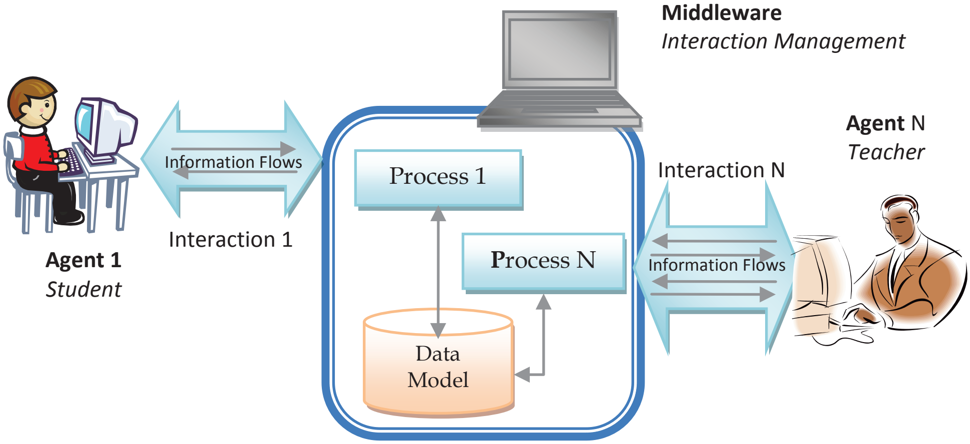

Fig. 1. Scenario with the proposed elements used to define the framework of M-I2P5

As can be seen in Figure 1, three different **entities** are distinguished: students, teachers and the computer application or middleware. The middleware is a key entity for the methodology as it is the entity in charge of implementing the methods to manage the interaction. In fact, two main types of **interactions** are considered:

- **The student-middleware interaction:** students log into the on-line Blended Learning system and interact with the computer (middleware). Similarly, the middleware has to provide a response to any action of the student in a way that s/he can understand, without having any kind of specific computer training.

- **The teacher-middleware interaction:** teachers also need to interact with the middleware. Two subtypes of interactions can be distinguished here: firstly, the editing of the content of the Blended Learning course, and secondly, the monitoring of student learning progress (individuals or groups). It is important to remember here that while in an e-learning system the teacher totally disappears, in Blended Learning, the teacher changes his/her role from being the source of knowledge (in traditional teaching) to becoming a guide and facilitator of the learning.

Regarding the **data model**, note that while the kind of data that an on-line Blended Learning system needs to store can vary widely (questions, algorithms, numbers, texts, etc.), for most educational learning systems these data can all be expressed as a set of concepts and their relationships (Novak & Gowin, 1984).

In this work we therefore propose to use a **conceptual model** as part of the data model. A conceptual model can be defined as a set of related concepts and their relationships. Each concept can be associated with text, figures, sounds, etc.

It is also important to bear in mind that besides the content of the course stored in the **domain model**, in order to make the on-line Blended Learning system adaptive to the student, a **student model** should also be kept (Brusilovsky & Eklund, 1998). Moreover, the student model should be stored in a form that allows it to be shown to the students, allowing them to keep track of their progress (Dimitrova, 2001; Zapata-Rivera et al 2007). Therefore, we propose to use a conceptual model not only as part of the domain model, but also as part of the student model.

Finally, Figure 1 also shows the middleware as containing a set of **computational processes**, which can be defined as a series of actions which are carried out in order to correctly manage the interaction between pairs of the identified entities (students, teachers and the middleware itself). The description of these processes is presented in the following sections: the computational processes which manage the interaction between the student and the middleware are included in Section 3.1, and the computational processes which manage the interaction between the teacher and the middleware are included in Section 3.2.

3.1 Processes for the management of the student-middleware interaction

As can be seen in the scenario of Figure 2, three processes have been distinguished: the local assessment process, the global assessment reporting process and the learning process. All of them are described below.

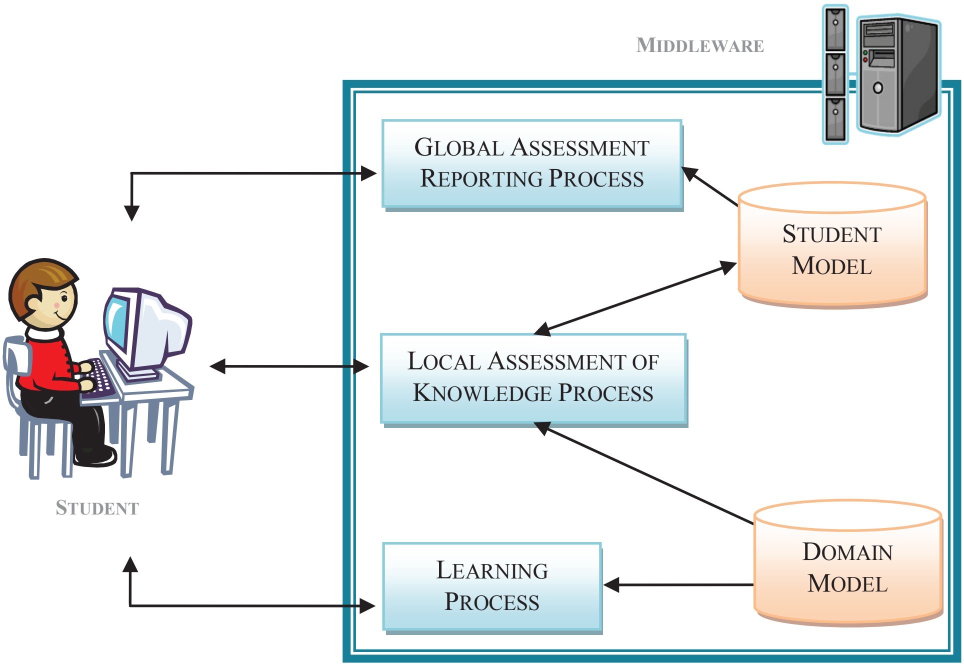

Fig. 2. Scenario showing computational processes for managing the student-middleware interaction in the methodology M-I2P5

3.1.1 The local assessment process

The goal of the local assessment process is to capture the student's knowledge for evaluating it. In order to achieve this goal, the procedure should be as follows:

1. The middleware asks the student a question.
2. The student answers the question, providing the middleware with indicators of how well s/he knows the answer.
3. The middleware evaluates the knowledge indicators and returns feedback to the student indicating the assessment.

Furthermore, from an interaction point of view, some HCI principles that should be taken into account in this procedure:

- **To** ***communicate following a dialogue metaphor***: Human-Computer communication is facilitated when it is similar to Human-Human communication. Therefore, given that humans communicate with each other using dialogues, it is natural for us to communicate with computers using, if not dialogues (as they are still too complex to analyze from a Natural Language Processing point of view), at least dialogue metaphors.
- ***To adapt of the information presented to the student***: each student, according to his or her learning style, can manage information in a different way. Thus, the information presented to them should be adapted to their abilities and preferences.

- ***To limit the cognitive overload***: human working memory is limited. Thus, the number of elements in the interface should also be limited and also important ideas that are needed from one screen to another should be repeated.
- ***To provide immediate feedback***: for each exercise or question the student should be given textual or visual feedback. It is an HCI principle that each action of the user has to have a visible reaction. That is, for each question answered by the student (action), the system should provide the student with feedback (reaction).
- ***To provide the possibility of self-assessment***: the student should not be regarded as a passive agent in the student-middleware interaction. Rather, the student should be able to intervene not only in their learning process, but also in their assessment process, as an active critique part. When the automatic assessment of the system is not perfect (e.g., as when free text answers are assessed), the student should have scope to modify the assessment, perhaps with later review by the teacher.

3.1.2 The global assessment reporting process

The goal of global assessment reporting process is to provide to the students global feedback information about their progress in the course. Hence, this process is different from the previous process in that it provides assessment for the whole course, rather than a single question. To achieve this goal, there are five important HCI principles that any on-line Blended Learning system designer should take into account:

- ***To provide multimodal information***: all information, including the feedback, should be presented in several representation formats. That way, different aspects can be highlighted in each representation, and in the case that one student cannot understand one representation format, s/he would still be able to understand one of the others.
- ***To provide a summary of the information***: as with the local assessment process, limited working human memory should be taken into account (indeed this factor is more important here due to the larger amount of information to present). Thus, summaries should be provided instead of providing all detailed information on one screen.
- ***To provide feedback***: this feedback is not the same than the immediate feedback of the local assessment process, but feedback that should be available to the student anytime s/he wants it. This is particularly relevant to many Blended Learning systems in which the goal of the assessment is not summative (i.e. to score the students), but formative (i.e. to teach with feedback adapted to the mistakes found in the answers provided by the students).
- ***To show state indicators***: students should also be aware of the subtasks needed to pass the course. Furthermore, the system should mark the level of progress made by each student in each subtask. Thus, the student can identify which subtasks need more work, and which have already been successfully completed, and his/her efforts can be oriented towards the pending subtasks.
- ***To allow students to review their previous work***: even if a student has completed a subtask, s/he should be permitted to review the work done. For instance, a history of already passed exercises could be provided. In this history, both theoretical and practical content could be stored together to allow students to review the theory of the course with practical examples.

3.1.3 The learning process

The goal of the learning process is to manage the interaction between the student and the middleware whenever the student is learning new content. The difference with the previous processes is that their focus was more on assessment (albeit formative assessment). Thus, in this process there is no capture of knowledge from the student, rather, it is the student who captures knowledge from the system.

Some HCI principles that designers should take into account when implementing this process are similar to the ones previously explained for assessment, but taking into account that here the focus is on teaching and not on evaluating:

- ***To promote the anchoring of new information with previous information***: this HCI principle is based on the Meaningful Learning Theory (Ausubel, 1963), which claims that, in order to learn new concepts, students should understand previous concepts to which the new concepts are linked. In fact, according to Ausubel, this is the only way to learn something meaningfully. Thus, it is important that the organization of the structure of the course facilitates the anchoring of new information to previous one, and the existence of prerequisites.
- ***To generate local explanations for specific doubts***: similarly to the local assessment process, and taking into account the limitation of the short term human memory, not only it is necessary to provide local feedback, but also to provide local explanations so that students can focus on those specific aspects of the course which could be more complex to understand.
- ***To remove irrelevant information***: any irrelevant information might distract the attention of the student from the key content of the course. Thus, the interface should be designed to remove irrelevant elements and to help the student maintain their focus.
- ***To adapt the learning to each student***: similarly to the assessment process, the learning should also be adapted to each student. Thus, not all students should be presented the same information, but according to each student profile, the information presented should be different.
- ***To provide multimodal information***: as with the assessment process, students are not equally able to understand information presented in particular representation formats. That is, the adaptation of the content should also cover the representation format. For instance, according to each student learning style, some students may understand the content of the course shown in diagrams, while other students may understand it better presented as text. Moreover, even among students who prefer a certain learning style, not all of them may understand the concepts written in the same way. This could be solved by asking two or more teachers to collaborate when creating the Blended Learning course (considering also that usually one course is not imparted just by one teacher, but by several).

3.2 Processes for the management of the teacher-middleware interaction

As can be seen in Figure 3, two processes have been distinguished: the domain model creator process and the monitoring process. Both of these are described below.

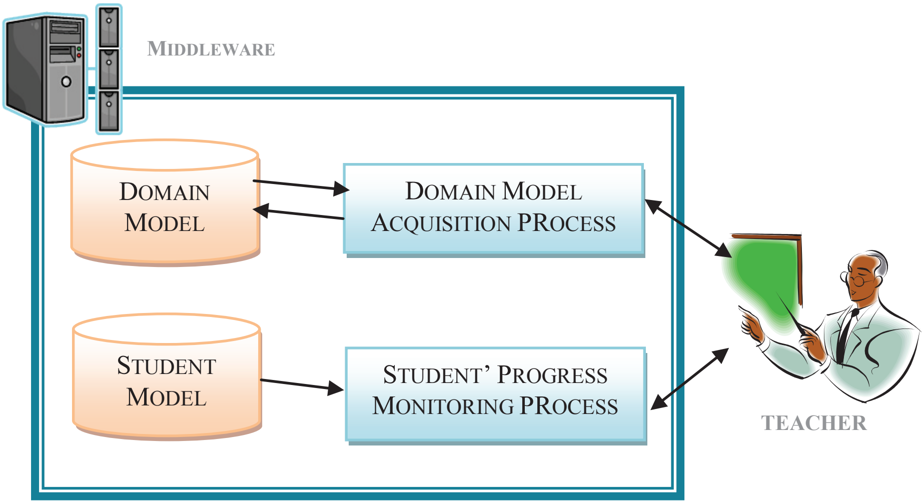

Fig. 3. Scenario showing the computational processes for managing the teacher-middleware interaction in the methodology M-I2P5

3.2.1 The domain model acquisition process

The goal of the domain model acquisition process is to manage the acquisition of the content of a Blended Learning course as provided by the teachers. However, the process of transferring that knowledge into the Blended Learning system is not easy. The goal of the domain model creator process is to facilitate the creation of the domain model of the course by making the authoring tool interface more targeted and easier to use.

Moreover, the process to manage the interaction between the teacher and the authoring tool is necessary because teachers tend to have more difficulties than students to learn to use on-line applications (Muir-Herzig, 2004). Therefore, the system should apply at least the following HCI principles:

- ***Allow teachers to use document editors***: teachers should be permitted to complete the information for the domain model of the course by using text templates. Many educators know how to use document editors and they already have an electronic version of their course material. Therefore, by using a document editor to create the domain model, they would not have to learn a new computer application, and it would be easier for them to reuse previous material.
- ***Allow teachers to update the content of the course***: teachers may need to modify information previously introduced in the course and they should have an easy way to do it with the authoring tool of the Blended Learning course, or just by uploading a new version of the text template. In any case, they should not be forced to find in which places they have to make the change, but the task should be facilitated by allowing them to introduce the modification and thus, automatically updating the rest of the course accordingly.

- ***Allow teachers to use a natural hierarchy for the structure of the courses***: usually teachers in their courses follow a hierarchical structure. Thus, they should be permitted to transfer this hierarchical structure to the electronic version of the course in case they want it.
- ***Limit the information presented in the screen***: similarly to the processes for the student-middleware relationship, the interface to be used by the teachers should also be limited to the necessary information. This is because of the limited short term memory that humans have. Moreover, it is not advisable to make teachers scroll through the text as it deviates his or her attention from the main task of editing the course.
- ***Allow teachers to introduce multimedia content***: on-line Blended Learning courses are not only composed of text. Therefore, the task of uploading videos, images, sounds, etc. should be easily found so that teachers feel encourage to use this feature.

3.2.2 The student's progress monitoring process

The goal of this process is to provide the teacher with the possibility of keeping track of the progress made by their students in an easy way. Many educational computer applications generate logs registering the actions performed by the students; however these logs are difficult to understand by non Computer Science experts (Mazza & Dimitrova, 2005).

Therefore, a graphical interface should be presented to the teachers according to the following HCI principles:

- ***To organize the presentation of the information of the students' progress***: teachers should be given the possibility of choosing by clicking on the name or photo of their students any group of students to which they want to see their progress. For teachers, it is intuitive to have a list of the class with the students' names (sometimes even with their photos). From this list, they can choose one student to get an individual report about him/her, or to choose a group of students, even the whole class to get a summary report from the individual reports of the students chosen.
- ***To provide complete and multimodal information***: similarly to the assessment processes for the student, the feedback for the teacher should also be shown in several representation formats. That way, teachers can get a more complete view of the progress made by their students as each representation focuses on a different aspect.
- ***To guarantee that the information is updated***: teachers would only consider updated information as the student reports may greatly change during the course. However, teachers are usually too busy to be able to update by hand the student reports. Therefore, an automatic mechanism should be activated that guarantees that the information is always updated, without loading the teacher with more work.
- ***To allow teachers to choose the level of detail of the students' progress reports***: unlike students, teachers should have the possibility of looking the reports of any of their students up to the level of detailed the teachers required. Intuitive tools such as presenting an augmenting zoom to provide more details should be shown in the interface to make this task easier.
- ***To generate automatically reports out the tool***: teachers may not have time to use the on-line Blended Learning tool on a weekly basis. However, this does not usually mean that they are not interested in looking at the reports. Therefore, teachers should be given, for instance, the possibility of automatically receiving the reports in their mail boxes.

4. Experiments and results

In order to find out whether the use of the HCI Educational Methodology proposed for on-line Blended Learning systems allows these systems to be used without problems by students and teachers without any computer training, we implemented the processes of the previously described methodology in our own on-line Blended Learning tools, Atenea and COMOV, which did not implement M-I2P5, resulting in a system, now with M-I2P5 incorporated, called Will Tools (Pérez-Marín et al., 2006b; Pérez-Marín et al., 2007b).

The reason why the tools were not originally designed according to HCI principles lies in the fact that we are Computer Science teachers and our students are Computer Science students, who do not usually have any problem in using new software. However, our insight was that the systems could and should be easily adapted to use by students and teachers without computer training too.

The only requisite was to have a proper HCI Educational Methodology. Therefore, once we had devised the methodology, we implemented it in the Will Tools. Moreover, we tested the new tools with students and teachers from English Studies in our home university, who do not have any specific computer training.

The methodology has been evaluated using three metrics: usability tests, satisfaction questionnaires and personal interviews. Both objective and subjective aspects were addressed by the metrics.

Furthermore, the evaluation was done in two different case studies: the first focusing on the evaluation of the processes to manage the interaction between the student and the middleware (described in Section 4.1); and the second focusing on the evaluation of the processes to manage the interaction between the teacher and the middleware (described in Section 4.2).

4.1 Case Study 1: evaluating the impact of the use of the proposed HCI Educational Methodology (M-I2P5) on the student-middleware relationship

There are three main research questions to answer with the results of this case study:

- *Do students with computer training notice the application of the principles of the proposed methodology M-I2P5 in Willow?* This was tested by contrasting the level of satisfaction and frequency of use of Atenea+COMOV to the level of satisfaction and frequency of use of Willow. This question will be answered in Section 4.1.1.
- *Do students without computer training use all Willow's features, and how does their behaviour when interacting with the system differ from the behaviour of the students with computer training?* These two questions will be answered in Section 4.1.2.

The experiments performed were classified as indicated in Table 1.

	Profile without specific computer training	**Profile with specific computer training**
System without M-I2P5 (Atenea+COMOV)	----	Computer Science Studies
System with M-I2P5 (Willow, Willov, Willed)	English Studies	Computer Science / Telecomunications Studies

Table 1. Organization of the experiments

The first experiment was performed during the 2006/2007 academic year. In this experiment, 24 (41% of the class) Engineering students (with computer training) voluntarily used Atenea (see Figure 4) to review their Operating Systems course, from October to January.
The second experiment was performed during the 2007/2008 academic year. In this experiment, 22 (49% of the class) English students (without computer training) voluntarily used Willow (see Figure 5) to review their Pragmatics course, from October to January.
The third and last experiment was also performed during the 2007/2008 academic year. In this experiment, 133 (77% of the class) Engineering students (with computer training) voluntarily used Willow to review their Operating Systems course, from May to June.

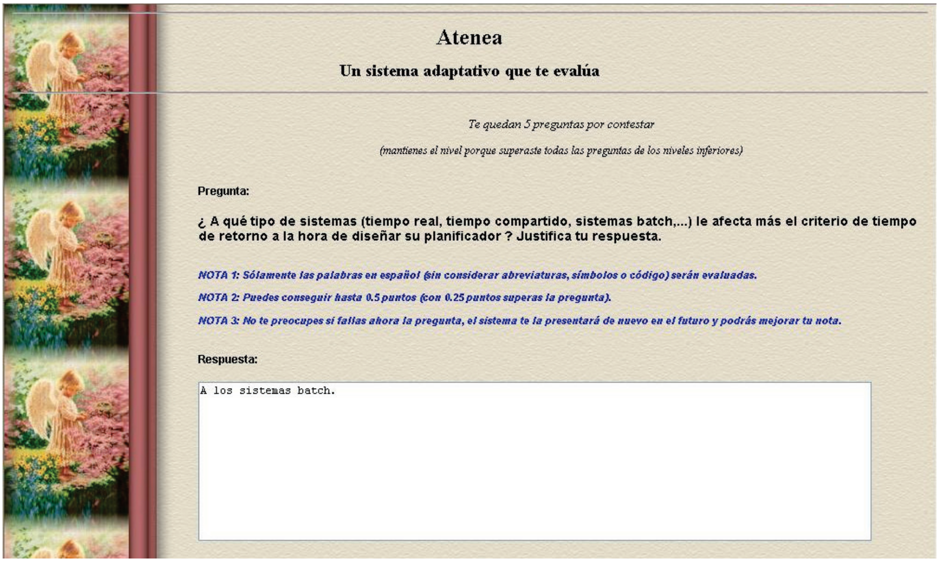

Fig. 4. Sample snapshot of Atenea (without M-I2P5) asking a question to the student

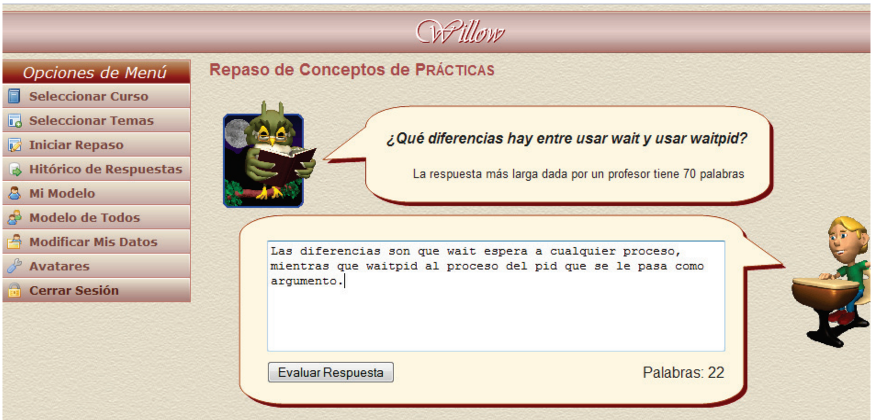

Fig. 5. Sample snapshot of Willow (with M-I2P5) asking a question to the student

4.1.1 Impact of the methodology for students with computer training

In order to answer the question whether students with computer training would notice the application of M-I2P5 in Willow, the results achieved in the first experiment (using Atenea+COMOV without the methodology), and in the third experiment (using Willow with the methodology) were compared.

The students of both experiments were motivated in the same way: they were told that students with borderline fails would be passed if their scores in the system showed progress.

We also provided a 5-minute explanation of the goal of the systems and very little information about how to use it. We recommended the students to use the system on a weekly basis, rather than trying to review the whole course before the exam.

At the end of the course, we measured the frequency of use of the systems. Figure 6 shows a histogram with the frequency of use of Atenea by the 24 Engineer students of the first experiment. It can be seen how, in general, students did not follow our recommendation of using the system weekly. Rather, most of them used it only on the days just before the mid-term exam in November and to the final exam in January. It is also important to highlight that the number of students using the system increased for the final exam. This could be considered as an indicator that the students found the system useful when reviewing for the mid-term exam. However, there are weeks in which no student logged into Atenea. Regarding the use of the monitoring tool COMOV, only 11 (46%) students used the system during the semester.

Figure 7 shows a histogram with the frequency of use of Willow (with the methodology implemented) by the 133 Engineering students of the third experiment. It can be seen that the frequency of use is now higher (in fact, the scale of the diagram is not weeks but days). Moreover, it can be seen that they tended to use the system daily and not only the days before the exam, which was in June. From the logs of Willow, we observed that usually after answering a set of questions, students looked at their conceptual models or the conceptual models of the class with the information about their progress in the course.

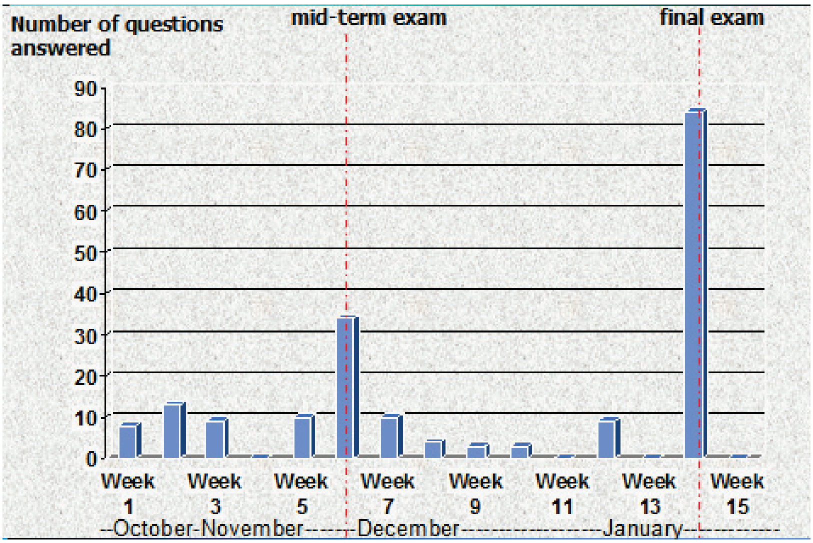

Fig. 6. Frequency of use of Atenea (in weeks) by students with computer training.

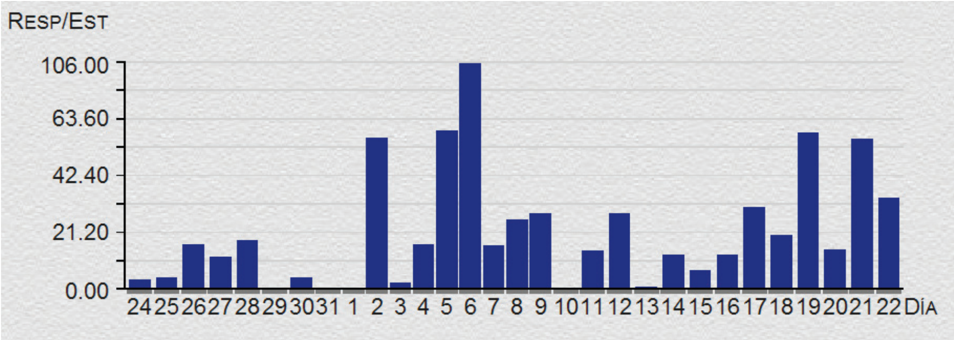

Fig. 7. Frequency of use of Willow (in days) by students with computer training

Regarding the level of satisfaction achieved by the students, they were asked to fill in a voluntary and anonymous satisfaction questionnaire. Given that filling in the questionnaire did not have any impact on the students' score, only 5 (21%) of the students from the first experiment completed it. All these respondents considered Atenea useful and easy to use.
We also performed personal interviews of three randomly chosen students, each interview lasting for about 30 minutes and focusing on the student's opinion of the system, and how it could be improved. Firstly, all of them stated that they liked the system, and that it was useful to review concepts. Later, when we started asking about features of the system, the students declared that the problem they found was that the system was too strict, and sometimes it seemed unfriendly. Two of them declared that they felt they were being examined, and that they felt that they did not have freedom to interact with the system.
When the students were asked why only 11 students had used COMOV, they said that the COMOV system had not worked for them. COMOV had been developed using a particular browser, and, while the students had been told to use that browser, many of them did not, and thus 54% students could not get the system to work, and did not report the problem to us.
77% of the students in the third experiment filled in the satisfaction questionnaire because in the 2007/2008 academic year, the questionnaire was given in hand to the students in class, and although it was also voluntary, teachers stressed its relevance. All of the students considered that Willow is easy to use and interesting. None of them said that Willow was unfriendly or too strict. On the contrary, most of the students stated that they liked reviewing the course with Willow because it is interactive and engaging. These students also used the global feedback features more, as they were integrated in Willow, and they did not have to use a different system such as COMOV.

4.1.2 Comparison of the impact of the methodology between students with and without computer training

In order to answer the questions whether students without computer training are able to use all Willow's features, and if their behaviour when interacting with the system is different from the behaviour of the students with computer training, the results of the second experiment (students without computer training using Willow), and of the third experiment (students with computer training using Willow) are compared.
Figure 8 shows the percentage of English Studies students who have used one or more of Willow's features without having any computer training, and just with a 5-minute

explanation of Willow's goal and philosophy. We found that none of the students had any difficulty in using Willow. 95% of the students chose different topics to review, 77% of the students changed his or her avatar in the system, 77% of the students visited the history of questions, 27% of the students changed his or her personal data, 68% of the students looked at the global feedback information; and, in fact 18% of the students tried to cheat.
All the students stated that Willow was friendly and useful, and they recommended it to any other student with or without computer training.

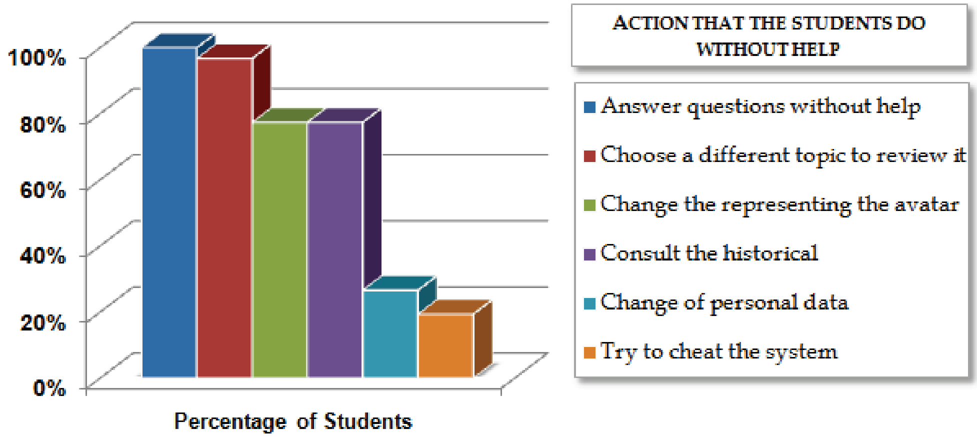

Fig. 8. Percentage of students of Pragmatics who used Willow's features with no help

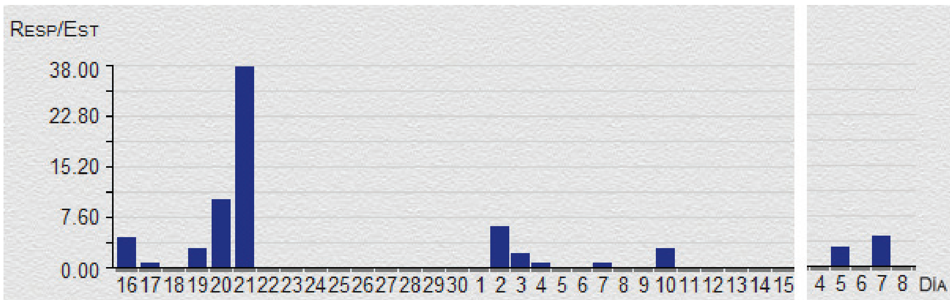

Fig. 9. Frequency of use of Willow (in days) by students without computer training

Figure 9 shows the frequency of use of Willow by the Pragmatics students. As can be seen, they logged into the system in different days, however the frequency of use of Willow is lower than in the case of students with computer training (see Figure 7)
Therefore, a first difference that can be highlighted between the interaction of students with and without computer training and Willow is that students without computer training tend to use it with a lower frequency.
Regarding the satisfaction achieved by the Pragmatics students, we also asked them to fill in an anonymous and voluntary satisfaction questionnaire. The results were very similar to the case of the first experiment, in which given that there was no impact in the final score of the

subject and we were not their teachers, only 5 students completed the questionnaire. On the other hand, the results were different as all declared that Willow was easy to use, and interesting.
These satisfaction results are very similar to the ones reached by the students of the third experiment (students with computer training using Willow).
In general, the behaviour of students with and without computer training when interacting with Willow is similar. They find it useful and friendly and they are able to use all the features, without any restriction because of lack of computer knowledge. However, there are some differences such as the greater number of times that Pragmatics students used the self-assessment feature, and the longer answers they provided to the system.

4.2 Case Study 2: evaluating the impact of the use of the proposed HCI Educational Methodology (M-I2P5) on the teacher-middleware relationship

There are two main aspects to consider in this case study:

- The evaluation of the methods to acquire the domain model, which will be treated in Section 4.2.1.
- The evaluation of the methods to monitor student progress, which will be treated in Section 4.2.2

4.2.1 Evaluation of the methods to acquire the domain model

There are two main research questions regarding this evaluation: whether M-I2P5 increases the level of satisfaction of the teachers in creating and editing the content of the electronic courses, and how the use of the authoring tool differs depending on the computer training of the teachers.
The first experiment to answer those questions was performed in the 2006/2007 course. 6 teachers of the Computer Science department were asked to complete a usability test of the Atenea's question editor, and after that to fill in a satisfaction questionnaire (Alfonseca et al., 2005).
All of the teachers successfully completed the tasks of the usability test, and they considered that none of the tasks had been difficult. In fact, 67% of the teachers stated that the tool was quite easy to use. However, when we did a personal interview to the teachers, we observed that some of them would only consider the tool useful if it saves them time. For instance, they would like to have some feature in the tool which allows them to reuse electronic content of previous courses.
The second experiment was performed in the 2007/2008 academic course with 2 Pragmatics teachers without any computer training. They were also asked to complete the usability test with the Atenea's question editor. However, the teachers did not finish all the tasks, and they considered that it was difficult to find out where they should introduce the information and which steps they should follow to create the course. They also remarked on the inability to reuse previous electronic content.
Given that in the 2007/2008 academic course, we had already devised the methodology M-I2P5 and implemented it in Willed, we asked the Pragmatics teachers to repeat the usability test but this time with Willed. The result was that one of the teachers was able to finish all the tasks, and the other teacher that was more reluctant to the use of a new computer tool, was happy to find out that she could edit the content of the course with her

document editor, and after that, she could upload the file to the system.
As there were only two teachers, we did not ask them to fill in a satisfaction questionnaire, but we did a personal interview to them. From these interviews, we concluded that Willed was considered easier to use, as it guides the user and they get graphical helps in each screen of the system.
The third experiment was performed in the 2007/2008 academic course with 2 Computer Science teachers using Willed. These teachers had also participated in the first experiment with Atenea's question editor, and they could compare the differences between the Atenea's questions editor (without M-I2P5) and Willed (with M-I2P5). Again, they could finish the tasks of the usability test without problems. In fact, this time, it took them less time to finish the test (it could also be because they had already used an authoring tool before). However, the most relevant difference became evident from the personal interviews, as now both teachers stated that they considered Willed more useful because it was easy to reuse content from previous courses.

4.2.2 Evaluation of the methods to monitor student progress

There are three main research questions regarding this evaluation: whether M-I2P5 increases the level of satisfaction of the teachers using the monitoring tool, and how the use of the monitoring tool Willov is different depending on the computer training of the teachers.
The first experiment to answer those questions was performed in the course 2006/2007. 6 teachers of the Computer Science department were asked to use COMOV (the monitoring tool without M-I2P5 implemented), and after that, to fill in a satisfaction questionnaire. The teachers rated the usability of the interface with a 3.8 value in a scale 0-low usability to 5-high usability. When the teachers were asked the reason for this mediocre value, they answered that despite liking the idea of the system, the interface was difficult to understand, and it was too static. Moreover, they thought that COMOV lacked important features such as providing frequency or performance graphs.
In the second experiment, we asked the 2 teachers of Pragmatics to use COMOV, and to give us their opinion. Again, the teachers did not understand some information presented by the system, and they stated that they would like to have graphs with information such as how long their students have reviewed each day. Furthermore, the Pragmatics teachers told us that they felt overloaded with too many computer tools, and that they did not have time to learn how to use all of them.
Therefore, when we showed them Willov, the monitoring tool of the Will Tools with M-I2P5 implemented, they highlighted the ability to send automatically generated reports to their email, and the automatic generation of interactive graphs with information about the work done by their students in Willow.
The third experiment was also in the 2007/2008 academic course, but this time with 2 Computer Science teachers. In particular, two of the six teachers who participated in the 2006/2007 academic course experiment, but this time instead of using COMOV (without M-I2P5), they were asked to use Willed (with M-I2P5 implemented).
Both teachers declared that the interface had been greatly improved and was more usable than COMOV's interface. They also highlighted the new features of choosing the students, topics, report generation and interactive monitoring graphs without needing to look at textual logs, or having to do the graph by hand.

Regarding the question of the differences between the use of the monitoring tool Willov depending on the computer training of the teachers, in this case, they were greater than in the case of the authoring tool Willed.
Teachers with computer training indicated their preference of using Willov interactively on-line. In fact, the feature that they considered as the best one was the ability to choose any group of students just by clicking on their names, and get updated information about the group.
While teachers without computer training indicated that they felt overloaded with too many computer applications. In fact, the feature that they considered as the best one is the ability to automatically receive student reports in email.

5. Conclusions and Future Work

Human-Computer Interaction (HCI) has become a very important research field (Dix et al., 2003), with many international and national conferences devoted to its study (e.g. CHI, Persuasive, LOCA, ICEIS, WIAMIS, etc.). HCI principles should be taken into account when designing any computer system, including educational computer systems, in order to maximize their easiness of use, and to increase the level of satisfaction of users who interact with the systems.
However, to our knowledge, **no formal methodology exists to gather how HCI principles can be used for educational applications**. In particular, a HCI methodology for Blended Learning applications, in which the idea is to combine face-to-face instruction with computer activities during the class, or to review after class, and more types of student-middleware-teacher interactions have to be taken into account.
In this paper, **we have proposed such a methodology, which has been called M-I2P5, and it has been implemented in a set of Blended Learning tools called *Will Tools***, which have been used since October 2006 by 6 teachers and 157 students with computer training, and by 2 teachers and 22 students without computer training.
Students with computer training were asked to interact with a version of the student system without the methodology implemented (called Atenea), and a version of the student system with the methodology implemented (called Willow). In both cases, students stated that the systems were useful to review concepts. However, in the case of Atenea, when we did a personal interview with some of them, they considered it was unfriendly and too strict. On the other hand, similar interviews for the users of Willow showed that they had not only used the system to review the course, but also enjoyed using the system.
Moreover, while the frequency of use of Atenea was weekly, and in some weeks no student logged into the system, the frequency of use of Willow was daily. In the case of the students without computer training, the frequency of use of Willow was also higher although not so constant.
None of the students without computer training found any problem using Willow, and even 18% of them tried to cheat the system. In fact, the use of Willow by students with and without computer training mainly differ in the attitude towards the system. While students with computer training regard it as an enjoyable way to review after class, students without computer training regard it as a self-assessment tool to complement the work done in class.
Teachers with computer training were asked to interact with a version of the **authoring tool** without the methodology M-I2P5 implemented (called Atenea's question editor), and also

with a version of the authoring tool with M-I2P5 implemented (called Willed). In both cases, teachers were able to complete all the tasks of a usability test. However, the task took less time when using Willed than when using the Atenea's question editor. Moreover, when we interviewed the teachers, we found that they would not consider the system useful unless it allowed them to reuse previous content of other courses. This feature is included in Willed with M-I2P5, but it was not in the Atenea's question editor.
Moreover, neither of the teachers without computer training finished the usability test of the Atenea's question editor, while one of them finished the usability test of Willed. The other teacher preferred just to use her document editor and after that, uploaded the document in Willed.
Teachers with computer training also had the possibility of interacting with a version of the **monitoring tool** without having M-I2P5 implemented (called COMOV), and a version of the monitoring tool having M-I2P5 implemented (called Willov). In this case, the teachers declared a greater difference between COMOV and Willov.
Teachers without computer training did not use COMOV at all, and although teachers with computer training used it, they rated the interface as mediocre. On the other hand, they thought that Willov was highly useful to get information from any group of students they choose, and follow always updated performance and frequency graphs.
The main difference here between teachers with and without computer training was that while teachers with computer training were happy using Willov, teachers without computer training felt overloaded with too many computer applications. Hence they considered the possibility of receiving automatically generated student reports in their mail boxes as the most interesting. That way, they could have the monitoring information without having to use a new computer application. Nevertheless, the teachers without computer training also noticed that Willov seemed easier to use and was friendlier than COMOV.
Therefore, it can be concluded that using M-I2P5 has increased the level of satisfaction of both teachers and students with and without computer training. Even, in some cases, the use of M-I2P5 meant that teachers or students who were more reluctant to the use of Blended Learning tools, even thinking that the time and effort devoted to it was worthless, changed their mind and started using them noticing not only that the interface was easier to use, but also new interesting functions such as receiving information by mail.
Our **main lines of future work in relation to M-I2P5** are:

- To improve M-I2P5 so that it includes other types of interaction such as student-student or teacher-teacher relationships. This could be interesting, for instance, to manage collaborative work between students, or between teachers.
- To evaluate the relative importance of each method in M-I2P5 through a comparative study on the impact of the implementation of each particular method identified by M-I2P5 in a system.
- To include in M-I2P5 accessibility methods as one of the main goals to manage the interaction of disabilities in Blended Learning tools.
- To study the management of interaction achieved when M-I2P5 is applied to other working systems, different from Atenea or COMOV, used for Blended Learning.
- To consider the use of a pedagogical model and its relationship with the methods of M-I2P5.

The **main lines of future work in relation to the Blended Learning tools** are:

- To allow the students new ways of interaction where the conceptual model can be visualized as they are doing exercises.
- To explore the possibility of extending the dialogue metaphor by using a pedagogic conversational agent that engages students in guided conversations.
- To incorporate automatic Information Extraction techniques in the authoring tool, so that in the case of courses without previous content, teachers are shown a repository of possible reliable sources from the Internet such as University web pages, encyclopaedias, etc.
- To increase the flexibility of generating student reports in the monitoring tool. For instance, teachers can be given the ability to limit the information contained in the report.

Finally, we would also like to encourage other designers of Blended Learning tools to apply the proposed methodology M-I2P5 to their educational systems, and to report whether they get similar benefits to those we experienced when using the Will Tools with the methodology implemented.

6. Acknowledgment

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A Conceptual and Technological Framework for Building Collaborative Learning Environments

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1. Introduction

Computer-Supported Collaborative Learning (CSCL) has emerged as a multidisciplinary research field around 1990 (Koschmann, 1996). The purpose of CSCL is to support students in learning together effectively via networked computers. During the first decade CSCL researchers have created a large number of ad hoc systems focusing at a microscopic level on particular situations and contexts and aiming at triggering specific learning processes (Lonchamp, 2006a). Their evaluation has been based mostly on the experimental paradigm, through statistical analysis of variables in relation with the learning processes, and less frequently on descriptive analysis in the ethnomethodological tradition (Stahl et al., 2006a). These early research works have contributed to the emergence of concepts, practices, and mechanisms of general interest for the CSCL domain. At the macroscopic level of institutional politics and processes, CSCL has been recognized as a possible way for preparing people to the knowledge society, for achieving deeper learning than traditional methods and for better meeting the expectations of the net generation (Resta & Lafferière, 2007). The current challenge is probably situated at an intermediary level (Jones et al., 2007), where new approaches and technologies for the effective diffusion of collaborative learning practices are needed. Many researchers think that the first generation of ad hoc, specialized, and closed tools should be replaced by systems "richer and appropriate for various collaborative settings, conditions and contexts" (Dimitracopoulou, 2005), "reconfigurable, adaptive, offering collections of affordances and flexible forms of guidance" (Suthers, 2005), "very flexible and tailorable" (Lipponen, 2002). Moreover, these generic (i.e. end-user deeply customizable) and malleable (i.e. statically and dynamically evolvable) CSCL systems should be integrated into larger environments aiming at supporting the communities of interest and communities of practice necessary for educating, training, and guiding teachers often frightened by these new approaches and technologies (Haatainen & Korhonen, 2002). The research described in this chapter explores the combination of these three concepts of "genericity", "malleability" and "community support". It is situated at an intermediary level between microscopic and macroscopic approaches, and follows the iterative design tradition. Iterative design is driven by the interactions among evolving theories, informal observations and experimentations of successive prototypes which explore the space of possible designs (Stahl et al., 2006a).

The chapter is structured into four parts. The first part outlines a conceptual framework for collaborative learning. First, the notions of collaboration and collaborative learning are discussed. Then, collaborative learning is analyzed along four dimensions: collaborative knowledge building, mediation by artifacts, distributed scaffolding and co-construction of the learning activity and its supporting system. The discussion is synthesized into a dozen of fundamental requirements. The second part describes a functional architecture that meets these requirements. This architecture includes a multi-model reflexive kernel, clients that scaffold artifact-centered collaboration and a hosting web platform for collaborative learning practice, evaluation and dissemination. The third part discusses the detailed design of the most important and original components of the proposal. Finally, the last part describes the current state of Omega+ generic synchronous CSCL system (Lonchamp, 2006a) and Escole+ hosting platform (Lonchamp, 2007c) which together implement that architecture. This proposal results from an iterative process of design and evaluation whose continuation is discussed.

2. Conceptual Framework

2.1 Collaboration and collaborative learning

There is no universally adopted meaning of the terms “collaboration” and “collaborative learning”. Ingram & Hathorn (2004), define collaboration as consisting of three crucial elements: participation, interaction and synthesis. Collaboration cannot occur within a group unless there is roughly equal participation among its participants. If some participants do the main part of the work while others barely contribute, then the group is not truly collaborating. Interaction requires that group members actively respond to one another, react and change their minds as the discussion progresses. Finally, the product that the group creates must represent a synthesis of ideas and input from all members of the group. Collaboration is more than the exchange of information and ideas. It implies the synthesis of shared information and ideas that creates a product different from any that the individuals could have produced alone (Kaye, 1992), i.e. the production of new knowledge by the group. Every collaborative learning environment should at least create the basic conditions which enable collaboration: (R1) equal participation of all participants, (R2) genuine interaction among learners, and (R3) collaborative production of new knowledge.

Dillenbourg (1999) proposes four dimensions for analyzing collaborative learning: (1) the collaborative situation, including in particular the kind of artifacts that are manipulated; (2) the interactions that take place within the participants; (3) the learning processes and mechanisms; and (4) the set of effects in terms of individual and group performance. The collaborative situation is an artificial situation in which particular forms of interaction among people are expected to occur in order to trigger learning mechanisms. For increasing the probability that these forms of interaction occur, it is important to build a situation with adequate characteristics, such as:

- Group size: quite small, in most cases.
- Group composition: either homogeneous or taking advantage of a variety of knowledge and skills.
- Activity duration: rather short, in general.
- Activity orientation: for instance, an activity that stimulates critical thinking.
- Activity diversity: i.e. with unique or multiple roles.

- Activity partitioning: in general quite low; a fixed division of labor, where participants solve sub-tasks individually and then assemble the partial results into the final output, corresponds to the cooperative mode.

Interactions are characterized by their:

- Mode: rather synchronous.
- Negotiability: collaborative partners should have the possibility to negotiate how to interact at the meta-communicative level (Bateson, 1973).

Interaction rules and process structure may be imposed for facilitating productive collaboration. In a generic approach, the design of the collaborative situation, of the interaction rules, of the learning process structure, and of the way of measuring individual and group performance should be performed as far as possible by the involved teachers. This fundamental issue will be discussed in more details later.

2.2 Collaborative Knowledge Building

In several theories learning is understood through a knowledge-creation metaphor and address the same kinds of questions concerning how new knowledge is created by innovative communities (Paavola et al., 2002). Nonaka and Takeuchi's theory (1995) is based on an epistemological distinction between two sorts of knowledge, i.e. tacit and explicit. Explicit knowledge means knowledge that is easy to articulate and express formally in clear terms (Polanyi, 1962). It can be articulated in formal language including grammatical statements, mathematical expressions, specifications, manuals and so forth. Tacit knowledge means "personal knowledge embedded in individual experience and involves intangible factors such as personal belief, perspective, and the value system" (Nonaka & Takeuchi, 1995). Tacit knowledge is difficult to transfer (Spender, 1996). The dynamics of Nonaka and Takeuchi's model comes from the interaction between tacit knowledge and explicit knowledge. A knowledge spiral (see Figure 1) is based on four alternative types of knowledge conversion:

- Socialization: from tacit knowledge to tacit knowledge, when tacit knowledge and experiences are shared at the group level; socialization creates common understanding and trust within the group.
- Externalization: from tacit to explicit knowledge, when tacit knowledge is explicated and conceptualized by using concepts, models and theories.
- Combination: from explicit to explicit knowledge, when already existing explicit knowledge is exchanged, discussed, reused, and reworked.
- Internalization: from explicit to tacit knowledge, when explicit knowledge at the group level is internalized into individuals' tacit knowledge and into action. After internalization a new round in the knowledge spiral can start again.

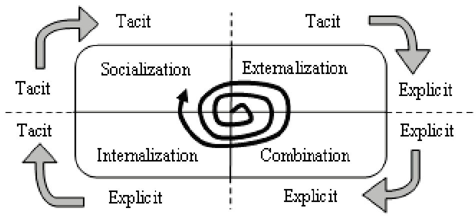


Fig. 1. Nonaka and Takeuchi's knowledge spiral

Every collaborative learning environment should (R3.1) facilitate socialization, through informal exchanges of subjectivities, emotions, opinions, doubts, (R3.2) facilitate externalization, through knowledge formalization and justification, (R3.3) facilitate combination, through knowledge comparison, synthesis, restructuring, generalizing, (R3.4) facilitate internalization, through knowledge exploration and analysis.

2.3 Mediation by Artifacts

Other theories, like Bereiter's knowledge building theory (2002), emphasize the fact that collaborating learners are elaborating, transforming, extending, and criticizing conceptual artifacts, such as ideas, methods, models and theories. Conflicting perspectives are essential to this process, through discourse activities such as questioning, proposing, arguing, critiquing, clarifying, negotiating, accusing, repairing, and agreeing. This knowledge elaboration process is greatly facilitated by knowledge materialization into shared digital artifacts (Paavola et al., 2002). These artifacts play many roles including focalization points, memories, constraints and inciters. It is worth noting that some artifacts do not contribute directly to knowledge building but serve for negotiating frames of reference such as glossaries, taxonomies, domain models, and ontologies. Figure 2 summarizes Miao's conceptual model of collaborative learning based on artifact mediation (Miao, 2000).

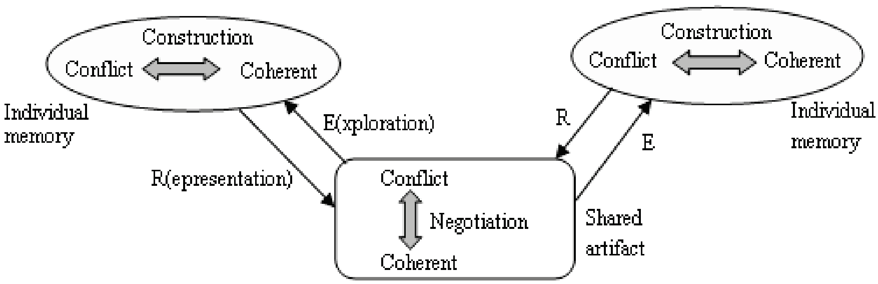


Fig. 2. Miao's conceptual model

"Representation" and "exploration" information flows can be related to Nonaka and Takeuchi's externalization and internalization processes. Knowledge in individuals' minds and the information which is held in the shared artifact can each be defined as being in "conflict" or "coherent" state. The term "conflict" has a large meaning, corresponding to all situations that can trigger a reaction from learners, including inconsistency, incompleteness, contradiction, and impreciseness. At the individual level, each learner constructs new knowledge by integrating new information into his own cognitive structure. Conflicts occur when new information contradicts existing knowledge. The learner must therefore solve this cognitive dissonance (Festinger, 1957) by constructing a new cognitive structure, i.e. by learning. At the group level, conflicts occur when one or more learners disagree with existing information in the shared workspace. In this case, the learners in the group might negotiate together to construct a new consensual state for the conflicting artifact (e.g. by combination). This dialogue can trigger learning mechanisms. Miao derives three requirements from this conceptual model of collaborative learning which make more precise the requirements deriving from Nonaka and Takeuchi's analysis. Every collaborative learning environment should (R3.2) facilitate representation of shared knowledge, (R.3.3) facilitate negotiation of shared knowledge, and (R3.4) facilitate exploration of shared knowledge.

Shared digital artifacts have physical properties that facilitate some usages, ways of thinking and objectives. Suthers (2003) has experimentally analyzed how shared, learner-constructed representations can influence collaboration in face-to-face and online situations. For instance, during an on-line collaboration with Belvedere, evidence maps are used for entering directly new ideas without preliminary discussion with the textual chat tool. Textual exchanges are used for brief confirmation dialogues and, in exceptional or problematic situations, at the metacognitive level. In a more recent work, Suthers (2006) show how many aspects suggested by knowledge construction theories can be observed experimentally during the manipulation of evidence maps: grounding (Clark & Brennan, 1991) by implicit uptake of the interlocutor's actions in the graph, interactions that respond to and address differences of interpretation, and transformations of representations by multiple individuals leading to a joint solution.

A generic environment should allow to define many different external representations and to adapt them to the specific situation and context. It should, in particular, allow the manipulation of multiple views, either partial ones, or described at different abstraction levels, or with different representation systems. When they are compared or transformed, these views can raise a new category conflicts that trigger corresponding learning processes. Multiplicity of artifacts and views makes deixis issues (referencing elements or actions within the shared workspace) more complex. Figure 3, extends Miao's conceptual model with the concept of multiple views. It also highlights the complementing roles of direct interpersonal communication and indirect communication through shared digital artifacts.

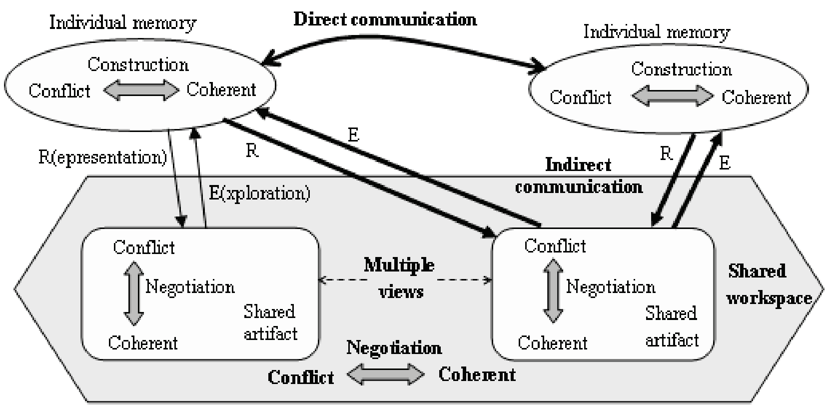


Fig. 3. The extended conceptual model

2.4 Distributed Scaffolding

The traditional concept of scaffolding involves support as provided by a teacher or more knowledgeable peer to a learner. Some researchers have tried to analyze this kind of scaffolding at a conceptual level. Bruner (1983), for instance, relates scaffolding with Vygotsky's notion of "zone of proximal development," which characterizes the region of tasks between what the learner could accomplish alone and what he or she could accomplish with assistance (Vygotsky, 1978). Bruner identifies six characteristics of effective scaffolding which are aimed at engaging and keeping the learner to task: recruitment of interest in and adherence to the task, reduction in degrees of freedom, direction maintenance, marking critical features, frustration control, and demonstration (of idealized solution paths).

A growing attention focuses on the potential of computer software to provide cognitive support for learners engaging in complex intellectual activities or "software scaffolding". More precisely, scaffolding is distributed across the various agents that play a role in learning, including teachers, peers, software and paper and pencil tools (Puntambekar & Kolodner, 2005). Every collaborative learning environment should facilitate both (R4) software scaffolding of learners and (R5) interpersonal tutor-learner and learner-learner scaffolding. For Reiser (2002), software scaffolding may occur through two complementary mechanisms: structuring the learning task (planning, decomposition and guidance) and problematizing concepts (i.e. making something in students' work more problematic). The software can force students to encounter important ideas or processes. While making the task more difficult in the short-term, instead of directly assisting learners, such scaffolded tools create more productive learning opportunities. Quintana's framework (Quintana and al., 2002) proposes a set of scaffolding strategies organized around three major cognitive challenges for learners: process management (learners need support to navigate through the different work processes and activities), sense-making (learners need support to analyze and make sense of their work products to gain insight and drive the direction of their work), and articulation (learners need support to express an understanding of the work through explanations and descriptions of material they have analyzed). Table 1 summarizes the main strategies that are suggested for these cognitive challenges.

Challenge	Strategy
Process management	Structure tasks (plans, guides, visualizations…) Provide access to expert knowledge (content guidance, information for using the tool, metacognitive information) Automate non-salient, routine tasks
Sense making	Organize the tool around the semantics of the discipline (concepts and strategies) Use representations that can be inspected by learners (multiple, modifiable views) Use representations and language that bridge learners' understanding
Articulation	Facilitate articulation of descriptions and explanations (prompting, templates…) Facilitate articulation of work plans and progress

Table 1. Quintana's framework

2.5 Co-construction of the Learning Activity and its Supporting System

Activity Theory explains that the structure of any cooperative activity, described by Engeström (1987) in terms of object (motive), subjects, tools, rules, community and division of labor, is dynamic and continuously evolves. Rules can be bypassed, renegotiated and adjusted. Tools alter the activity and are, in turn, altered by the activity (Jonassen & Rohrer, 1999). Subjects drive these evolutions for taking into account the new needs and the contradictions that appear during the course of the activity. New activities may emerge, what Engeström (2001) refers to as "expansive learning".

A computerized collaborative learning support system should continuously reflect the current structure of the supported learning activity, putting a strong requirement on malleability by end-users, i.e. teachers and students (Bourguin, 2000). Malleability of computerized systems is considered a difficult issue because the more efficient mechanisms are also the more difficult to use and many users are not willing to make the efforts necessary to use them. Two kinds of system malleability can be distinguished: definitional malleability, for static (i.e. before execution) adaptation to the learning situation and context as it is perceived and operational malleability, for dynamical (i.e. at run-time) flexibility. All tasks involved in designing, preparing, using, evolving and evaluating the learning activity and its computerized support constitute meta-activities in a meta-process. Bardram (1998) highlights the fact that it is a collective process, through the concept of "co-construction level" where subjects collectively reconceptualise their activity. In the specific context of collaborative learning systems, the most important meta-activities aim at:

- Designing the learning situation and customizing the CSCL system.
- Monitoring the learning process and dynamically evolving the CSCL system.
- Post-analyzing learning process results for further improvement of the situation and CSCL system.
- Supporting the technical and pedagogical development of teachers within dedicated communities of interest and communities of practice.

A community of practice consists of practitioners undertaking the same task. Learning within a community of practice takes the form of "legitimate peripheral participation" (Lave & Wenger, 1991) in which newcomers enter the community from the periphery and move toward the center as they become more and more knowledgeable. At the opposite, a community of interest brings together people interested in a given problem. Learning within a community of interest is based on "informed participation" (Arias et al., 1999) in which the knowledge is collaboratively constructed by social debate and discussion.

Every collaborative learning environment should (R6) be designed for evolution by providing a high level of malleability, both (R6.1) definitional and (R6.2) operational, together with (R7) a support for meta-activities and related interest and practice communities.

3. Architectural Design

In the light of the conceptual framework introduced in the previous section, the objective of the research can be defined as the design and implementation of a system that facilitates the creation and usage of malleable learning environments oriented towards scaffolded collaborative knowledge building through direct interpersonal communication and indirect communication via shared digital artifacts. This section discusses the main architectural design choices aiming at meeting the set of requirements summarized in table 2.

	Requirement
R1	Equal participation of all participants
R2	Genuine interaction among learners
R3	Collaborative knowledge building through:

R3.1 R3.2 R3.3 R3.4	- Socialization (informal exchanges of subjectivities, emotions, opinions, doubts...). - Externalization (knowledge formalization and justification, with simultaneous manipulation of complementary views). - Combination (knowledge comparison, synthesis, restructuring, generalizing…). - Internalization (knowledge exploration and analysis).
R4	Software scaffolding of learners (process management, sense making, articulation)
R5	Interpersonal tutor-learner and learner-learner scaffolding
R6 R6.1 R6.2	Designed for evolution by providing a high level of malleability, both: - Definitional - Operational
R7	Support for meta-activities (designing, using, monitoring, post-analyzing, educating) and related interest and practice communities

Table 2. System requirements list

3.1 A Multi-model Reflective Kernel Dealing with Exceptions

As explained in section 2.5, a malleable system (R6) can be changed by its end-users, even during its execution (operational malleability – R6.2). Mörch (1988) describes three implementation approaches of malleability, by customization, integration, and extension. Customization means to modify the parameters of existing components. Integration means to create new subassemblies of components. Extension means to change the implementation through a (more or less abstract) language. In malleability by customization, users have to select one or several values in a predefined set in order to adapt a system to their needs. System designers must anticipate all possible adaptations which is not realistic in most cases. In malleability by integration, users can add predefined components in a system in a more or less transparent way (for instance, like plug-ins installation into browsers). By creating new components it is possible to satisfy emerging needs. But the effort for developing such components is often substantial. The most direct way to achieve the conformance between the system and the supported activity is to provide a reflective system, i.e. a system which includes an explicit representation (model) of the activity. The behavior of such a reflective system depends on that (continuously queried) representation and changes when the representation is modified, thanks to the causal relationship which is implemented between the activity model and the system behavior (Maes, 1987). Omega+ generic collaborative learning system which is presented in this chapter implements this architecture extended with parameterized customization for all adaptations that can be anticipated.

Modeling cooperative learning activities both for human and machine interpretation is one of the main challenges in this approach. In the broader e-learning field, IMS Learning Design multi-level meta-model has been criticized both for its complexity and for its incompleteness, in particular for dealing with synchronous collaborative activities (Hernandez et al., 2004). The solution explored in Omega+ associates a separate (sub-) model for each facet of collaborative learning activities (in accordance with Dillenbourg's analysis evoked in section 2.1): process model, interaction model, artifact meta-model, and "effects model". This multi-model approach makes possible to build the activity representation at different levels of abstraction, adapted to the skills and needs of different

categories of users by:
- Just reusing existing models.
- Building new combinations with existing sub-models (i.e. following a very high level configuration process).
- Defining or customizing simple sub-models through high-level visual languages.
- Developing complex sub-models through low-level specification and programming languages.

Omega+ reflective kernel also includes predefined tools (chat, shared text editor, shared whiteboard, and generic shared diagram editor) and mechanisms (floor control, referencing, monitoring, and group awareness) that can be selected and parameterized for fine-grained contextual adaptation.

Lastly, the kernel can also handle exceptional situations. For instance, if a learner cannot take the floor during a phase including a "round-robin" interaction protocol, a menu item allows the room operator to skip to the next learner in the circle without changing the interaction model itself. A large number of constraints can be dynamically relaxed or sidestepped thanks to ad hoc mechanisms. The system is in charge of making other users aware of these rule breakings. Table 3 summarizes these different levels of malleability.

Action	Type	Author	Objective
Model change in the library	Definitional	Teacher (as designer)	Enrichment or correction
Model change during instantiation	Definitional	Teacher (as designer)	Static adaptation
Model change during execution	Operational	Teacher (as tutor) or student	Dynamic adaptation
Constraint relaxation with ad hoc mechanisms	Operational	Teacher (as tutor) or student	Exceptional events handling
Parameter change	Operational	Teacher (as tutor) or student	Personalization

Table 3. Different levels of malleability

3.2 A Dual Interaction Space with Software Scaffolds

Omega+ provides on the client side a "dual interaction space" including a communication space and a task space (Dillenbourg et al., 2005). Such a dual space allows collaborative knowledge construction through direct interpersonal exchanges in the communication space, and indirect communication in the task space, via artifacts sharing. Several research works demonstrate that it is not easy for learners to use efficiently such dual spaces for cognitive and meta-cognitive exchanges, even in the simplest configuration with a chat and a whiteboard (Dillenbourg & Traum, 1999). Various scaffolding mechanisms are required. In Omega+, they mainly rely on the four sub-models evoked in the preceding section. They are discussed in relation with requirements R1 to R5.

3.2.1. Equal participation of all participants (R1)

Direct communication can be constrained by protocols either predefined or ad hoc, i.e. specified via interaction models. For instance, equality of participation can be imposed by the "round robin" predefined protocol (Fuks et al., 2006). Ad hoc protocols including application-related roles such as "presenter," "criticizer," "reviewer," "synthesizer," constitute another way of regulating participation (Pfister & Mülpfordt, 2002), in particular when roles are exchanged between participants. Moreover, in a dual interaction space, protocols can be used to control both direct and indirect communication if the "right to speak" includes the "right to manipulate" shared artifacts (Lonchamp, 2007a).

In a less constraining manner, meta-cognitive tools which visualize participation characteristics can also incite participants to perform best, either directly through self-regulation or indirectly through a tutor (Jermann, 2004). In Omega+, "effects models" are used for producing customized meta-cognitive tools (Lonchamp, 2008).

3.2.2. Genuine interaction among learners (R2)

Dialog structuring with tailorable sentence openers (Soller, 2001) is a first elementary technique provided by Omega+ for promoting effective interaction through questioning, clarification, agreement, contradiction, etc.

Typed messages and application-related roles specified into interaction models constitute a more powerful technique for promoting particular forms of interaction. For instance, the reviewer role can be associated with specific interaction types such as "correct," "comment" or "complement" (O'Donnel & Dansereau, 1992).

Some artifacts, corresponding to explicit representations of the space of debate between learners (Baker et al., 2003), can play a similar structuring role for indirect communication.

Lastly, referencing means (between tools and between spaces) can make easier questioning and reacting (Lonchamp, 2007b).

3.2.3. Collaborative knowledge building (R3)

Socialization (R3.1), i.e. informal exchanges of subjectivities, emotions, opinions, doubts, etc., is not easy when participants are not in a face to face setting. The interest of adding a video/audio channel to the textual chat is complex to analyze. A study from (Scholl et al., 2006), for instance, demonstrates no effect on dialog regulation and effects on task content highly dependent on video quality. Chat and whiteboard will likely remain the preferred tools for informal exchanges in distributed settings.

A large spectrum of artifact types makes easier externalization (R3.2). This spectrum ranges from loosely structured artifacts, such as concept graphs or representations using the card metaphor (Cox & Greenberg, 2000), to formal artifacts with a precise operational semantics allowing to animate them, like finite state automata or Petri nets. All these artifact types, independent of their degree of formality, are defined through artifact models using ontologies adapted to the domain and to the learners. During artifact construction, prompting techniques can help to trigger and guide properties elicitation.

Composition (R3.3) requires simultaneous manipulation of several artifacts of the same type or of different types in the same shared workspace. Omega+ workspace can be configured with multiple tools specified in the process model. Knowledge exploration can be made easier thanks to various kinds of representations and mechanisms such as hierarchical representations (multi-level graphs), multi-page representations (in whiteboard tools), thumbnail views for manipulating complex artifacts and a session history search window (Lonchamp, 2009).

3.2.4. Software scaffolding of learners (R4)

Besides sense making and articulation, scaffolding also concerns process management. This point meets the collaborative learning scripting research stream. Scripts aim at formalizing the sequence of activities, the way the task is distributed within the group and the mode of interaction among the participants (Jermann & Dillenbourg, 2003). Recent works distinguish between micro-scripts which specify the activities of individual learners during collaborative phases and macro-scripts which specify the overall structure of the learning process (Dillenbourg & Tchounikine, 2007). For instance, some micro-scripts based on role switching describe application-related roles and the way learners are statically or dynamically assigned to these roles (Pfister & Mülpfordt, 2002). Macro-scripts emphasize the idea that collaborative activities are embedded into larger processes including also individual and cooperative activities. It is the case for instance when learners write personal positions before a collaborative debate on a given topic. In the following, we use the terms "micro-process model" and "macro-process model," instead of micro and macro scripts. These models can either inform participants of the process they should follow (Carell et al., 2005) or guide them step-by-step through their interpretation by the supporting system (Wessner et al., 1999). In this last approach, implemented in Omega+, it is important to avoid procedural over-specification (Dillenbourg, 2002) and straight-jacket effects (Schmidt & Bannon, 1992). A high level of operational malleability is required when (micro or macro) process models are machine-enforced.

3.2.5. Interpersonal scaffolding (R5)

This kind of scaffolding relies in part on aspects that are not directly related to the supporting environment, like group composition: for instance, mixing different levels of experience and competence can favour peer scaffolding (Lai & Law, 2006).

Some functionalities of direct communication tools can also help interpersonal scaffolding between learners or between tutors and learners. For instance, chat tools should provide private channels for more individualized help than through the public channel. Lastly, all the approaches for genuine interaction described in section 3.2.2., also contribute to interpersonal scaffolding.

3.3 A Web Platform for Collaborative Learning Design, Practice, Evaluation and Dissemination

Collaborative learning tools slowly disseminate in real settings. Two important reasons are the lack of technical and pedagogical expertise from regular teachers and the lack of concrete assistance and guidance they can receive. The solution which is explored in this research is a web platform, called Escole+, aiming at satisfying several objectives (R4, R7):

- Support the collective learning macro-processes, including both collaborative activities supported with Omega+ and cooperative or individual activities.
- Support the collective meta activities of modelling, practicing and evaluating collective learning macro-processes.

- Host the communities of practice around these learning processes and meta activities.
- Host the global community of interest including teachers simply curious, or interested by, or practicing collaborative learning and specialized researchers.

All participants, including students, can access Escole+ platform and Omega+ environment by using a regular web browser.

This approach generalizes the communities of practice for the professional development of teachers, such as Tapped In 2 (Schank et al., 2002), by adding to an information-oriented support a process-oriented support. The "Community, Content and Collaboration Management System" concept (C3MS) is also closely related to Escole+. A C3MS is an extension of a Content Management System (CMS), like Zope or PostNuke, with bricks for constructing socio-constructivist scenarios: communication and argumentation tools (synchronous and asynchronous), project-based learning tools, tools for designing scenarios, etc. (Schneider et al., 2002). The C3MS approach suffers from serious flaws resulting from the weaknesses of CMS as integrating kernels. For instance, CMS are specialized for web content production processes and cannot support arbitrary defined macro-processes.

3.4 Functional Architecture

The functional architecture reflecting the previous design choices is summarized in Figure 4. The next section discusses the detailed design of its more important and original components.

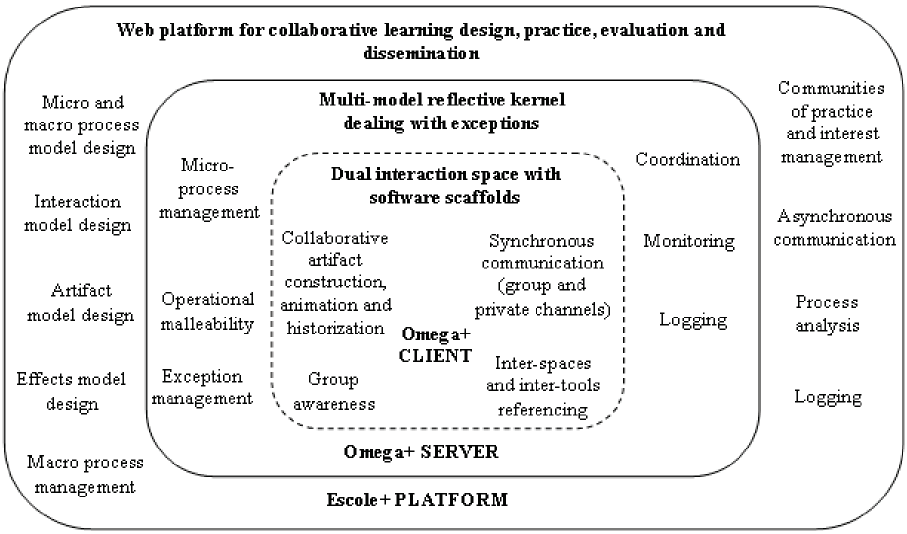


Fig. 4. The proposed functional architecture

4. Detailed Design

The following subsections describe the detailed design of the most important and original components of the proposal. Figure 5 summarizes the overall conceptual model of Omega+ and helps for understanding how the different sub-models are structured and interrelated.

It is worth noting that all important concept types - roles, tools, protocols, floor control policies (FCPs) - are specialized into predefined and application-specific sub types. This reflects the fact that Omega+ provides both hard-coded mechanisms and model-based features which are customizable and evolvable by its users.

4.1 Collaborative Micro-Process Modeling

Activity theory highlights the importance of plans for guiding work in collaborative settings (Bardram, 1997). A plan is not a rigid prescription of the work to be done but a guide that can be changed in accordance with the context during its execution. In Omega+ a collaborative micro-process specifies a sequence of phases taking place into rooms, i.e. shared spaces: simple phases where all the participants collaborate to the same activity into the same room and split phases where participants perform simultaneously different activities within sub groups into distinct rooms which all start and terminate synchronously. A plan "A;B;C" does not prescribe the execution of phases A, B and C exactly in that order. ABBC, AB, AB'C (where B' is a modified version of phase B), ABCBC are other possible execution traces. Concretely, participants playing the predefined role of "Room operator" have two buttons for selecting the next phase to execute, either by following the plan ("Next" button) or by selecting another existing phase in the plan ("Jump" button), i.e. starting a "process deviation" which is explained below.

A micro-process model includes a set of phase types, a set of tool types, precedence links between phase types and inclusion links between phase types and tool types. Each phase

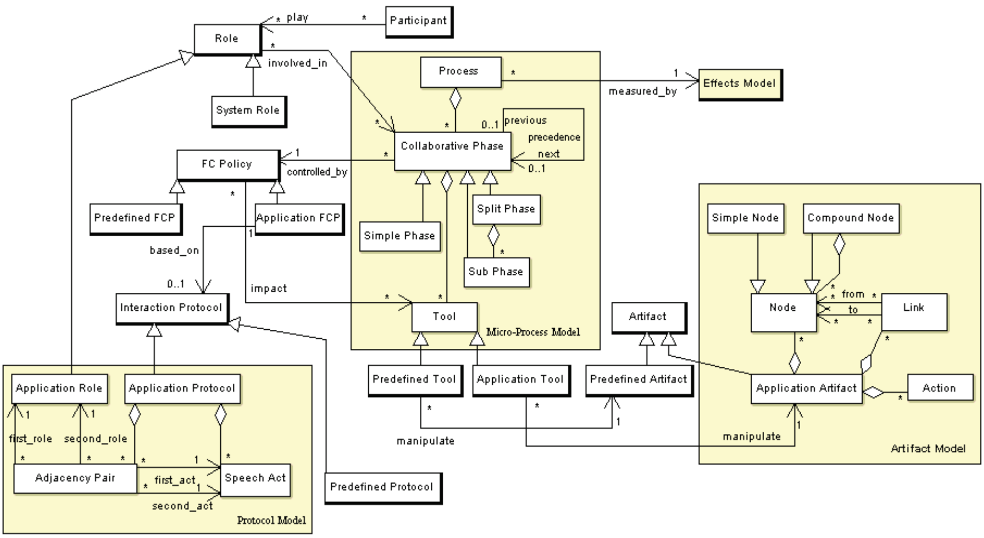


Fig. 5. Omega+ conceptual model

type is characterized by its name, its type (simple or split), its informal description, its interaction model (see section 4.2), the coordination mode (see section 4.5) which applies into the room(s) and the phase types which cannot be reached from that point with the "Jump" button. Each tool type is characterized by its name, its type (shared text editor, shared whiteboard, shared artifact editor), a boolean indicating if the tool is in read-only mode and, possibly, the name of a file that should be automatically loaded into the tool at the beginning of the phase (or the name of its type) and the name of a file that should be automatically created by the tool at the end of the phase. A micro-process model can be created off line on Escole+ platform, with a shared graphical editor or directly in its XML representation. A micro-process model can also be created interactively by a Room Operator when it is launched. The same forms are also used for changing dynamically the micro-process model definition. When a phase instance is created, the Room Operator:

- Gives it a name (by default the type name plus the instance number).
- Defines its participants, if room access is controlled, and the binding of participants to application-related roles defined in the interaction model (for instance, who is the Moderator in a phase with a moderated interaction protocol).
- Can provide informal instructions to the participants.
- Can parameter the chat tool with sentence openers (when it is consistent with the interaction model), sentence numbering and explicit referencing through these numbers.

When a process deviation is requested, the phase to which control should be transferred (or "END" for terminating the process) is selected. This process deviation request is analyzed on the basis of the deviation tolerance information included into the process model. If the requested phase belongs to the explicit list of exclusions associated to each phase type the deviation is refused and a message is displayed explaining that this deviation would violate the intrinsic constraints of the process model. In the other case, the jump is accepted and a "deviation step" takes place before the effective start of the selected target phase. During this step, all input and output resources are displayed and can be freely edited by the tutor. This includes input resources declared as read-only in the process model. Output resources are opened with their last content which is automatically saved each time a phase terminates. The system also helps in determining which phases and resources are potentially impacted ("polluted") by the deviation process.

4.2 Interaction Protocol Modeling

Interaction protocol models define specific patterns of textual communication. The set of predefined protocol models (such as "round robin," "moderated," "unique contributor") can be extended by application-dependent models. These ad hoc models define a set of application-dependent roles, a set of application-dependent message types (speech acts) and a set of adjacency pairs (Clark & Schaefer, 1989) saying "if a participant playing the role X send a message of type M1 then a participant playing the role Y – anyone, the next one in a circular ordering, the same one if X=Y - must send a message of type M2". The protocol model also defines which role(s) can speak first. An interaction model can be created off line on Escole+ platform, with a shared graphical editor or directly in its XML representation. Dynamic change of the protocol model definition is not supported. However, it is possible to change at any moment the model which applies during a phase and some exceptional situations are managed for predefined protocols, such as skipping a participant in a round robin phase or temporary excluding a participant.

4.3 Artifact Modeling– the Generic Shared Artifact Editor

An artifact model, which is in fact a meta-model, formalizes how the generic shared artifact editor is customized for manipulating target models of a given type. These target models are defined as hierarchical graphs in which a node can be refined into a sub-graph. Among the predefined meta-models one can find for instance finite automata, UML schemas, concept graphs, Petri nets, IBIS graphs (Kunz & Rittel, 1970), conceptual graphs (Sowa, 1984), logical circuits and card-based approaches (Cox & Greenberg, 2000). Teachers can also define any ad hoc representation by specifying three aspects. (1) The visual representation of node types (icon for the editor button, icon into the graph, label position, property list with, for each property, its name, type and prompt) and edge types (icon for the editor button, colour, dash-dot pattern, arrow type, type-related label, instance-related label). (2) The structural constraints defining which node types can be related by which edge types, through a structural graph. (3) The operational semantics possibly attached to node types and to the overall graph. The specification of actions is made by program like in CoolModes (Pinkwart, 2003). An action name can be attached to a node type. The action name appears on the contextual menu of nodes of this type and triggers a local action. The local action is specified through a method with the same name in the class associated to the node type. This class inherits from a predefined class in the kernel called DiagramNode which allows accessing all useful information about a node. An "action" component can also be integrated into a graph. It creates a specific "action button" in the editor whose name and icon are properties of the action component. The action button triggers a global action on the graph. The global action is specified through a method with the same name in the class associated to the graph type. This class inherits from a predefined class in the kernel called DiagramFormalism which allows accessing to all useful information about a graph. All these methods work on a server-side representation of the graph and send visual modification messages to the clients when it is required (e.g. change the colour, label or icon). By this way, it is possible to animate representations such as Petri nets or logical circuits and, more generally, to associate any transformation to the artifacts and their components.

The generic shared artifact editor takes an artifact model as parameter. Besides this definitional malleability, it also provides a number of sophisticated functionalities such as browsing the different levels of hierarchical graphs, browsing their construction history (Mühlpfordt & Stahl, 2007) and browsing large graphs through a bird's-eye view allowing direct manipulation.

4.4 Effects Modeling – Meta-cognitive tools

In Omega+, the process of building high-level visual representations (meta-cognitive tools) from low level raw data is generic. The "effects model" describes how the indicators are computed and presented.

Omega+ distinguishes between (Lonchamp, 2008):

- Simple indicators which are combination of predefined low-level variables presented as stacked time series or stacked bar charts: they can measure for instance the participation (number of messages, number of tool actions) which should be roughly equal for all learners, the balance between conversation events and action events for verifying that both spaces are used, the communication style (message size) because rich and explicit messages are necessary for externalizing knowledge or the usage of the referencing mechanisms.
- Complex indicators that are based on complex customizable mechanisms. A first example is a mechanism for distinguishing between "on-task" and "off-task" messages. The underlying algorithm is a Naïve Bayes Classifier extended with stemming and

stop-words removal. The specialized language to be learned by the classifier is defined through a set of resources including the files loaded into the text board (e.g. the problem description), the meta-model files which parameter the generic diagram editor (for learning concept type names), the created diagrams (for learning node and link names) and a set of explicit textual resources specified into the "Effects model" (e.g. formalism descriptions). A second example of complex customizable mechanism is a mechanism for counting patterns reflecting either interaction situations (for instance, two participants who modify successively the same component or directly related components in a graph) or actions aiming at facilitating interaction (for instance, a participant who modifies a graph and immediately sends an on-task message with the chat tool). The "Effects model" contains explicit pattern definitions that use a simple but extensible pattern definition language.

4.5 Coordination Mechanism

The dual interaction space provides both a multi tools task space and a communication space where interaction can be regulated by protocols. This raises several issues in terms of user coordination:

- Granularity level where coordination policies should apply: environment, space, artifact, component.
- Possible coexistence of several different policies.
- Relationships between communication and coordination of actions.

Omega+ provides a small number of global floor coordination policies (FCPs) at the environment level. These global policies are specified, for each phase, in the micro-process model. Every global policy is defined in terms of local policies at the space level. Table 4 summarizes all the possibilities which are detailed and illustrated in (Lonchamp, 2007a). "Free floor" means that users have no restriction for accessing the tools in the space without consistency guarantee (unless if the tool itself ensure some consistency at a finer grain level). "Exclusive control" is implemented through a button for asking the floor, a button for releasing the floor and an adaptable floor assignment policy. By default, it is a FIFO policy (first in first out). It is also possible to define a delay time before preemption. The Room Operator can also explicitly pass the floor from a participant to another. Regulation through a protocol ("protocol-based policy"), either predefined or ad hoc, can impact only the communication space or the whole environment.

Global policy	Task space policy	Communication space policy
Free floor	Free floor	Free floor
Free talking, exclusive doing	Exclusive control (adaptable)	Free floor
Free doing, exclusive talking	Free floor	Exclusive control (adaptable) or protocol-based
Parallel floors	Exclusive control (adaptable)	Exclusive control (adaptable) or protocol-based
Common floor	Exclusive control (adaptable) or protocol-based	

Table 4. Omega+ coordination policies

Thanks to this set of policies, all the options for floor acquisition defined by Myers (2000) – explicit, by designation, by protocol-, unless implicit acquisition which is problematic in a multi tool context, and all options for floor release – explicit return, explicit taking, preemption on inactivity- are made available.

4.6 Referencing Mechanism

Linking conversations and task objects is fundamental for establishing comprehension and shared attention (Stahl et al., 2006b). There are many different techniques to achieve referencing. Textual messages can include spatial references ("the blue square on the right"), temporal references ("your last created node"), quotes ("in the message where you say …"), references to participant's name or pseudo and references to line numbers. Graphical editors can provide non persistent mechanisms such as telepointers (Hayne et al., 1994), mechanisms for changing objects appearance when they are designated with the mouse (Suther et al., 2003) and graphical pointers that shade progressively (Dongqiu & Gross, 1999). Graphical editors can also provide persistent mechanisms like graphical pointers and annotations, either textual (Fidas et al., 2001) or graphical (Giordano & Mineo, 2005), whose positioning implicitly designate the referenced object. Finally, at the environment level, Concert-Chat provides explicit inter tool links (Mühlpfordt & Wessner, 2005).

The more complex links, with several sources and/or several targets, which are likely to occur into multi tools dual spaces, are difficult to express by these means. Omega+ provides a new application-independent mechanism which generalizes annotations and allows complex referencing. In all tools of both spaces users can stick freely annotated snapshots of the whole environment (or SAS for "sticky annotated snapshot"). SAS can be included into other SAS, thus creating powerful discussion threads. Textual annotations and persistent pointers are available as simplified versions of SAS. Besides the classical usage for referencing (for instance, showing the correspondences between two graphs or highlighting the main ideas in a set of chat messages through circling, connecting and underlining) some more surprising usages have been observed (Lonchamp, 2007b). Firstly, SAS can serve as fully fledged intermediary objects as defined by (Vinck & Jeantet, 1995), i.e. ephemeral and shared representations appearing during collaborative design processes which serve as mediators to discussion and reflect some transformation or translation of the designed artifact. Secondly, SAS can help to bypass constraints which result from some coordination policies. They can be used either as a private space when free floor policy applies, because SAS are not shared before they are saved, or as a way to communicate when the exclusive control policy applies and the floor is away, because SAS creation is not submitted to any control unlike all other communication channels.

4.7 Modeling Environment

Process models (micro and macro), interaction models and artifact models take the form of graphs with specific properties attached to their components. The modeling environment is simply a collaborative space where the generic shared artifact editor is parameterized with the corresponding meta-models and extended by generation actions for producing the internal XML representation of models.

Other tools can enrich this modeling environment like a concept map editor for discussing the knowledge content of the envisioned learning activity and editors of high level notations for pedagogical design (Lonchamp, 2008).

4.8 Escole+ Platform

Escole+ web platform includes three specialized spaces:
(1) A pedagogical space, including:

- A community space for exchanging general information among the community of interest through asynchronous communication tools such as forums, wikis or document sharing areas.
- A design space where Omega+ models and macro-process models are developed by teachers and specialists within specialized subspaces for each project, through the modeling environment described in the previous section and asynchronous communication tools for the communities of practice.

(2) A learning space, where tutors and students execute model-driven learning processes within subspaces dedicated to each process instance.
(3) A platform administration space, for managing Escole+ users, generic roles, backups, etc.
Macro-process management raises some specific issues. Few collaborative platforms provide workflow support and when it exists the level of operational malleability they provide is low. In a first experiment (Escole platform) this kind of support has been evaluated (Lonchamp, 2006b). It was hard to implement and rigid, for the small benefit of automating some repetitive tasks. In Escole+, we take advantage of the possibility of dynamically creating hierarchical workspaces, assigning them resources and controlling their access for different categories of users (Lonchamp, 2007c). Controlling the process is done simply by dynamically modifying the access rights to the workspaces where the different activities defined in the macro-process model (individual, cooperative or collaborative) are implemented. These workspaces can be generated from the macro-process models which specify the activities, tools, roles, precedence and inclusion relationships.

5. Implementation and Evaluation

Omega+ is written in Java and can run either as a client/server application on a LAN with socket communications or as a web application (applets for clients and servlet for the server) with HTTP tunnelling for dealing with firewalls. Escole+ is build on top of Libresource cooperative platform (www.libresource.org) developed in the same research team. Quite all the functionalities summarized in Figure 4 are implemented. Only, the post mortem analysis tool and the tool for replaying off line collaborative sessions from the log file are still under development.
A series of preliminary experiments have been conducted with Omega+. For instance, a collaborative micro-process model for object oriented design has been tested with computer science students. In this model, small groups of four students receive the description of a situation in the read-only text editor that can be seen in the middle left pane in Figure 6. Their objective is to build a UML class diagram corresponding to that situation. During the first phase of the two-phase process whose structure is displayed in the “Model structure” sub-window at the bottom of Figure 6, students must specify a set of use cases through short textual descriptions (with the shared editor in the top left pane) and draw the use case diagram (with a specialization of the generic shared graph editor in the bottom left pane). The global policy “free talking, exclusive doing” is associated with this phase for allowing a free debate like during a brainstorming but with a strict coordination for accessing the shared artifacts. Figure 6 shows Jack’s client who owns the floor at this moment (see the

"release floor" button on the top left and the white backgrounds of editors that indicate the right to contribute – unless for the read only editor). All participants, including Jack, can communicate at any moment through the chat tool of the communication space on the right. As Jack also plays the generic role of Room Operator, he can use the "Next" and "Jump" buttons, described in section 4.1, for flexibly controlling the micro-process.
The second phase is the core of the design activity. Students can see the use cases previously defined in the read only text editor in the top left pane of Figure 7. They transform these use cases into collaboration diagrams, with the customized shared graphical editor in the middle left pane, and introduce progressively new classes into the class diagram, with the customized shared graphical editor in the bottom left pane. For guaranteeing both a disciplined way of working and equality of participation, the interaction model called "CircularWork" is used for piloting the environment. Each student can take the floor in turn for acting with the editors and commenting with the chat tool. The predefined "round robin" protocol is not well adapted because the floor changes of owner after each contribution. The "CircularWork" protocol is a model-defined protocol that allows making several contributions before passing explicitly the floor to the next learner in the circle.
Figure 8 shows the "CircularWork" model in the shared graph editor of the modeling environment. At each moment, a learner can only select with the combo list at the bottom of Figure 7 one specific type of message in accordance with his/her role and the adjacency pairs in the interaction model ("Say" or "Pass" for the floor owner and nothing for all others). In the chat history the sequence of messages reflects this protocol. It is worth noting that at every moment the Room Operator could change this global policy and select for instance a "free floor" policy.

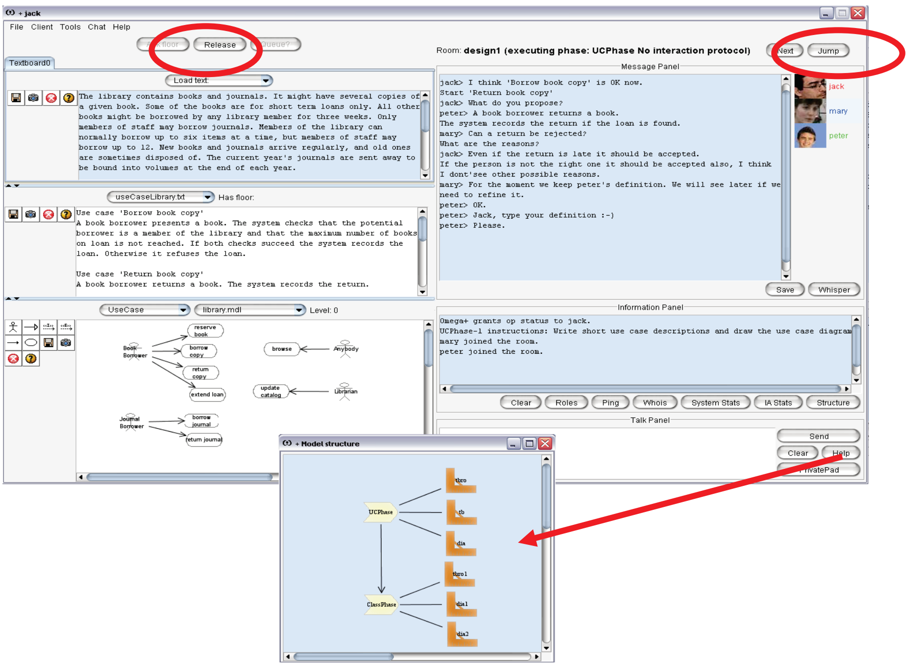


Fig. 6. Jack's client during the first phase

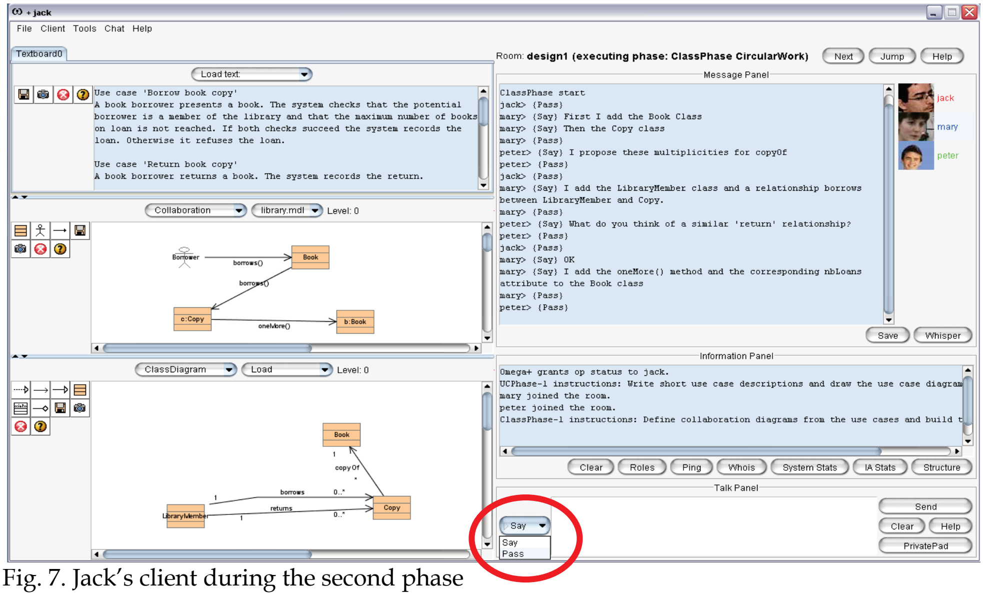


Fig. 7. Jack's client during the second phase

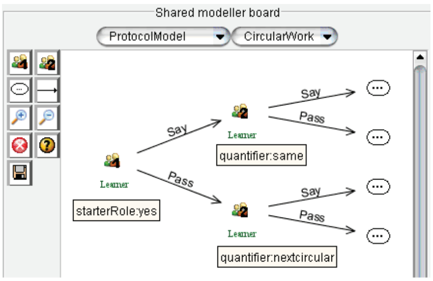
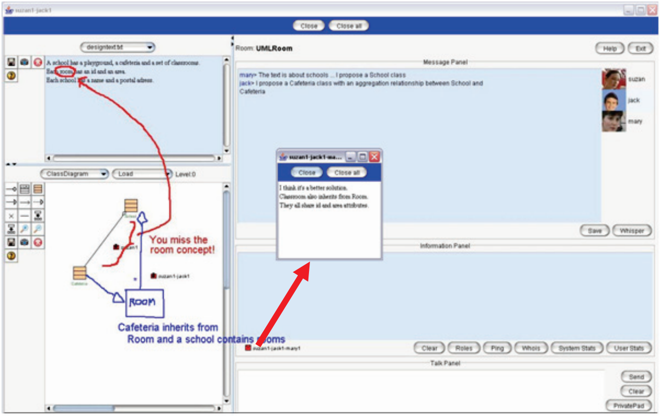
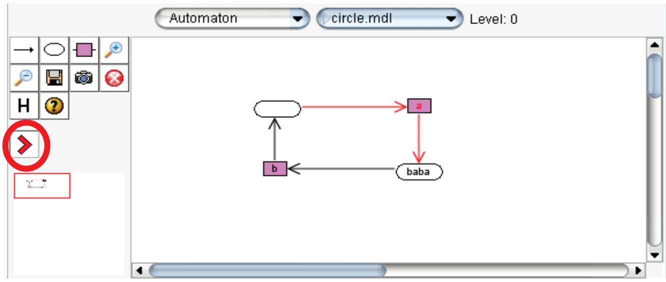
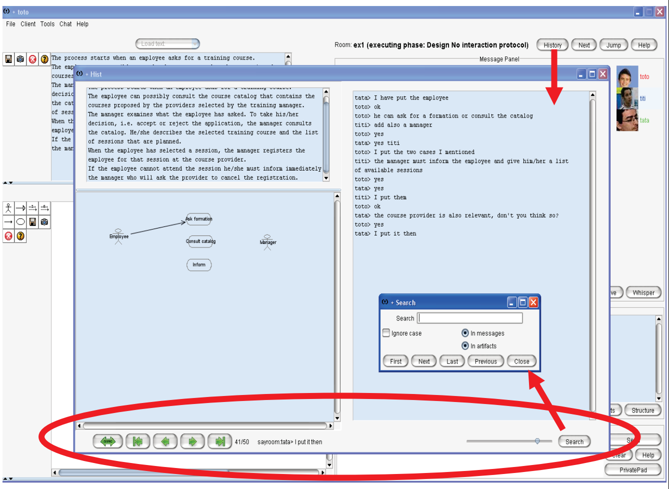


Fig. 8. The "CircularWork" protocol model

This example focuses on collaboration guidance through micro process models, coordination policies and protocol models. Additional examples of mechanisms supporting learners at the cognitive and meta-cognitive levels are shown in Table 5.

Due to the number of its functionalities and its malleability the environment is difficult to evaluate. All classical evaluation approaches evoked in the introduction, either quantitative or qualitative, can only evaluate design elements by isolating them. This problem has already been highlighted by other researchers: "As Co-Lab is a large comprehensive system, evaluation studies have had to focus on specific aspects of it, rather than evaluating the whole system" (van Joolingen et al., 2005).

Level–Objective–Description	**Example**
Cognitive–Referencing- A SAS displayed in the SAS viewer. It contains free hand drawings, annotations and an example of inter-tool reference. It contains several other SAS. One of them is a sticky note which has been opened in its own viewer.	
Cognitive -Artifact animation and scrollable bird's-eye view- This graphical editor contains an action button (in the middle left part) for animating the finite state automaton and a bird's-eye view for quick browsing (in the bottom left part).	
Cognitive–Session history browser- Participants can browse the history step by step by directional buttons or with a slider located in the bottom panel of the browser. When a learner presses the "sync" button on the left of the bottom panel a browser is automatically launched in each client environment (if it is not already started) and all browsers are synchronized for enforcing a shared focus on a given point of the process history. A textual search facility (on the right) is also provided.	

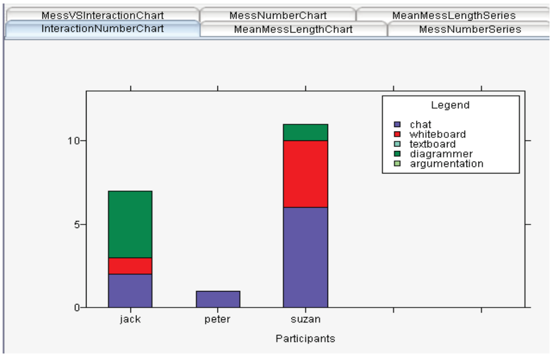
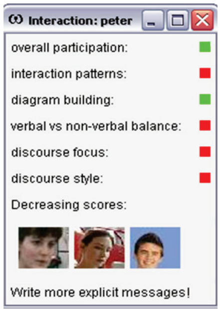
Meta cognitive– Customizable high level visualizations- A stacked histogram of the number of initiatives for each learner and each tool.	
Meta cognitive-Interaction analysis- A customizable interaction report: for each criterion a red (green) square means a result under (over) the average result. Learners are also classified by decreasing aggregated scores. A guidance message is also displayed for the worse indicator (Lonchamp, 2008).	

Table 5. Cognitive and meta-cognitive support

The central question in our approach is the capacity of teachers and learning technology providers to make use of the definitional and operational malleability provided by Omega+. A first step in that direction has been done by defining a methodological approach for conducting qualitative interaction analysis oriented toward the improvement of the supporting environment that can be applied to any learning task and any environment configuration. This "generic analysis approach" is organized into three levels (Lonchamp, 2009):

(1) At the dialog level, a task-independent dialogical model is proposed for analyzing action/communication traces as "generalized conversations". A graphical notation is provided for visualizing the syntactical characteristics of collaborative sessions.

(2) At the knowledge level, a typology of task-independent collaborative knowledge building episode types that can occur during such generalized conversations is proposed. Thanks to that classification scheme, recurrent meaningful elements that structure the low-level descriptions can be detected and characterized. These regularities help for passing from local interpretations to a global interpretation of the whole process.

(3) At the action level, task-dependent socio-cognitive interpretations of why the collaborative learning process unfolds as observed are proposed. These interpretations can constitute a firm basis for improving the customization of the generic environment in order to support learners more efficiently.

In the next future, we plan to conduct both cross-application comparisons in search of differences, commonalities and generalisations at the macro level, and cross-configuration comparisons for the same application in search of the best supporting strategies and mechanisms at the micro level, leading to the further iterative improvement of both the technical infrastructure and the methodological approach.

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3

Concerto II: A Collaborative Learning Support System Based on Question Posing

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1. Introduction

With the rapid advance of information society, many Web-based learning support systems have been developed (Yu et al., 2005). Providing Web-based learning environments enables learners to learn at anytime at any places.
We focus on learning based on question posing and propose a Web-based learning support system for such a learning style. Some literature pointed out that question posing is a highly intelligent activity, and that it contributes to improve learners' problem solving ability. Learning effectiveness is also expected by learners (respondents) answering questions, which were posed by other learners (posers), and by collaborative learning (Brindley & Scoffield, 1998) such as inquiries and answers between posers and respondents or comments by respondents.
Many research projects with respect to a question posing based learning support system have been launched in recent years (Rafaeli et al., 2004), (Takagi et al., 2004), (Yu et al., 2005). While they have some common features, each study provides its unique features. We developed a question posing based collaborative learning support system called Concerto and applied it to an actual university course (Hirai & Hazeyama, 2007). As the result, we identified necessity that facilitated positive communication among learners and issues on quality of questions. We propose a collaborative learning support system based on question posing called Concerto II in this chapter.
The rest of this chapter is organized as follows: we start describing related work in the next section. Section 3 discusses some problems on communication support that emerged from the results of application of Concerto. We also describe requirements for communication support in Concerto II. Section 4 describes system design of Concerto II. We applied Concerto II to an actual university course. Section 5 presents some results and discussions. Finally we conclude this chapter.

2. Related Work

This section describes state-of-the-art of question posing based learning support systems. Some research projects have been conducted with respect to a question posing based learning support system; QSIA (Rafaeli et al., 2004), CollabTest (Takagi et al., 2004), and QPPA (Yu et al., 2005).

QSIA is a Web-based learning environment, which provides question posing, knowledge sharing (recommendation of questions to learners), and assessment as major facilities. It mainly focuses on knowledge sharing and assessment. Questions are created by instructors in most cases. When they are created by learners, the instructors review them and then they are opened.

CollabTest supports the following learning process: (1) learners pose questions based on the course contents, and the posed questions are reviewed by groups which are composed of several learners, (2) the question posers register the questions that have finished review into the database, then the instructor reviews the registered questions, (3) the instructor prepares the online tests by extracting questions from the database and opens them, and (4) learners pose questions that are similar to the opened ones. Takagi et al. obtained results on learning effectiveness through group review and posing similar questions.

QPPA is a Web-based learning support environment which provides four major functions: (1) question posing, (2) assessment, (3) browsing of questions, and (4) exercises in the form of drill. In question posing, only the mode of multiple choices is supported. In order to validate the environment, it was applied to learners of the upper grades in an elementary school. The evaluation was carried out from the viewpoint of usability of major functions and difficulty (easiness) of question posing among subjects (the system was applied to mathematics, natural science, and social science) by questionnaire. The authors did not evaluate QPPA from an aspect of learning effectiveness.

We aim at constructing a Web-based collaborative learning support system of which goal is to improve understanding of what learners learned by learner-centered learning with not only question posing and assessment of questions posed among peers but also communications with respect to questions. Our approach is similar to that by CollabTest and by QPPA in that it focuses on question posing by learners. As we think assessment for questions from many learners and communications with many learners contribute to enhance effectiveness of learning, we suppose that the abovementioned activities are carried out not by groups but by the whole class. As for communication support, Takagi et al. describe group review by a face-to-face fashion for questions learners posed. QPPA and QSIA do not provide communication support. We develop a system, which emphasizes on collaborative learning such as modifications of questions based on the assessment results from peers and distributed asynchronous communications with them, and version management of questions. Table 1 shows summary of state-of-the-art of question posing based learning support systems.

3. Results of application of Concerto and some enhancement requests toward Concerto II

We described state-of-the-art of question posing based learning systems in the previous section. As the result shows, CollabTest and our system provided communication support functions. Although CollabTest provided communication support, it only supported group review for posed questions in a face-to-face manner.

	QSIA	CollabTest	QPPA	Concerto
main question poser	instructors	learners	learners	learners
mode of posing	multiple-choice question	multiple-choice question (text base)	multiple-choice question (allow to use figures)	multiple-choice and story question (allow to use figures and tables)
assessment	*	-	*	*
communication support	-	group review (a face-to-face environment)	-	each question has BBS (a face-to-face environment) (a distributed asynchronous environment)
others	recommendation	online test (instructors' review)	drill-and-practice exercise	request comments for the instructors

Table 1. Comparison of question posing based learning support systems

We developed a question posing based learning support system called Concerto. It provided following major functions:
* Question posing
* Answering questions
* Assessment
* Communication support
* Data analysis

Please refer detail of Concerto to (Hirai & Hazeyama, 2007). We applied it to an actual university course. This section presents some results from its application with respect to communication support particularly. Based on the results, we describe the system design of Concerto II, which facilitates communication in question posing based learning.

3.1 Communication Support in Concerto

Each question had a Bulletin Board System (BBS) for it in Concerto. We provided a function of "request comment for the instructors" which was the function to receive assistance from the instructors when a question was not solved by discussions by learners. If a learner uses this function, an e-mail message is sent to the instructors that a learner requested for help from the instructors for the corresponding question. The learners may receive comments from the instructors in a prioritised manner. This function may lead to reduction of burden of the instructors.

3.2 Results of Application of Concerto

The course we applied Concerto was "Introduction to a computer system." The objective of the course was to give lectures on principles of digital computers. The course was offered for the first year undergraduate students of Department of Information Education at Tokyo Gakugei University. The period of application was during 22 May 2006 through 10 July 2006. Table 2 shows the results of its application. We analyse the results of application from both the data that were stored in the system and those from the questionnaire.

Item	Result
Number of users who registered to this system	51
Total number of login	637
Total number of questions registered	50
Total number of modifications of questions	16
Total number of answers to questions	1454
Total number of assessments registered	926
Total number of messages submitted to BBS	33
Total number of threads in BBS	11

Table 2. Usage results of Concerto

As we presented in the above table, fifty questions were posed and learners answered 1454 questions in total and wrote 926 assessment comments. However few discussions occurred (they were only eleven threads and thirty three messages were exchanged). "Request comment for the instructors" was not used. We analysed communication patterns from eleven threads in the BBS. We found the following four patterns:

(A) Inquiries and/or comments from the learners who tackled the question, and responses to them by the question posers (seven threads)

(B) Responses by the question poser to the comments written in the assessment field (two threads)

(C) The question poser announced mistakes to the question he/she posed, then learners who answered it wrote the comments of agreement or encouragement, and finally the question poser appreciated peers' comments (one thread)

(D) A learner requested peers for posing other questions that were similar to the question he/she answered because he/she was not good at the theme. Then another learner wrote a comment that he/she had posed a question that met the request (one thread)

Responses were written by question posers to the messages with respect to all inquiries or requests. In many threads, question posers finally appreciated to the comments or questions from peers. Some inquiries were written as the assessment comments. However question posers did not respond them except for only two cases (pattern (B)). As all communications were closed in the BBS, the learners who asked inquiries should have written them in the BBS.

As for pattern (D), we did not anticipate such a communication pattern in designing of the system. If such a message stays in a particular thread of a particular BBS, it may be buried. Such a message may become a hint for question posing. Therefore we will provide the function, which allows a learner to request for question posing and to manage the follow-up in the next version of Concerto.

As a negative opinion from the questionnaire, a learner gave a comment, "as question posers are learners, posed questions are not accurate and reliable." We also tackle this problem in Concerto II.

3.3 Requirements toward Concerto II

From the results of analysis in the previous sub-section, we identified the following requirements for communication support in Concerto:

(R1) Request of question posing: in the pattern (D) we identified in the previous sub-section, a learner asked classmates for question posing with respect to a theme he/she was not good at. This request will become a hint for those who have intention to pose questions. It is also necessary to manage the status whether the request was achieved or not.

(R2) Disposition with respect to quality of questions created by learners: it is necessary to present information on who created the question as well as the question itself because some learners were anxious about accuracy and reliability of posed questions.

(R3) Support as a kind of SNS (Social Networking System): we can think Concerto has an aspect of SNS for individual learners. In recent years, many people use SNS. It is said that in SNS, especially Weblog, feedback comments from others accelerate motivation to write Weblog (Chika, 2006). In our application, the learners who received feedback comments from peers increased motivation to use Concerto. This led to good achievement of the subject. Therefore we will provide a portal page for each learner and users can browse feedbacks (comments, inquiries, and so on) from peers in the page. We expect this page gives motivation to learners.

4. Development of Concerto II

This section describes enhancement items from Concerto to Concerto II.

(1) Enhancement of question posing facility

In response to the requirement (R1), we provide a function that a learner can request the classmates for question posing. The posed questions that were responded to the request by the classmates are associated with the request. Also, communication space for discussions with respect to the requests between the requester and the classmates is given.

In response to the requirement (R2), we provide information on who posed what questions and how they were evaluated by peers like Amazon (Amazon). As another solution to the negative comments for question posing based learning by learners, we suppose learners make communications on the posed questions through the communication support function.

(2) Portal page

Each learner has his/her own page (we call this page "my page"). This page presents feedback information for questions he/she posed (ranking points determined by level of difficulty and the number of answers to questions he/she posed, and contribution to the classmates). We expect such information improves learners' motivation. This is a solution to the requirement (R3). This page also presents all the questions by classmates, list of requests of question posing, and announcements from the instructors. Fig. 1 shows a screen shot of "my page" of Concerto II.

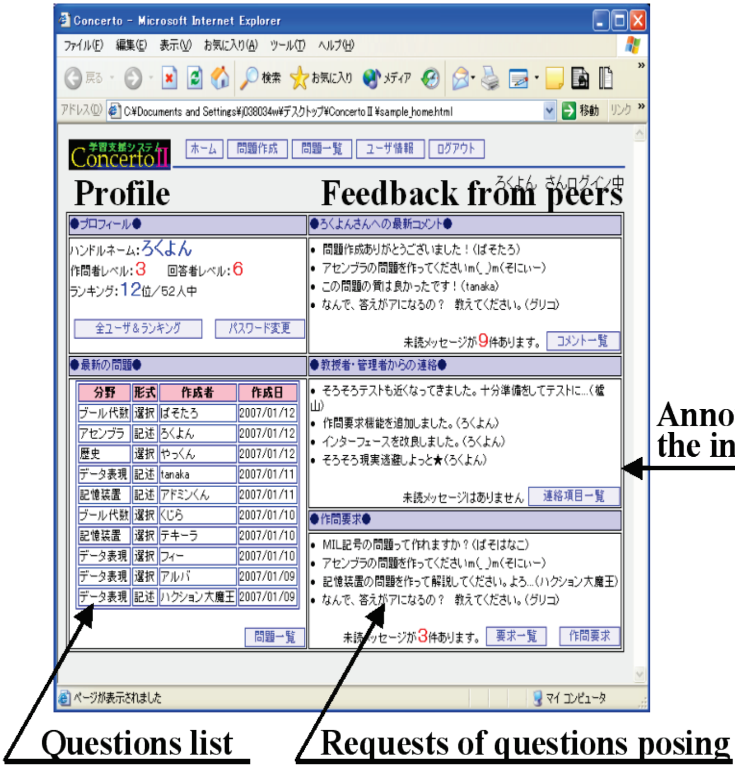

Fig. 1. Screen shot of "my page"

5. Evaluation

5.1 Overview of the experiment

We applied Concerto II to a university course "Introduction to computer systems" in the 2007 academic year. We provided it during 21 May 2007 through 9 July 2007 and then asked the learners in the course for responding to questionnaire. The questionnaire is composed of some items in the form of Lickert Scale (four ranks; 1: disagree, …, 4: agree) and qualitative comments that corroborate the evaluation of the items by Lickert Scale.

5.2 Results

Table 3 shows the usage results of Concerto II.

5.3 Discussions

We discuss effectiveness of enhancement of communication function and that of the function "request of question posing."

(1) Enhancement of communication support

Table 3 shows the number of questions increased 6.2 times, the number of threads 10 times from Concerto (Table 2) to Concerto II respectively. In Concerto, learners could use BBS only in a window to select a question. In Concerto II, as “my page” presents various types of awareness information including in which questions messages are exchanged, we think this information contributed to high usage frequency of BBS.

Item	Result
Number of users who registered to this system	91
Total number of login	3291
Total number of questions registered	311
Total number of modifications of questions	187
Total number of answers to questions	7239
Total number of assessments registered	4196
Total number of threads in BBS	110
Total number of request of question posing	6

Table 3. Usage results of Concerto II

(2) Effectiveness of request of question posing

Six requests of question posing were submitted during the experiment as shown in Table 3. Questions were posed for four out of them. The average score of Lickert Scale for the item “Did the function of request of question posing give you a chance to pose questions?“ in the questionnaire was 3.07. This result suggests the function gave a chance to pose questions. This function also enables learners to answer questions they would like to tackle.

On the other hand, some learners pointed out drawbacks for this function as follows: “I think requesters should pose questions by themselves before requesting others.” However, from the data that was stored in the system, the learners who requested for question posing posed at least four questions. This means they were not free riders, and collaborative learning by posing questions in an interdependent manner was observed.

Another learner wrote, “I could not respond a request because it was too ambiguous.” For example, the following request was submitted: “please pose questions on storage devices”. There are various learning topics on storage devices, for example, terminology, characteristics of devices, performance calculation, and so on. He/She could not grasp what the requester wanted. We provided communication space for discussions with respect to request of question posing, but it was not used in this experiment.

In our study, question posing and a series of discussions were done outside of the classroom. That is, collaborative learning based on question posing was accomplished under a distributed and asynchronous environment.

(3) Effectiveness of a metric to measure quality of questions

The average score of Lickert Scale for the item “Did the ranking points function for you to select questions to answer?“ in the questionnaire was 2.83. Seven students gave comments for the item “Which questions did you answer?” as follows: “I tried to answer questions that colleagues who got higher ranking points posed, in particular when I just started to use the system.” These results suggest the ranking points were metrics to measure quality of questions.

6. Conclusion

We have proposed a collaborative learning support system based on question posing that solved the problems detected from the results of application of the initial version of our question posing based learning support system called Concerto. Concerto II enhances communication support, provides a solution to a problem that posed questions are not accurate and reliable because posers are novice learners, and a mechanism for motivation improvement similar to Social Networking Systems (SNS).
We will show usefulness of the system by its application to university courses in longer terms.

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A collaborative medical case authoring environment based on the UMLS

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Abstract

In Intelligent Tutoring Systems, the domain or expert model determines how to ensure learner mastery by monitoring the student model in relation to the domain model. The strength of these programs, therefore, depends on the underlying validity of the curriculum or domain expertise. This chapter presents a novel collaborative authoring tool that was designed to allow medical teachers to formalize and visualize their knowledge for medical intelligent tutoring systems. The goal is to increase the efficiency and effectiveness in creating the domain model representing the problem solution—often referred to as the bottleneck in developing intelligent tutoring systems. The Unified Medical Language System (UMLS) knowledge base was incorporated to assist the authors in creating the problem solution collaboratively via a videoconferencing platform. The system consists of a shared workspace gathering information visualization and tools necessary for collaborative problem-solving tasks. In order to evaluate the effectiveness of the authoring tool, we measure the quality of the created problem solution network. We compared the network built using the authoring tool, with the network of a benchmark solution built from scratch using the conventional paper-based approach for the same domain. We found that the authoring tool can be used to effectively elicit the knowledge structure of the domain model. This was achieved in hours compared to months for the conventional paper-based approach.

1. Introduction

There has been increasing interest in intelligent medical tutoring systems that utilize a wide range of Artificial Intelligence techniques to model the domain knowledge that specifies what to teach, and pedagogic strategies that specify how to teach. This explicit knowledge encoding makes it possible to make inferences about a student's mastery of topics or tasks in order to dynamically adapt the content or style of instruction [1]. The Collaborative Medical

Tutor (COMET) provides an environment that emulates that of human tutored medical problem-based learning (PBL) sessions while at the same time permitting the students to participate collaboratively from disparate locations [2,3]. The system combines concepts from computer-supported collaborative learning with those from Intelligent Tutoring System (ITS). COMET contains four primary components similar to any typical ITS: domain clinical reasoning model (or domain model), student clinical reasoning model (or student model), pedagogic module, and student multimodal interface.

In PBL group discussion the students evaluate the patient problem presented to them exactly as they would a real patient, attempting to determine the possible underlying anatomical, physiological, or biochemical dysfunctions and to enumerate all possible causal paths (hypotheses and their causal links) that would explain the progression of the patient's problems. Generating appropriate tutorial actions requires a model of the students' understanding of the problem domain and of the problem solution. However, as in human tutored PBL sessions, COMET must provide an unrestricted interaction style that gives students the freedom to solve the patient case without having to explain the rationale behind their actions. This complicates the modeling task because the system must infer the student's level of understanding from a limited number of observations. To deal with the resulting uncertainty, we selected Bayesian networks as our modeling technique. For each scenario (patient problem) taken from the PBL curriculum, the domain model is contained in the part of the structure of the network that represents the hypotheses (possible solutions) and the cause–effect relations among them as well as how the hypotheses are derived. The student model is contained in the part of the network that represents how the hypotheses are derived and in the network's probabilities.

The system implementation is modular and the tutoring algorithms are generic so that adding a new scenario or case requires only adding the appropriate model representing how to solve a particular case (domain clinical reasoning model). Although COMET has been proved to be effective [3] creating the domain model is not a trivial task and requires significant expert knowledge. The model for each problem scenario required about one person month to build for a 3-hour PBL session. The aim of this study was to develop an authoring tool for medical PBL tutor to assist the creation of new cases.

Researchers have been investigating ITS authoring tools almost since the beginning of ITS research in order to allow non-programmers to formalize and visualize their knowledge. Several authoring tools have been built for authoring the domain model, e.g., IDE [4], Eon [5]. They were all designed to work in a single-user mode. However, developing a complicated case particularly in medical PBL usually requires experts from different areas such as anatomist, physiologist, pathologist, and specialist in the field. The necessity to collaborate to produce high-quality PBL cases lead us to the requirement of collaboration support in the authoring tool, which is the first contribution of our work.

A second issue is to support use of standardized medical terminology. In medical problem solving, there are often many ways of expressing the same idea using synonymous phrases, like ''Pneumonia'', ''Lung inflammation'', or ''Pulmonary inflammation''. Consequently, free text is not suitable to represent medical problem solutions in the domain model where student hypotheses are matched against. Terminological standardization helps to solve this problem. In this way, students have freedom to use the synonyms representing the same standard terminology and they will be recognized as correct if they appear in the domain model. Furthermore, using standard terminology permits ready linking to rich sources of medical knowledge. Our approach is to integrate the Unified Medical Language System (UMLS) [6] directly into the authoring environment in such a way that case authoring becomes a process of browsing through UMLS and selecting the relevant medical concepts. This ensures standardization of terminology and linkage of the problem solution to a rich source of medical knowledge, which can be used by the tutoring module. An additional benefit is that because authoring becomes a process of browsing and selecting, the authors may be reminded of hypotheses that they might otherwise neglect to include.

The UMLS was designed by the National Library of Medicine to integrate many authoritative biomedical source terminologies into a unified knowledge representation. The UMLS knowledge base includes: (i) a Metathesaurus of terms and concepts from many different biomedical vocabularies and classifications. Each concept in the Metathesaurus is assigned to one or more semantic types; (ii) a Semantic network of relationships among the semantic categories to which concepts of Metathesaurus are assigned; and (iii) a Specialist lexicon and programs for generating the lexical variants of biomedical terms. There have been several attempts to reuse the UMLS knowledge base in a variety of contexts, e.g., in patient care [7], clinical radiology [8]. The use of UMLS to obtain relevant domain knowledge and remind oneself of useful relations between concepts that might otherwise be overlooked by a free-text search engine or a human being has been addressed, e.g., in a medical search engine for all [9] and HealthCyberMap's tool for building an RDF metadata base [10]. We are the first to use it in this way in an ITS domain model authoring tool and the first to combine it with a collaborative tool that includes text chatting and video conferencing.

The next section will introduce the reader to the standardization needed in constructing the medical domain model as well as the overview of the UMLS. In section 3 we describe the COMET authoring tool with an emphasis on the techniques we use to provide efficient collaborative knowledge acquisition and organization among authors and the incorporating of the UMLS. Section 4 deals with an evaluation of COMET authoring tool and in Section 5 we discuss work related to this project as well as the advantages of the tool we developed. We present our conclusions and future work in Section 6.

2. Standardization needed in medical domain models

Usually in COMET domain model terms or phrases like "pneumonia" are used. However, there are many ways of expressing the same idea using synonymous phrases, like "lung inflammation". Another example is demonstrated by "Pulmonary inflammation". Unfortunately, there are well known critical language phenomena like the immense variability of paraphrases and the problem of ambiguity in medical communication. Free text data can hardly be used for representing the medical problem solutions in the domain model where student hypotheses are tested against. This is the reason for the need of terminological standardization.

The Unified Medical Language System (UMLS) [6] is one of the largest knowledge bases in existence. The *metathesaurus* as the most important component contains semantic information of more than 1.5 million English terms about biomedical concepts, their various names (synonyms), and the relationships among them. It is built from over 60 sources of the relevant medical vocabularies. It contains and interconnects these vocabularies by linking the entries, respectively codes, to one unique concept in the metathesaurus identified by a concept unique identifier (CUI). With UMLS there is not a new medical vocabulary, but an integrated union of existing vocabularies with many added values. There are other components going beyond the usual content of medical vocabularies. The *semantic network* is a network of general types to which all concepts in the metathesaurus have been assigned. Furthermore, there is a proposal for semantic relationships between the semantic types. Furthermore, there is a *SPECIALIST- lexicon* that contains morpho-syntactic information about biomedical terms. In Figure 1 typical concept attributes and concept relations with respect to "Pneumonia" are illustrated.

Metathesaurus Search for: Pulmanary inflammation in UMLS Release 2006AD
Concept: Pneumonia
CUI: C0032285
Semantic Type: Disease or Syndrome

Definition:
Inflammation of the lungs. (MeSH)
inflammation of the lungs with consolidation and exudation. (CRISP Thesaurus)
(noo-MONE-ya) An inflammatory infection that occurs in the lung. (NCI Thesaurus)

An acute, acute and chronic, or chronic inflammation focally or diffusely affecting the lung parenchyma, due to infections (viruses, fungi, mycoplasma, or bacteria), treatment (e.g. radiation), or exposure (inhalation) to chemicals.
Symptoms include cough, shortness of breath, fevers, chills, chest pain, headache, sweating, and weakness. (NCI Thesaurus)

Synonyms:
Pneumonia
Lung Inflammation
Pneumonitis
Pneumonitis (disorder)
Pulmonary Inflammation

Fig. 1. Concept attributes of Pneumonia in the UMLS.

Looking at Figure 1 one part of UMLS is about terms and codes. Concepts are expressed in different ways, either by multilingual phrases expressed by humans or in a more standardized way using codes for processing them by machines. Together with morpho-syntactic knowledge from the SPECIALIST- modules and the language-specific word-indexes the meta-thesaurus can be accessed very efficiently, given phrases and codes in existing medical communication.

Semantic knowledge about concepts is another part of UMLS. Again, the different medical vocabularies are the main source. There are concept definitions in Figure 1 and especially, there is the huge amount of concept relations in Figure 2. Basically, there are three types of concept relations: first, most of the relations are derived from the source vocabularies; i.e. the concept "Lung diseases" is parent of the concept "Pneumonia". Second, the vocabulary independent semantic network provides semantic types and relationships. All concepts are categorized by semantic types, i.e. the concept "Pulmonary inflammation" is categorized as a disease. This makes it possible to access and navigate the UMLS concepts independent of the source vocabularies. Third, the inclusion of the co-occurrence relations between concepts originating from pairs of MeSH-codes in literature citations in the MEDLINE database is another kind of vocabulary independent semantic knowledge within UMLS.

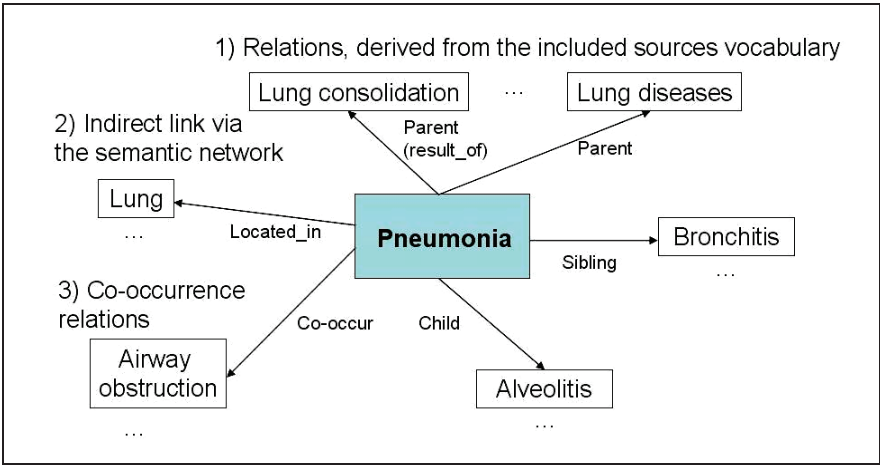


Fig. 2. Concept relations in UMLS.

The COMET authoring system is a UMLS plugin that includes its Metathesaurous, Semantic Network, and SPECIALIST-lexicon. To author a newly acquired case, the author starts by indicating the concepts from the Metathesaurous and SPECIALIST-lexicon and explore the concept relation in the Semantic Network that represents the current case. The user interface is more fully described in the next section.

3. COMET Authoring Tool Description

The COMET domain model is contained in the part of the structure of the network that represents the hypotheses explaining the patient problem and the cause-effect relations among them. To construct the model for each specific scenario using hand-coded cognitive analysis, we consulted medical textbooks and experts to obtain the hypotheses, the goals, and the medical concepts used to derive the hypotheses. The model for each problem scenario required about one person month to build. To maximize the flexibility and adaptability of COMET authoring tool to the authors, we adopted the paradigm of computer-supported collaborative work that allow several authors from different locations to work together in synchronous or asynchronous manner.

Medical problem-solving is a complex medical task, which require search, perceptual, and problem-solving cognitive skills. The overall goals of the COMET authoring tool are to: i) decrease the effort (time, cost, other resources) for making intelligent tutors; ii) decrease the skill threshold for building intelligent tutors by allowing non-programmers to take part in the design process; iii) help the authors articulate or organize their domain knowledge; and iv) support good design principles. The interface should present an overview of the domain model, and allow direct modification of this model as it evolves since high-quality model are more likely to evolve than to be completely designed from the ground off. Therefore, the interface must allow for both model creation and later maintenance. Consequently, our interface incorporates the UMLS for knowledge management and knowledge re-use, model templates for scaffolding knowledge, the graph visualization for knowledge visualization with the tools essential for collaborative work via the videoconference. An overview of the authoring and knowledge acquisition techniques used is described in the following subsections.

3.1 Knowledge Management

As in many other ITSs, COMET predefines some of the main components including the tutoring module, student model and student interface, and requires from the author to construct only the domain model for each scenario. Essentially, authors who are medical PBL experts, are asked to create the problem solution. In this process, medical problem-solving consists in the real-time construction of a problem model in the form of a network comprising hypothesis nodes characterized by their ontological levels—enabling conditions, faults, and consequences—that the authors can enumerate further from a scenario. The semantic relations are cause–effect relationships among hypotheses. Every hypothesis node has a unique apply node as one of its parents. The apply node represents the application of a medical concept to a goal in order to derive the hypothesis. During this process, the problem is progressively transformed into a solution model by assigning particular goals and medical concepts to each hypothesis. The resulting network which is a shared mental model of the authors becomes the structure of the Bayesian network (BN) domain model. The details of the BN domain model are explained in [11].

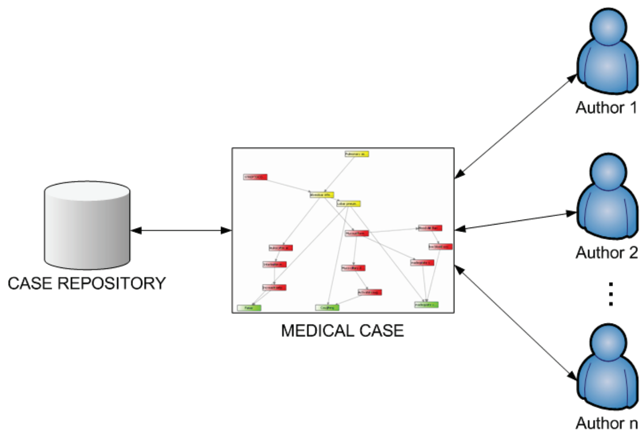


Fig. 3. Design of the tool.

The design of the COMET authoring tool is illustrated in Figure 3. The expert authors start working collaboratively with the authoring tool by either creating a new case or working on the unfinished one stored in the case repository over the internet. Case authoring tool abstracts the underlying BN structure by the simpler directed acyclic graph representation. This facilitates the authoring of content by medical experts who are not familiar with BN editing software. The tool also provides online communication between authors in different locations via text chat and video conference. Connections to medical terminology in the Unified Medical Language System (UMLS) were included so that the effort required to bind medical concepts to nodes in the model was reduced, compared to manually selecting the concepts from the medical textbooks. UMLS also used to standardize our medical model so that authors can use the same concept name to refer to the same thing.

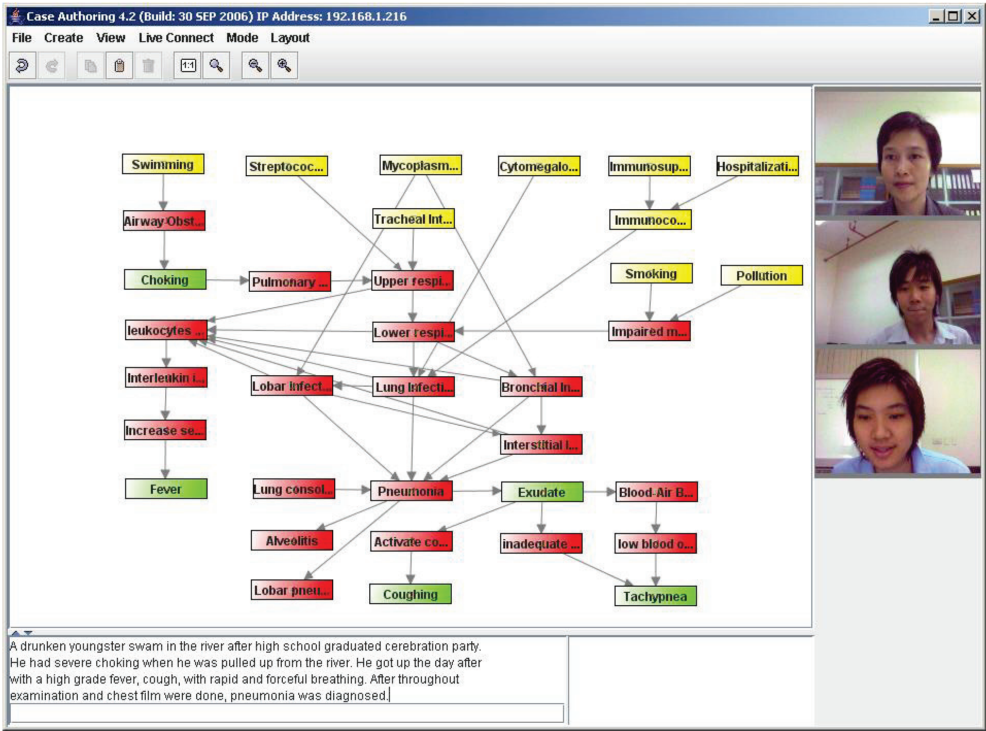


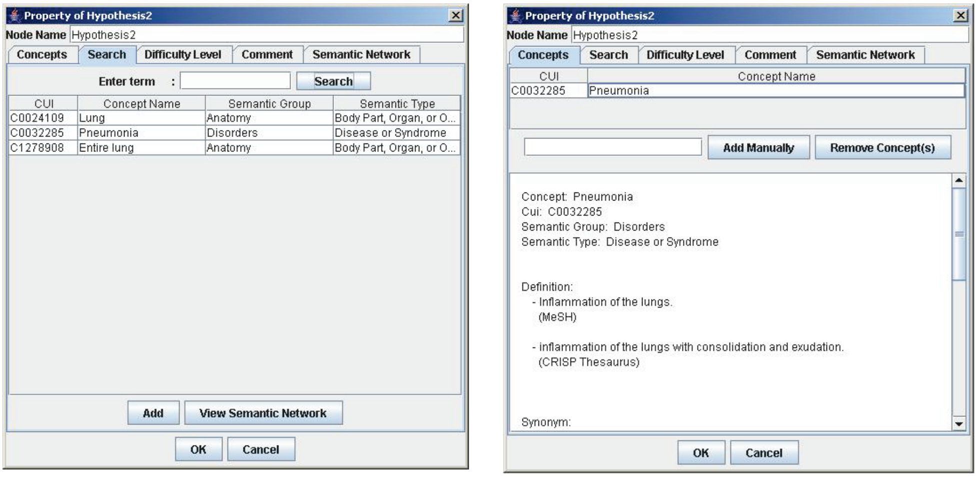
Fig. 4. User interface of the COMET authoring tool.

Figure 4 illustrates the main interface of the tool. The drawing pane (Figure 4, upper left pane) dominates most of the interface and allows interaction and visualization of the created model. Basic graphical tools are provided in the toolbar, e.g., copy, paste, undo, redo, and zoom (Figure 4, menu bar). The experts with the write privilege can edit the model simultaneously while those with read privilege can only see the changes in real-time and discuss with others via the chat pane.

A hypothesis node can be created from the context menu and a link can be drawn to represent the cause–effect relationship between two nodes. Colors are used to indicate different kinds of nodes. Goal, concept, and apply nodes are shown in gold, pink, and blue[1], respectively. Hypothesis nodes have three sub-categories, enabling condition, fault, and consequence. They are in red, yellow, and green, respectively, as shown in Figure 4 (drawing pane). Double clicking each node brings up its property window as shown in Figure 5a. The Search tab allows searching for a medical concept in UMLS. Returned concept results including their explanation can be selected and added to a node name. Note that the input for searching can be a phrase or a sentence containing many medical terms, e.g., lung inflammation (Figure 5b). The Metamap Transfer (MMTx) program provided by

[1] For interpretation of the references to color in the text, the reader is referred to the web version of this article.

the UMLS is called to convert the input string to a list of medical concepts to be searched (lung, pneumonia, and entire lung).



(a) The search tab (b) The concept tab

Fig. 5. (a) The property window of a hypothesis node showing the UMLS concept name (pneumonia) including its semantic group, semantic type, and synonym. (b) The search tab of the property window showing the input medical term (lung inflammation) and the search results (lung, pneumonia, and entire lung).

Below the drawing pane is the chat pane (Figure 4, lower left pane). The last pane located on the right is the video conference interface. This allows experts with web camera and microphone to communicate via voice and video in addition to text. The video and audio conference is implemented over the Java Media Framework (JMF) using the unicast Real-Time Protocol (RTP). Changes made to model data are sent to all authors synchronously using a TCP/IP socket. Text data in the chat pane is also transmitted this way.

3.2 Scaffolding knowledge articulation with models

The most significant method that authoring tools employ to allow non-programmers to build tutors is to scaffold the task by incorporating a particular model or framework. COMET domain model has the generic structure of the network which we obtained from PBL and medical reasoning process. This structure includes the application of medical concepts to goals to derive hypotheses, and the classification of hypotheses into enabling conditions, faults, and consequences. COMET authoring tool provide authors with templates of these notations that help them organize and structure the case solution by decomposing the solution into a set of related elements.

3.3. Knowledge reuse

There have been several attempts to reuse the UMLS knowledge base in a variety of contexts, e.g., patient care and clinical laboratory [7], building a terminological knowledge base [12], and identifying concepts in medical school curriculum [13]. The COMET authoring tool is built to take advantage of the reusability of concept relations in the UMLS Semantic networks. We have experimented with the UMLS knowledge base for providing classes, concepts, terms and interconcept links for creating the medical PBL domain model. Browsing through the UMLS Semantic networks helps remind the author of the potential relationships between concepts of two particular semantic types which can be added to the domain model. Figure 6 and 7 show part of a pneumonia model built using the UMLS Semantic network of pneumonia concept, its parent and child.

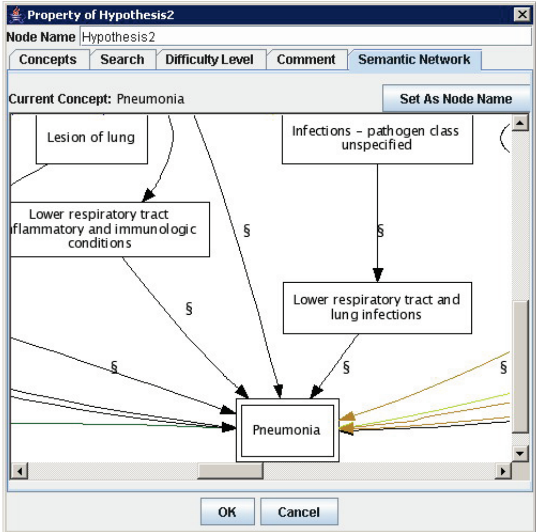


Fig. 6. UMLS Semantic network of a concept

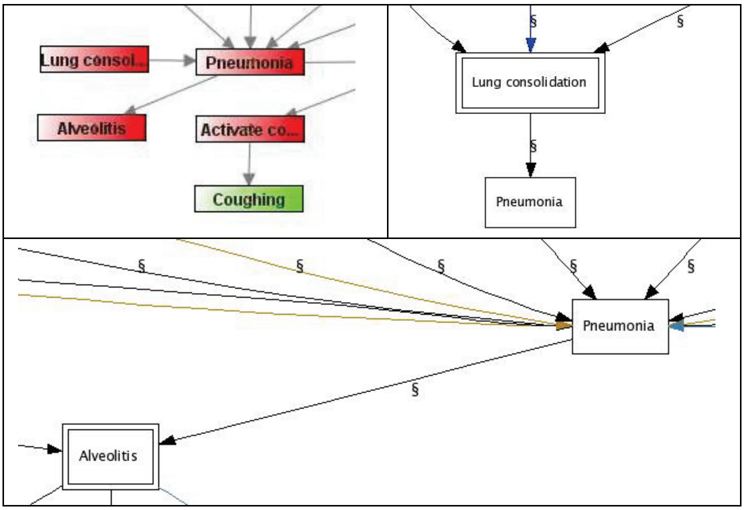


Fig. 7. A part of pneumonia model built using the UMLS semantic network of pneumonia concept and its parent (Lung consolidation) and child (Alveolitis).

3.4. Knowledge visualization

One effective way to help authors comprehend large amounts of complexly interconnected knowledge is with visualization tools. The system provides key features such as copying, pasting, zooming, undo/redo, event-handling, and drag-and-drop support. These functions are implemented using JGraph an open source Java graph visualization library. JGraph is compliant to Java Swing[2] API. Therefore, it is compatible with Swing features such as serialization[3], and datatransfer.

The medical case for our application has its specific layout. The goal and concept nodes, which are parents of apply nodes, are placed on the left most. The apply nodes, which can have multiple parents, are placed next to the right. The hypothesis nodes are placed on the right most and in hierarchical layout to illustrate the causal relationship among them. The authors can draw a case easily by following this layout; however, the authoring tool also provides the automatic layout feature using JGraph to help creating a better visualization of the layout such as moving nodes to the straight alignment and minimizing the crossing of edges.

4. Evaluation

The success of ITS authoring tools depends on two main factors – the usability and the effectiveness of the authoring tool. A number of qualitative and formative methods can be used to evaluate ITS authoring tools, e.g., usability, productivity, acceptability, and the effectiveness of the created learning environments. By far, there have been relatively few evaluations of ITS authoring tools. This is in part because the tools have numerous features and it is difficult to measure the effect of individual features and difficult to create control situations against which to compare the results. The summative evaluations, which ostensibly prove that an entire system "works," may be less valuable that formative evaluations, which give indications of what parts of a system do and don't work and why. The following is the study on the effectiveness and the report on the usability of COMET authoring tool.

4.1. Effectiveness of the authoring tool

In order to evaluate the effectiveness of the authoring tool, we measured the quality of the created problem solution. The problem solution is in the form of a network consisting of nodes (hypotheses) linked together by semantic relations. We compared the network built using the COMET authoring tool, with the network of a benchmark solution for the same domain. The benchmark solution was built from scratch using a paper-based problem solving approach.

[2] Swing is a graphical user interface (GUI) toolkit for Java. It is one part of the Java Foundation Classes. Swing includes GUI widgets such as text boxes, buttons, split-panes, and tables.

[3] Serialization is the storing of an object's current state on any permanent storage media for later reuse.

4.1.1. Method

Six medical PBL tutors participated in the study: 2 physiology majors, 2 anatomy majors, 2 pathology majors. Each tutor had at least five years experience in conducting the PBL course at Thammasat university medical school. The participants were divided into two groups with the same proportion of expertise. Each group was asked to create a problem solution for three different scenarios Pneumonia, Heart attack, and Diabetes—which provide a reasonable diversity of the case. The first group used the COMET authoring tool via the school LAN to elicit the problem solution on given domains collaboratively, and the resulting semantic networks of the problem solutions were compared with the benchmark group. The benchmark group created the problem solution collaboratively using the conventional paper-based problem solving approach. Medical Textbooks, journals, and online resources were used in both groups.

All valid medical hypotheses and the links created were counted. The validity of hypotheses and links were verified by an expert in the area of Pneumonia, Heart attack, and Diabetes. In order to represent a global property of the networks that could account for the interdependence of the elements in the representation, we used a numeric function called Integration [15]. An integration mark (I) is defined by taking the ratio of the number of links (L) within the network to the number of nodes (N). We can generalize that formula for the whole representation:

$I=L/N$

4.1.2. Results

Figure 8 shows resulting networks for Pneumonia scenario created by benchmark group and the COMET authoring tool. The numbers of hypotheses, links and value of integration of all scenarios are presented in Table 1. With the support from the COMET authoring tool, there was a greater number of nodes and number of links, and the value of integration demonstrated by the authoring tool group was greater in all scenarios. The results show that from the same scenario, the authors who work with the COMET authoring tool built solution networks that were both richer and more integrated.

Although there was no gold standard in this evaluation, we found high degree of overlap of the resulting networks between the benchmark and the COMET authoring tool group. The following is the explanation of some differences. Despite the fact that the results reflect the effectiveness of the authoring tool, we are aware that we did not provide an analysis that clearly addresses the effectiveness of each tool feature in this study. Consequently, other explanations of our data might exist. For example, in the Pneumonia case, some of the pneumonia node's parents and children; e.g., Lung consolidation, Alveolitis and Lobular pneumonia; which did not appear in the benchmark group are UMLS concepts (Figure 8, box B and D). This could be explained by the reminding that occurs when browsing through UMLS in the authoring process. Another feature of the tool that can affect the problem solution is the use of colors to represent hypothesis categories. This helps the users to quickly perceive and comprehend the evolving model, particularly in a multi-author environment. This feature could explain the fact that there are more ideas related to the enabling condition for the Upper respiratory tract infection in the COMET authoring tool group (Figure 8, box A and C).

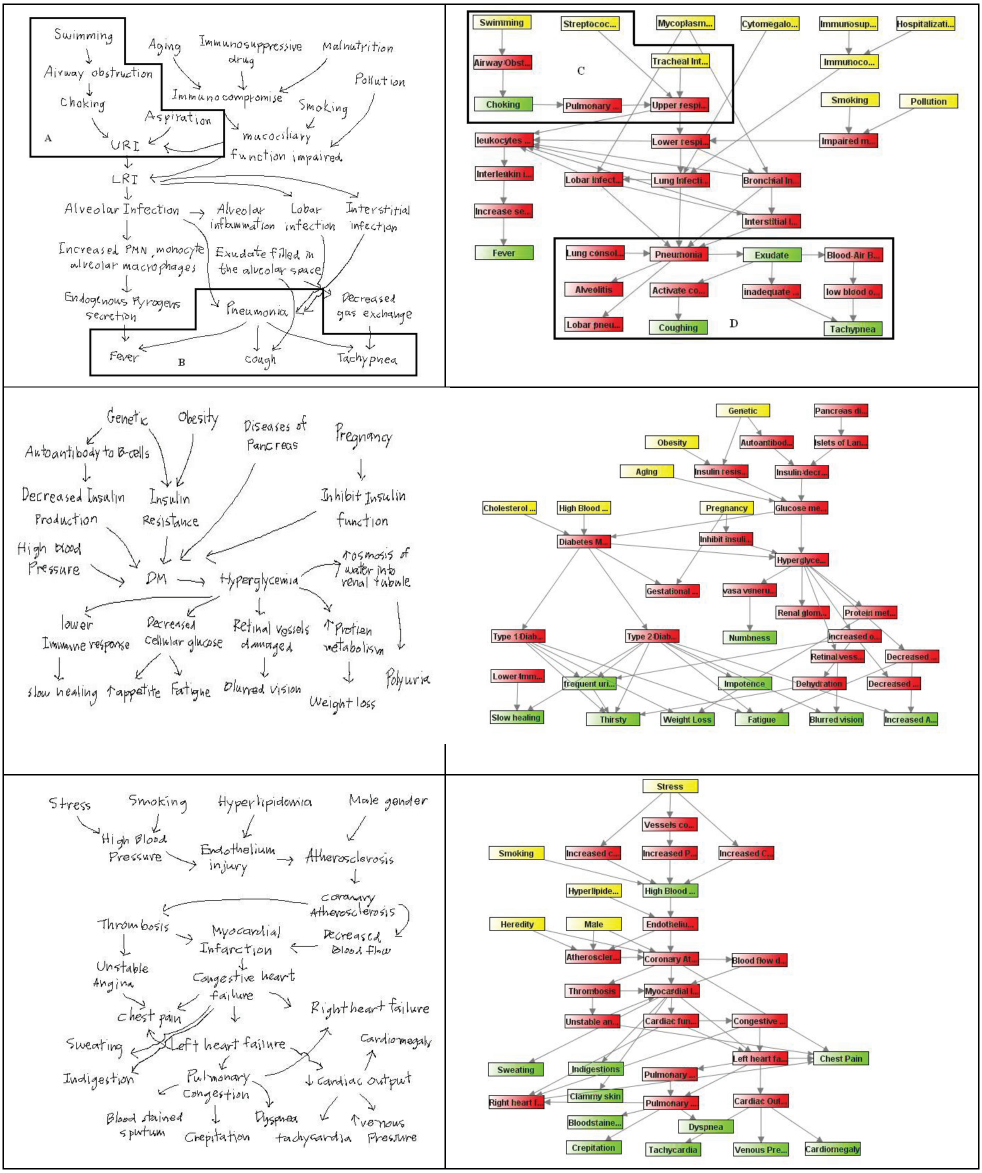


Fig. 8. Resulting semantic networks of Pneumonia, Diabetes, and Heart attack scenario.

Scenario	Cohort	Number of hypotheses	Number of links	Value of integration
Pneumonia	Benchmark	26	28	1.08
	COMET	35	43	1.23
Heart attack	Benchmark	22	23	1.05
	COMET	36	49	1.36
Diabetes	Benchmark	26	29	1.11
	COMET	34	49	1.44
All	Benchmark	74	80	1.08
	COMET	105	141	1.34

Table 1. Numbers of hypotheses and links as well as value of integration, by cohorts and scenarios

4.2. Usability of the authoring tool

The COMET authoring tool has been tested and improved to fulfill the authors' requirements during the system design and implementation. Initial training in the use of the tool requires between 1 and 2 h. Authors took between 6 and 11 h (to author a 3 h problem analysis session on pneumonia, heart attack, and diabetes)—a ratio of around 3 h per hour of tutoring. According to the follow-up interview, no author has found creating the problem solution incompatible with his or her approach. For the most part authors wanted the functionality that COMET provides and they were able to use it to create problem solutions that reflect their own pedagogic preferences. The participants mentioned in the follow-up interview that the visual communication, allowed by the realtime video-conferencing modality, as well as synchronous data transmission increased their level of confidence in their discussions and facilitated problem-solving.

5. Discussion

Intelligent Tutoring Systems have been shown to be effective in a number of domains, but they remain hard to build. One way to make ITSs more widespread is to create authoring tools that speed up tutor development. Authoring tools have the potential to increase the efficiency of building ITSs through reuse of common elements. Realizing reuse would require a resource library structure, where authored topics, activities, strategies, interface components, and/or domain knowledge could be stored independently from a tutor, and loaded from this library into any tutor. REDEEM [16] is built to take advantage of courseware libraries. The content and interactive screens of a REDEEM ITS are not authored using REDEEM, but are authored using ToolBook, an off-the-shelf multimedia authoring tool. ToolBook authored content is exported to a library and from there it is imported by REDEEM. Some ITS authoring systems infer or create new knowledge or information from scratch, saving the author from having to derive, articulate, and enter this information. RIDES [17] uses example-based programming techniques to infer general procedures from specific examples given by the author. RIDES creates a device's operational procedure by recording the author's actions as he uses the device simulation to illustrate the procedure. The DIAG system [18] infers a large body of device fault diagnosis information from a relatively small number of qualitative failure symptoms entered by the author. In this paper we describe the COMET authoring tool built to take advantage of the reusability of medical knowledge in the UMLS. All the terms in the domain model are linked to the UMLS Metathesaurus. All the possible relations among them are automatically determined using the UMLS Semantic network. According to our preliminary results, the UMLS provides a useful corpus of medical knowledge for designing a domain model for medical ITS.

The development of learning content is a collaborative process in which authors with different backgrounds, experiences, and points of view can take part. However, the collaborative development support in current learning contents authoring tools is scarce, since they usually provide a uni-personal vision of the creation process. But educational technologies in general are moving towards the use of second generation web-based communities or Web 2.0, which facilitate collaboration and sharing between users by the move to the internet as platform [19]. WEAR [20] is a web-based authoring tool for the construction of ITSs in Algebra-related domains, such as physics, economics, chemistry. To promote collaborative work among instructors, authors are offered the choice of seeing what other authors have done along two dimensions; the structure of a similar course and a list of problems constructed by other authors. In CARLOS (A Collaborative Authoring Tool for Reusable Learning Objects) [21], key factors of the collaborative creation process are taken into consideration, first negotiation and assessments of ideas between developers, who delegate those processes on their representing agents. Secondly, the results of those negotiations are automated included in the reusable learning objects corpus. CARLOS is able to trace of all changes and versions of the reusable learning objects during it creation process and those changes occur simultaneously on the same section of the same physical file. Whitehead and Goland [22] took a protocol-centric approach with a focus on interoperability to generate network effects and to add collaborative authoring capability to existing tools. The protocol is a set of extensions to HTTP which provide facilities for concurrency control, namespace operations, and property management. The protocol allows users tocollaboratively author their content directly to an HTTP server, allowing the Web to be viewed not just as a readonly way to download information, but as a writeable, collaborative medium. In the COMET authoring tool, we integrate the most advanced technologies of computer-supported collaborative work and the information processing to provide a cooperative environment for authors to communicate for building the ITS medical domain model. The system can be operated by a number of authors in different locations to negotiate and solve the same patient case through the graph visualization tools and distributed environment. Although only a small number of subjects (six authors—three using COMET and three using pen and paper) were involved in this pilot evaluation of the tool, the study gave us encouraging results.

6. Conclusions and Future work

We have exploited computer-supported collaborative work environments and reused UMLS in the development of the COMET authoring tool. This has allowed us to provide flexible mechanisms and interfaces to allow authors to collaboratively building the domain knowledge of the medical PBL cases. The evaluation showed that the authors who worked with the COMET authoring tool built solution networks that were both richer and more integrated than the network of a benchmark solution built from scratch using the conventional paper-based approach for the same domain. This was achieved in hours compared to months for the conventional paper-based approach. Although our primary goal was to build the authoring tool for an ITS for medical PBL, we believe that the tool will also be useful for case authoring in medical PBL in general. In our future work, we plan to develop reasoning algorithms from the UMLS Semantic networks in order to automatically convert them into the medical ITS domain models.

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5

The Interaction Analysis with the ADULT environment (A pilot study)

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1. Introduction

ADaptive Understanding Learning Text environment (ADULT) is based on Kintsch's Construction-Integration model for text comprehension (Van Dijk & Kintsch, 1983; Kintsch, 1988; Kintsch, 1994). According to this model, there is a distinction between the text micro- and macrostructure and between the text-base and situation model. It assumes a minimum of two levels of text understanding, text-base and situational understanding and memory of a text does not necessarily imply learning from it as well (Kintsch, 1994). A good text-base understanding relies on a coherent and well-structured representation of the text, whereas a good situation model relies on different processes, primarily on the active use of long term-memory or world knowledge during reading. Links between text-base and world knowledge must be activated in the reader's mental representation of the text. Motivated readers encountering a gap in the text will attempt to fill it, and doing so requires accessing information from their world knowledge, which in turn results in the text information being integrated with long-term memory. This gap-filling process can only be successful if readers possess the necessary background knowledge. Consequently, for a good situational understanding, a single text cannot be optimal for every reader: low-knowledge readers should benefit more from an easier, coherent text, whereas high-knowledge readers should be allowed to infer with harder, less coherent texts. Texts have local and global structure. Microstructure refers to local text properties and macro-structure to the global organization of text. Micro-structure is generally cued by the text via explicit indicators of relations between concepts and ideas (e.g. connectives, argument overlap, and pronominal reference). Micro-structure can also be constructed on the basis of the learner's knowledge when there are details or relations left unstated in the text. A text's macro-structure can be cued directly by the text via topic headers and sentences. McNamara, E. Kintsch, Songer, & W. Kintsch, (1996) examined students' comprehension of four versions of a biology text, orthogonally varying local and global coherence. They found that readers with low- and high-background knowledge benefit from a coherent and a minimally coherent text respectively. Gasparinatou, Tsaganou, & Grigoriadou (2007, 2008c) investigated the role of text coherence and learners' background knowledge in the comprehension of scientific-and specifically Informatics-texts. The results showed that high-knowledge readers benefit from a minimally coherent text, in contrast to low-knowledge readers who learn better from a maximally

coherent text. In this line of research the ADULT environment was designed and developed (Gasparinatou et al, 2008c). Much research has been undertaken on the impact of different styles on learners' preferences and human learning in general (Riding and Rayner, 1998; Entlwistle, 1981; Schmeck, 1988; Kolb, 1984; Keefe, 1979). Style in educational psychology has been recognised as a key construct in the area of individual differences in learning. Different learners approach learning tasks in different ways, or using different styles and through the interaction with a learning environment they develop sets of behaviour that they are comfortable with (Entwistle, 1981). Such viewpoints have led to suggestions of tailoring educational interactions to learners' cognitive or learning style in the context of computer-based and web-based learning environments (Carver et al., 1999; Bajraktarkvic et al., 2003; Chen and Paul, 2003; Papanikolaou et al., 2003; Triantafillou et al., 2003). The flexibility offered by such environments should enhance learning, allowing learners to develop personal navigation patterns and interaction behaviour that reflects their own cognitive characteristics.
The remaining sections of this paper present: (1) An Outline of the ADULT environment, (2) Kolbs' Learning Style Inventory (LSI), (3) An empirical study where students' interactions with ADULT, have been analyzed, within the context of the "Informatics and Education" course, (4) The evaluation of ADULT by these students who are considered pre-service teachers. (5) The paper concludes with suggestions for improving the currently used learning environment in order to achieve more personalized learning.

2. An outline of the ADULT Environment

The Adaptive Understanding and Learning Text environment (ADULT) actively engages students in the learning process. It offers four versions of text with the same content but different coherence at the local and global level. It supports and assesses students' comprehension through text-recall measures, text-based, bridging-inference, problem solving questions and a sorting task. ADULT takes into account readers' background knowledge in order to propose the appropriate text. To achieve this goal, it suggests that the student performs a background knowledge assessment test, with scores characterized as "high", "median" and "low". ADULT motivates high knowledge students to read the minimally coherent text at both local and global levels (lg), median knowledge students to read the text with maximum local coherence and minimum global coherence (Lg) or with minimum local and maximum global coherence (lG) and low knowledge students to read the maximally coherent text (LG). ADULT also allows the student to choose the preferred version of text and records the time spent reading it. The four text versions have the same content but different coherence at local and global level. Text coherence refers to the extent to which a reader is able to understand the relations between ideas in a text. Before reading the text and after completing the assessment activities the system propose that the student performs the same sorting activity in order to examine how readers change their conceptual structures according to the text. This activity involves a set of concepts which are to be categorized into groups. The overall objective is to provide a group of concepts with several rational sorting principles, as well as clearly discernible, text-driven sorting principles.
The following three types of rules were used to maximize local coherence: (1) replacing pronouns with noun phrases when the referent was potentially ambiguous (e.g. In the phrase: *"This gives users the ability to move around within a broad coverage area and still be*

connected to the network", we replace *"This"* by *"A wireless LAN (WLAN)"*. (2) Adding descriptive elaborations linking unfamiliar and familiar concepts (e.g., *"The network topology determines the way in which the nodes are connected"*, is elaborated to: *"The network topology determines the way in which the nodes are connected, which means the data paths and consequently the possible ways of interconnecting any two network nodes")*. (3) Adding sentence connectives (however, therefore, because, so that) to specify the relation between sentences or ideas. In the global macro coherence versions of the texts (lG and LG), macro propositions were signaled explicitly by various linguistic means (i.e., macro signals): (1) adding topic headers (e.g., Types of wireless LANs) and (2) adding macro propositions serving to link each paragraph to the rest of the text and the overall topic (e.g., *"Afterwards the advantages and the disadvantages of Wireless LAN technology will be discussed"*) (McNamara et al., 1996).
ADULT supports and assesses students' comprehension through text-recall measures, text-based, bridging-inference, problem solving questions and a sorting task. In this study, in the text-recall activity, students were asked to complete the blanks in a text, taken from a text already read. In this way, the system examines students' recall of the text and consequently the text-based model developed after the reading of the text according to Kintsch's model. In text-based questions, the information necessary to answer the question is contained within a single sentence of the minimally coherent lg text (e.g., *"What is a wireless local area networκ?"*). In bridging-inference questions, the necessary information is contained in the text, but requires linking two or more sentences (e.g., *"In wireless local area networks, what do the first and second modes of transmission have in common?)"*. In elaborative-inference questions, linking text information to that from outside knowledge is required in order to answer the question (e.g., *"Which topology (wired or wireless) would you use in order to have a constant transmission rate in a network ?"*). Finally, in problem–solving questions, linking information from separate sentences within the text and applying this information to a novel situation is required *("Assume that you have to construct a wireless local network for a large facility such as an airport. Which transmission mode would you use?")*. ADULT examines the text-based model which the reader develops via text-recall, text-based and bridging-inference questions. Elaborative-inference, problem-solving and sorting activities assess if students developed a good situation model, meaning they gained a deep understanding of the text. The learner model in ADULT keeps information about:(1) learners' background knowledge level with respect to the text version/activities worked on, and (2) learners' behavior during interaction with the environment in terms of the learning sequence chosen, time spent on reading the text, time spent on an activity, etc. The learner model is dynamically updated during interaction with the system in order to keep track of the learner's present status. During interaction, learners may access their model and view the information kept concerning their progress and interaction behavior.

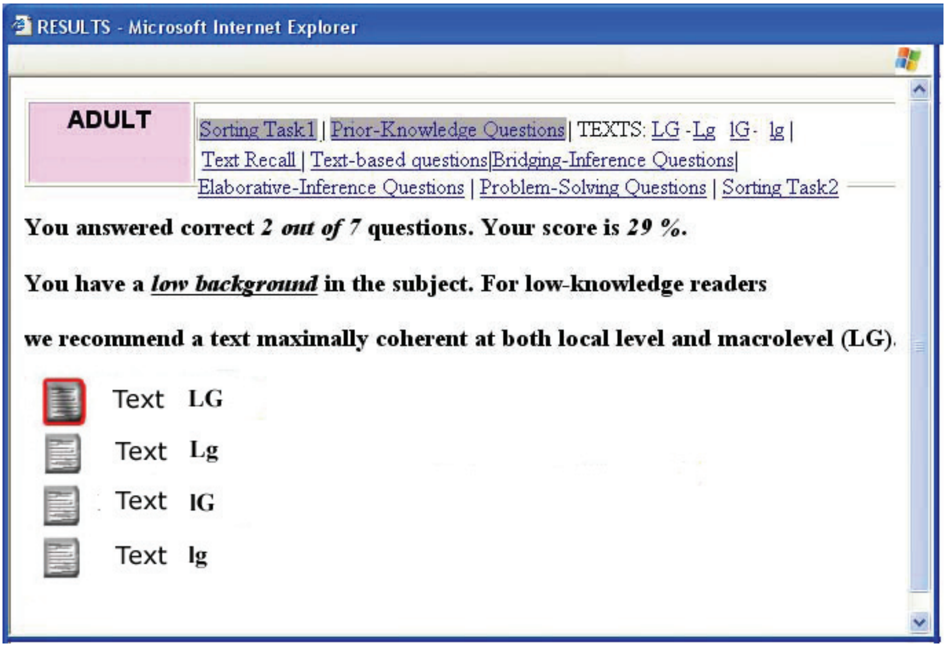

Fig. 1. ADULT characterizes the student and suggests the appropriate text

3. Kolbs' Learning Style Inventory (LSI)

According to Kolb (1984): 'learning is the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping experience and transforming it'. He proposes that experiential learning has six characteristic features: (1) Learning is best conceived as a process, not in terms of outcomes, (2) Learning is a continuous process grounded in experience, (3) Learning requires the resolution of conflicts between *dialectically* opposed modes of adaptation to the world. For Kolb, learning is by its very nature full of tension, because new knowledge is constructed by learners choosing the particular type of abilities they need. Effective learners need four kinds of ability to learn: from concrete experiences (CE); from reflective observations (RO); from abstract conceptualisations (AC); and from active experimentations (AE). These four capacities are structures along two independent axes, with the concrete experiencing of events at one end of the first axis and abstract conceptualisation at the other. The second axis has active experimentation at one end and reflective observation at the other. Conflicts are resolved by choosing one of these adaptive modes, and over time, we develop preferred ways of choosing, (4) Learning is a holistic process of adaptation to the world, (5) Learning involves transactions between the person and the environment, (6) Learning is the process of creating knowledge:'[which] is the result of the transaction between social knowledge and personal knowledge' (1984). Kolb describes the process of experiential learning as a four-stage cycle. This involves the four adaptive learning modes mentioned above – CE, RO, AC and AE – and the transactions and the resolutions among them. The tension in the abstract-concrete dimension is between relying on conceptual interpretation (what Kolb calls 'comprehension') or on immediate experience (apprehension) in order to grasp hold of experience. The tension in the active-reflective dimension is between relying on internal reflection (intention) or external manipulation (extension) in order to transform experience (Coffield et al., 2004).

It is out of this structure that Kolb defines four different types of knowledge and four corresponding learning styles. The main characteristics of the four styles are summarised below: (1) *Type 1: the converging style* (abstract, active) relies primarily on abstract conceptualisation and active experimentation; is good at problem solving, decision making and the practical application of ideas; does best in situations like conventional intelligence tests; is controlled in the expression of emotion and prefers dealing with technical problems rather than interpersonal issues, (2) *Type 2: the diverging style* (concrete, reflective) emphasises concrete experience and reflective observation; is imaginative and aware of meanings and values; views concrete situations from many perspectives; adapts by observation rather than by action; interested in people and tends to be feeling-oriented, (3) *Type 3: the assimilating style* (abstract, reflective) prefers abstract conceptualisation and reflective observation; likes to reason inductively and to create theoretical models; is more concerned with ideas and abstract concepts than with people; thinks it's more important that ideas be logically sound than practical, (4) *Type 4: the accommodating style* (concrete, active) emphasises concrete experience and active experimentation; likes doing things, carrying out plans and getting involved in new experiences; good at adapting to changing circumstances; solves problems in an intuitive, trial-and-error manner; at ease with people but sometimes seen as impatient and 'pushy' (Coffield et al., 2004).

4. The Empirical Study

4.1 Research Questions

The ADULT environment and the developed educational material in "Wireless Local Area Networks (WLAN)" were used in the 2007-2008 academic year, in the context of the undergraduate course "Informatics and Education". The primary objective was to investigate the interaction of undergraduate Informatics and Telecommunications students with the ADULT learning environment while studying the above thematic unit. Specifically, the main research questions were: (1) Do students follow the suggested learning sequence or their own one, during interaction with the system? (2) Do the background knowledge and the coherence of the text read influence students' performance? (3) Do the learning style influence their learning style? (4) What is their opinion on the effectiveness of ADULT in supporting the learning process in this undergraduate course?

4.2 Participants

The study sample consisted of 40 Informatics and Telecommunications undergraduates of the University of Athens, who were attending the "Informatics and Education" course. Their participation was in the context of an activity having the following objectives: (1) to study the educational material uploaded in ADULT, (2) to perform activities addressing the "Wireless Local Area Networks (WLAN)" domain and (3) to assess the course designed via ADULT. Most students had successfully completed the course titled "Data Transmission and Networks Communications". Therefore, they were considered as "high" knowledge readers. These participants are also considered to be pre-service teachers, since most of them intend to teach Informatics in the secondary education system, following their graduation.

4.3 Task and Materials

4.3.1 Learning-Style Inventory (LSI © David A. Kolb, Experience-Based Learning Systems, Inc.)

The Learning – Style Inventory describes the way a student learns and how he/she deals with ideas and day-to-day situations in his/her life. It includes 12 sentences with a choice of endings. The student has to rank the endings for each sentence according to how well he/she thinks each one fits with how he/she would go about learning something. He/she has to try to recall some recent situations where he/she had to learn something new, perhaps in his/her job or at school. Then, using the spaces provided, he/she has to rank a "4" for the sentence ending that describes the way he/she learns *best,* down to a "1" for the sentence ending that seems least like the way he/she learns. He/she has to rank all the endings for each sentence unit. Ties are not permitted.

4.3.2 The Educational Material

The educational material was based mainly on a chapter concerning "Local Network Topologies" (Walrand, 2003) and included: (1) four versions of a text, orthogonally varying local and global coherence, (2) a pre-reading sorting activity which included 26 concepts for the students to categorize in five broader categories, (3) a background knowledge questionnaire containing ten questions, (4) a text-recall activity, (5) six text-based questions, (6) four bridging-inference questions, (7) seven elaborative-inference, (8) four problem-solving questions and (9) the post-reading sorting activity, which was the same as the pre-reading sorting activity. All tasks included multiple choice questions. Students were asked to complete and submit the required tasks to the system. All tasks were completed remotely.

4.4 Procedure

The empirical study took place for three weeks and consisted of the following phases: (1) Students were administered the Learning-Style Inventory (LSI © David A. Kolb, Experience-Based Learning Systems, Inc.), (2) presentation of the ADULT environment in the classroom, (3) interaction with ADULT and working out activities, which took place for 2 weeks, and (4) completion of a questionnaire on the effectiveness of ADULT in supporting the learning process in such a course. This phase lasted one week. During these three weeks, students cooperated with one another and the researcher via a forum specifically created for this purpose.

4.5 Data Collection

In order to answer the research questions, we analyzed: (1) Students' answers to the Learning Style Inventory and the algorithm proposed by the Hay Group, (2) ADULT log files created automatically by the system. In particular, students' sequence during interaction with the system and performance in the activities was identified. This way, we obtained an indication of how ADULT supports students to develop an adequate situational model which is in *fact* its main purpose. (3) The assessment questionnaire completed by the students.

4.6 Data Analysis

4.6.1 Achievement measures

Having as an objective to investigate students' exploitation of ADULT facilities and particularly to identify the sequences of actions that students performed in order to study the aforementioned topic, we analyzed ADULT log files.

4.6.2 Questionnaire

The evaluation questionnaire, filled by the students, consisted of Likert-scale type questions asking students to express their opinion on the effectiveness of ADULT in supporting the learning process (10items; indicative item is *"ADULT proposed the most appropriate text according to your background knowledge"*). Students' answers varied from 1 to 5 (1 indicates "I strongly disagree" 5 indicates "I strongly agree"). Additionally the students were given the option to express their opinion about each one of these questions, as well as to make comments and suggestions for the improvement of ADULT.

5. Results

1st Research Question: "Do students follow the suggested learning sequence or their own one during interaction with the system"?

According to the log files: (1) All participants performed the pre-test sorting activity first and the post-test sorting activity last as proposed by the system. (2) Thirty eight out of forty students performed the background knowledge activity (95%). Thirty one of them scored over 0.65 and they were proposed to read the minimally coherent text (lg). (3) Twenty three out of thirty eight read the text version proposed by the system (60.5%). (4) All students performed the assessment questions.

2nd Research Question: "Do the background knowledge and the coherence of the text read influence students' performance"?

Students were divided in two groups: Those reading the text proposed by the system and those reading their preferred text. The results are presented in Tables 1 and 2 respectively. According to the data in Tables 1 and 2 most students had high background knowledge. This was because they had successfully completed the proceeding course titled "Data Transmission and Networks Communications".

Text	N	Backg. knowl.	Pretest sorting activity	N	Text recall	N	Text based	Bridg. infer.	Elab. Infer.	Probl. solving	Post-test sorting activity
lg	17	0.75 (0.16)	0.62 (0.14)	15	0.53 (0.20)	17	0.76 (0.20)	0.81 (0.23)	0.75 (0.23)	0.66 (0.25)	0.77 (0.13)
lG	1	0.50	0.65	1	0.17	1	0.67	0.25	0.57	0.50	0.77
LG	5	0.48 (0.25)	0.53 (0.25)	5	0.34 (0.92)	5	0.77 (0.28)	0.75 (0.31)	0.83 (0.25)	0.70 (0.41)	0.75 (0.22)
Total	23	0.68 (0.21)	0.60 (0.17)	21	0.47 (0.25)	23	0.76 (0.21)	0.77 (0.26)	0.76 (0.23)	0.66 (0.28)	0.76 (0.15)
P-sig[1].		*0.023*	*0.567*		*0.135*		*0.916*	*0.107*	*0.590*	*0.820*	*0.973*

[1] According to one-way ANOVA

Table 1. Students' (reading the proposed text) performance

According to the data in Table 1, students performed quite well in text-based and bridging-inference activities, as well as in elaborative-inference, problem-solving and post-test sorting activities, implying that they developed an adequate text-based and situation model respectively. In all activities, the score differences between students having read a different text version (lg, lG and LG) weren't statistically significant. This was expected according to Kintsch's model of text comprehension, because all students read the appropriate text according to their background knowledge. This was also the goal in designing the ADULT environment: to support readers with appropriate texts according to their background knowledge.

Text	N	Backg. knowl.	Pretest sorting activity	Text recall	Text based	Bridg. infer.	Elab. infer.	Probl. solving	Posttest sorting activity
κανένα	2	0.65 (0.07)	0.29 (0.41)	0.00 (0.00)	0.50 (0.24)	0.63 (0.18)	0.50 (0.30)	0.12 (0.18)	0.55 (0.25)
Lg	1	0.80	0.73	0.17	0.33	0.50	0.57	0.25	0.85
LG	12	0.70 (0.19)	0.65 (0.24)	0.53 (0.22)	0.86 (0.20)	0.88 (0.23)	0.86 (0.22)	0.73 (0.27)	0.75(0.24)
Total	15	0.70 (0.18)	0.61 (0.27)	0.44 (0.28)	0.78 (0.26)	0.82 (0.24)	0.79 (0.25)	0.62 (0.33)	0.73(0.24)
P-sig[1].		*0.812*	*0.208*	*0.014*	*0.050*	*0.157*	*0.111*	*0.020*	*0.533*

[1] According to one-way ANOVA

Table 2. Students' (reading the preferred text) performance

Table 2 reports the performance of students not reading the proposed text, but the one they preferred. Two students didn't read any text before performing the activities, but while performing the activities. Therefore, although having adequate background knowledge, they didn't develop an adequate situation model. One student reading Lg text instead of the proposed lg didn't develop an adequate situational model either. Twelve students reading the maximally coherent text instead of the proposed minimally coherent text developed an equally adequate situation model with the seventeen students (Table 1) reading the minimally coherent text proposed by the system. These students, despite having a high background knowledge, stated that they preferred to read the text with the maximum coherence at local and global level and this capability of the system to facilitate a personalized learning route most likely explains the high performance in the activities. Although these results constitute an indicative answer to the previous research question, we have to repeat the experiment above, with more participants in order to have more reliable results.

3rd Research Question: "Does the learning style influence students' performance?"

According to the students' answers to the Learning-Style Inventory and the algorithm proposed by the Hay Group, twenty students had the converging style, twelve the assimilating style, five the accommodating style and three the diverging one. In Table 3, we can see the number of students in each learning style reading a text version.

Learning style	N	No text	lg	lG	Lg	LG
diverging	3	1	1	0	0	1
assimilating	12	1	5	0	0	6
converging	20	0	10	1	1	8
accommodating	5	0	1	0	0	4
Total	40	2	17	1	1	19

Table 3. Students' learning style

Students' background knowledge performance, before reading the text, taking into account learning style, is presented in Table 4. As it can be seen students' background knowledge is independent of their learning style ($F(3, 34) = 0.283$, $p = 0.837$).

	Score Background knowledge		
Learning Style	N	M	SD
Diverging	3	0.77	0.21
Assimilating	12	0.69	0.18
Converging	20	0.69	0.22
Accommodating	5	0.63	0.13
Total	40	0.69	0.20
	P-sig.[1]	*0.837*	

[1] According to One-Way ANOVA

Table 4. Background knowledge according to learning style

As we can see in Table 5, students having the converging and the accommodating learning style performed better in elaborative-inference and in problem solving questions. This was expected because people having these learning styles, like doing things and are good at problem solving. The students with the assimilating learning style performed better in text-recall, text-based, bridging- inference and posttest sorting activity. This was also expected, because people having the assimilating style prefer the theory more than the action. Diverging students performed better in text-based and also in bridging-inference questions. This was also expected because diverging people like to learn by observation rather than by action (Coffield et al., 2004). Consequently, the results presented in Table 5 are towards the expected direction but they aren't statistically significant. We have to repeat the experiment with more participants, in order to have more reliable results.

Learning Style	N	Text recall	Text based	Bridg. infer.	Elab. infer.	Probl. solving	Pretest sorting activity	Posttest sorting activity
Diverging	3	0.45	0.78	0.67	0.63	0.55	0.51	0.65
Assimilating	12	0.59	0.83	0.83	0.66	0.56	0.66	0.81
Converging	20	0.39	0.73	0.78	0.80	0.69	0.57	0.72
Accommodating	5	0.52	0.80	0.80	0.84	0.61	0.56	0.70
Total	40	0.47	0.77	0.79	0.75	0.63	0.59	0.74
	P-sig[1].	*0.199*	*0.620*	*0.761*	*0.727*	*0.931*	*0.548*	*0.533*

[1] According to One-Way ANOVA

Table 5. Students' performance according to learning style

4th Research Question: "Assessment of the course designed via ADULT"

Item	**Description**	**Valid (%)**	**Mean (SD)**	**Median**	**% distribution of valid responses**				
					1	**2**	**3**	**4**	**5**
1	Proposed text supported learning	100.0	4.13 (0.81)	4.0	0.0	0.0	26.1	34.8	39.1
2	Pre-test sorting activity supported learning	100.0	3.42 (1.10)	3.0	2.5	20.0	30.0	27.5	20.0
3	Post-test sorting activity supported learning	80.0	3.62 (1.04)	4.0	0.0	18.8	21.9	37.5	21.9
4	Text-recall activity supported learning	100.0	3.50 (1.11)	4.0	5.0	15.0	20.0	42.5	17.5
5	Text-based activity supported learning	100.0	4.00 (0.85)	4.0	2.5	2.5	12.5	57.5	25.0
6	Bridging-inference activity supported learning	100.0	4.20 (0.85)	4.0	0.0	5.0	12.5	40.0	42.5
7	Elaborative-inference activity supported learning	97.5	3.95 (0.97)	4.0	0.0	10.3	17.9	38.5	33.3
8	Problem-solving activity supported learning	100.0	3.87 (1.13)	4.0	0.0	20.0	10.0	32.5	37.5
9	Activities were adequate	97.5	4.00 (0.95)	4.0	0.0	10.3	12.8	43.6	33.3
10	Personalized learning sequence	92.5	4.84 (0.37)	5.0	0.0	0.0	0.0	16.2	83.8

Table 6. Students' opinions about the ADULT Environment

Information pertinent to the responses is provided in Table 6, which displays the item descriptive statistics. Valid response rates are very high for all items. Mean scores, for each item, typically exceeded 3.5 which is a clear indication that students' have a favorable opinion about the ADULT environment. They had a positive opinion about the proposed text. The most noteworthy exception corresponded to the item *"Pre-test sorting activity supported learning"*, having a mean (median) value of 3.42 (3.0), which implies a relatively indifferent opinion about the support offered by this activity to learning. Students also proposed that the ADULT environment offer: (1) more open-ended than multiple choice questions, (2) more types of activities such as active experimentation, case-based studies and simulation activities, (3) more types of feedback , (4) a forum were students could collaborate with each other and the tutor.

6. Conclusions and Future Plans

Previous studies of Informatics text coherence and background knowledge pointed to the importance of considering prior domain knowledge in conjunction with active processing strategies in order to determine the most advantageous learning methodologies for individual students. The goal of the ADULT environment is to provide such advantageous learning methodologies, providing the learner with the text of the appropriate level of coherence according to background knowledge and supporting him with activities. In the study presented above, students performed well in the domain of "Local Wireless Topologies" during their interaction with the system. Students having the converging and the accommodating learning style performed better in problem solving and in elaborative-inference questions whereas assimilating and diverging students performed better in text-based, bridging-inference and in posttest sorting task. These results are in accordance with the learning preferences of these learning styles but we have to repeat the experiment with more participants in order to obtain more reliable results. Students had also a positive opinion about the ADULT environment because they were activated to use their background knowledge while reading and they believe that ADULT gives them the opportunity to achieve better results in learning from Informatics texts than reading a single text targeted at an average reader.

Our future plans include: (1) the consideration of the background knowledge and the learning style to present specific learning activities such as active experimentation, case-based studies and simulation activities, (2) to provide more types of feedback such as tutoring and reflective feedback, (3) the creation of a forum where students could collaborate with each other and the tutor.

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Mobile learning: two experiments on teaching and learning with mobile phones

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1. Introduction

After affecting broadly the way people communicate and do business the Internet is now changing the way people learn. Major breakthroughs in information and communication technologies (ICT) have changed the preference of the younger generations as far as learning is concerned. In a society of knowledge, mobility and ubiquitous learning (learning anytime, anywhere), have been gaining relevance. From this point of view, the emerging paradigm of m-learning seems to fully meet the needs of contemporary society. When we talk about m-learning we think about the mobility of learners, "in the sense that learners should be able to engage in educational activities without the constraints of having to do so in a tightly delimited physical location"(Kukulska-Hulme, 2005).

This change in the pedagogical paradigm also demands transformation in the way the educational materials should be designed, developed and made available to anyone who wants to learn. It's within this context that the learning objects are influencing the next generation of educational designers, due to its potential of re-generation, adaptability and scaffolding (Urdan & Weggen, 2000; Gibbons et al., 2000). Taking these concepts into consideration, podcasts appear as a good example of objects or resources for learning.

It was in this context that we have developed the Mobile Generation[1] project supported by mobile devices with varying screen sizes. For this project we have created a Learning Environment Supported by Mobile Technologies (LESMT), called "Mobile Generation". The aim of this project is to assess the implications of mobile technologies in individual and collaborative learning.

For an effective use of mobile technologies, we have produced a range of educational experiments using mobile devices such as mobile phones, MP3/MP4 players. The preference for these technological devices lays in the fact that they are in the students' hands and can, therefore, give a greater contribution to the education system. Among the experiments, we have highlighted the listening on curriculum contents, SMS text messaging and mobile quizzes, in java applications (midlets), such as vocabulary and Portuguese Literature tests/quizzes.

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[1] http://geramovel.wirenode.mobi/

For an effective use of mobile technologies we have produced a range of activities based on the Portuguese syllabus. In this chapter we will mention two experiments: one, using Podcasts for the study of Portuguese Literature, and another one in Portuguese language learning focused on the use of mobile phones as a productive tool: text, audio, image, video and as an information repository. We will present students' perceptions about the use of mobile phones for learning purposes, both inside and outside of the classroom.

2. Mobile Learning: a new paradigm in education

The information age, characterized by the transformation of atoms into bits, by the technological convergence and, above all, by the computerisation of modern societies (Castells, 1996) is today in a new platform. We are in the age of the connection (Weinberger, 2003), with mobile technologies becoming increasingly ubiquitous and pervasive.

The mobile technology has caused radical differences in the way society works, learns and has fun. Mobile phones have become one of the fastest growth communication technologies (Campbell, 2006). Today the majority of them have the capacity of a PC of the nineties (Prensky, 2004).

The access to multimedia contents is no longer limited to a personal computer (PC). Now, it is also been extended to mobile technologies such as mobile phones, PDA, Pocket PC, Tablet PC or Netbook, providing a new educational paradigm. This new model is called mobile learning or learning through mobile devices. The mobile learning, an extension of e-learning, has developed for several years, resulting in several research projects (Moura & Carvalho, 2008; Sharples et al., 2007; Waycott, 2004).

Mobile phones are changing the possibilities and practicalities of many components of daily life, as well as transforming the nature of communication, affecting identities and the relationships. They have also had a deep impact on the development of social structures and economic activities, not to mention the influence they have in the perception users have about themselves and the world.

Mobile technology, especially mobile phones, is becoming an integral part of modern life around the world. Increasingly powerful, with more and more features and services, it is providing access to content anywhere, any time (Walker, 2007; Sharples et al., 2007; Prensky, 2004). For years, the number of mobile phones has surpassed the number of personal computers and is becoming the most acceptable system of interpersonal communication (Aretio, 2004). These capabilities make it an appropriate tool to be used in educational contexts.

The changes occurring in education are directly connected with those in technology, as said by Nelson (1999) "Rapid changes in communications and information technologies are revolutionising education and providing new tools to customise learning environments".

The development of m-learning as a new strategy for education has implications on the way students learn, on the role of the teachers as well as in the educational institution. This paradigm has led to the discussion about the way the process of learning is developed in a learning environment and supported by mobile technologies. In this context, students have more autonomy because they can learn whenever and wherever they want. Nevertheless, this model raises some questions that do not arise in the traditional pedagogical model and they lack research. In conclusion, we can say that mobile learning consists of a series of adaptations of technology for the pedagogical strategy of distance education. The changes occurred in the way media is used for content transmission, the different formats that were acquired, based on new forms of communication among the ones intervening in the educational process, led to a change in the distance learning concept in recent years. Therefore, m-Learning is a natural evolution of technology's adaptations applied to the concept of d-Learning and e-Learning, as shown in Figure 1.

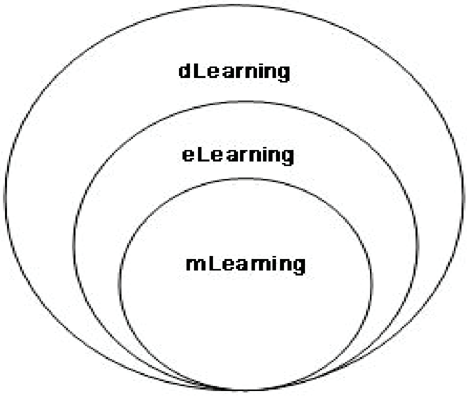

Fig. 1. The place of m-Learning as part of e-Learning and d-Learning (Georgiev et al., 2004)

2.1 Mobile phones in the educational context

Mobile phones seem to be, compared to all sorts of mobile devices, the most popular among younger people, probably the most widely owned handheld device (Trinder, 2005).
Though there are still some technical problems with regards to providing content such as graphics or complex Web pages, for highly interactive, future models will be more powerful and several current problems will be solved.
Thus, when creating mobile learning activities we must bear in mind all the limitations of equipment, in order to minimize the disadvantages. Therefore, units of content available only to learning just-in-time, practice and review of content, recordings, communication and access to information in the local set, sending reminders or relevant information for students, are good options (Thornton & Houser, 2002).
In future, teachers and students will no longer have to be restricted to a certain place and time to teach or learn. Mobile devices and wireless technologies will become, in the near future, an everyday part of learning both inside and outside the classroom.

2.2 Podcast: to learn anywhere, anytime

Since 2005, when Apple Computers incorporated the podcasts in its iTunes software, users can easily get an automatic update of recent podcasts (Chartrand & Pellowe, 2007). Moreover, the emergence of portals such as Podomatic or MyPodcast allow any user to write and publish their own podcasts for free. These circumstances provided a generalization of this technology, all over the world, and led us to create our podcasts as a complement for Portuguese Literature lessons, allowing students to access contents anywhere, anytime (Moura & Carvalho, 2006). Thus, the students have the Portuguese lectures available on audio files and they can easily download them, free of charge, to their mobile devices (mobile phone, iPod, MP3 and MP4), and listen to them whenever and wherever they wish.

3. The thumb generation: implications for education

The expression "thumb generation" or "thumb tribes" was used by Howard Rheingold in his book "Smart Mobs", to name the younger generation, for its ability to write and send text messages using only its thumbs. Taro Matsumura (2004), in Log Keita, speaks about the origin of the expression "thumb tribe" and gives the following definition: "The young generation that utilizes the keitai functionalities of phone, e-mail and Internet frequently as part of daily life. The name stems from the quick motion of thumb pushing buttons on a cell phone". The young generation is sending more and more content and information by SMS, MMS and Bluetooth in an instantaneous way. With the Game Boy, the PSP and the mobile phones, this generation started to use the thumb rather more than the index finger, resulting in new behaviours, such as moving to tighten the bells with the thumb. In a study led by Sadie Plant (2001) from the Cybernetic Culture Research Unit at Warwick University, this author believes that the relationship between technology and users of technology is reciprocal, affecting each other:

“The fact that our thumbs operate differently from our fingers is one of the main things that defines us as humans. Discovering that the younger generation has taken to using thumbs in a completely different way and are instinctively using it where the rest of us use our index fingers is particularly interesting”.

According to some researches, the youngsters’ thumb is now more developed as a result of the deep impact new technologies have had in their daily routine. This generation prefers being at home running their fingers across the game console or the mobile phone keypad rather than play in the street (Hill, 2002). They are sending almost 240 messages per week and at the age of sixteen they own more than three mobile phones (Basto, 2008)

Hence, it becomes urgent to discuss the role of today’s schools. They are now required to adjust their methods in order to meet the needs and expectations of a new generation, whose behaviour is undergoing significant changes as a result of the powerful influence television, mobile phones, Internet, YouTube and social networks (Facebook, Hi5, MySpace or Second Life) are having on the youths, as suggested by Fontana (2008): “Classrooms need to adapt to serve students who are plugged in online as never before, and corporations will need to adjust to the "thumb generation" and its thirst for connectivity and numerous computing devices”.

4. Studies Description

Two studies were conducted in two classes - one of Portuguese Literature and the other one of Portuguese language - focusing on the use of mobile phones in learning. In order to carry out these studies, a variety of activities were developed. The main aims of these activities were to enable an effective use of mobile technologies within the curriculum and to give students the opportunity of learning at their own pace, time and location. The Mobile Generation[2] project (Figure 2) aims at using smartphone for individual and collaborative

[2] http://geramovel.wirenode.mobi

learning. Throughout all the process, we have tried to develop students' ability to create their own contents, build knowledge and respect for the learning speed of each student.

Fig. 2. Mobile Generation Website Project

These are some of the activities our students were asked to carry out using some of mobile phones features:
- Listen to Portuguese Literature podcasts;
- Competition for the best picture;
- Competition for the best idea in video;
- Voice recording in an oral presentation (rehearsals), recording of a few minutes of reading;
- Write a collective story or a poem in which several students contribute by SMS;
- Write a dictionary for vocabulary enrichment;
- 5 minutes of daily reading onto students' mobile phones.

4.1 First Study

4.1.1 Sample Characterization

This study targeted 15 students (only male) from a school group attending a Public Professional Course at Carlos Amarante Secondary School, in Braga - Portugal, 81% of which aged 16 or 17 and 19% aged 19. More than half of them (56%) came from a rural background, while 44% came from an urban.
Based on a questionnaire for data collection regarding the ownership of mobile devices, results show that all students have mobile phone, 67% of them have an MP3 player and only 27% have an MP4 player. The minimum required conditions for the development of curricular activities using mobile phones were, therefore, be assured.

4.1.2 Data collection instruments

Two questionnaires for data collection were developed, both were filled in at the end of the study. The first questionnaire, "The phone in educational context," aimed at assessing information about the number of students owning mobile phones and using these devices to send photos to Mobile Flickr. Our purpose was to analyse the implementation of the mobile phones in education. This questionnaire included open and closed questions (affirmative/negative) and we used a Likert scale, with 3 options: disagreement, uncertainty and agreement about the use of the mobile phones in school. With the second questionnaire, "Attitudes of pupils on the use of podcasts about the Baroque Style", we intended to obtain information about mobile devices owned by students (mobile phones, MP3 and MP4 players), places where they used them and how often they did it. It was also our aim to gather information on the general use of podcasts and on the perception students had about the use of this tool with regards to supporting the study of a Portuguese Literature.
This questionnaire was composed of three parts, which included open, multiple-choice and closed questions (affirmative/negative). For the students' perceptions about the use of Podcasts on the Baroque, we focused on the following dimensions: i) Pedagogical value of podcasts, ii) Clarity and organization of podcasts, iii) Use of the podcasts to learn, iv) Students' attitudes towards the podcasts, and v) Podcasts' usefulness. For this chapter we will refer only to the first two dimensions.

4.1.3 Data Analysis

The first data below focuses on the characterization of the students' use of mobile phones in an educational context. The other information is followed by the data collected in the second questionnaire, which focus on the attitudes of students towards the use of podcasts.

4.1.4 Ownership and uses of mobile phones

According to data collected in this inquiry, all the students own mobile phones, 87% of them have Internet connection, and only 20% of the devices are not Nokia's. As far as the mobile phone's use is concerned, when asked about the available services they used more often, the students gave the following answers: text messages, listen to music, voice calls (making or receiving), play games, using block-notes, schedule, take pictures, make videos, checking email, using the Messenger (MSN), GPS, Bluetooth, the converter and phone book.
However, among these the most used services are listed in table 1.

Itens	Use		Use more often	
	f	%	f	%
Text messages	3	20	12	80
Audio	6	40	9	60
Make and receive calls	10	67	5	33
Calendar	10	67	5	33
Video, pictures, MSN, Internet	11	73	4	27

Table 1. The most used mobile phones services (N=15)

It should be noted that the two most frequently used services are text messages and listening to audio files. This may be explained by the fact that these services meet the preferences of students and does not represent financial expenses, as most of the time the students have access to free SMS. When we asked them about what prevented the use of most services, they said to be the high costs.

We asked the students if their parents also imposed rules on the use of the mobile phone and only two students responded affirmatively, which shows that the young people in this age group already have a great autonomy and freedom. All students responded that the SMS' recipients were friends and 57% also mentioned the family. No student referred sending messages to teachers.

We also wanted to know how many times they send SMS on a daily basis. Thus, 47% said to send more than a hundred messages a day, 27% more than 20, 13% by 20 and 13% by 5 and 60% of students would like to be able to send messages from computer to the phone. With regards to accessing the MSN service from the mobile phone only one student disliked it. When asked about this preference students mentioned: "it's always useful" (02), "could speak as I wanted" (08), "I don't need to be connected to the computer" (05), "to be talking with friends "(09)," because one could always be online "(10)," because we can be anywhere and talk on MSN "(11).

Only two pupils don't have a mobile phone with a camera and 60% of them have not yet filmed a video. All students consider the phone as a complement tool in the classroom and argue that it "is a different way of learning" (02), "helps much in class" (15), "does not allow parallel conversations" (14), "helps to improve learning" (13), "it's innovative" (12), "through it I can have access to content for learning" (11), "I learn more" (10), "it gives us a lot of information" (09), "we can find a lot" (07), "I can perform work through the phone" (06), "it allows us greater autonomy" (05), "it allows us to keep content" (03), "it motivates more" (04).

All students stated that they like to be able to revise the curriculum content from the phone, except one, who considered that the mobile phone does not have enough performance. These results demonstrate the existence of a widespread possession of updated versions of mobile phones, with free Internet access, some capacity for video, audio and storage. These students seem to recognize positive attributes to these devices as an educational tool.

4.1.5 Using mobile phones in schools

Regarding the perception of students about the use of mobile phone at school (table 2), the majority of students (53%) considered that the mobile phones promote the right format for school, collaborative work (66%), motivation for the school activities (73%), quick access to content for learning (73%), be pleased about learning (60%) and the opportunity to access the necessary information at any time and anywhere (73%). This data shows the agreement of students by using mobile phones in an educational context and a positive perception of the potential of this mobile device. These results also stress that the activities that students have made using the phones were well received.

Itens	Disagreement		Indecision		Agreement	
	f	%	f	%	f	%
To appreciate school	1	7	6	40	8	53
Collaborative work	1	7	4	27	10	66
Motivation for the school activities	0	0	4	27	11	73
Quick access to the learning content	0	0	4	27	11	73
Be pleased about learning	1	7	5	33	9	60
The opportunity to access the necessary information at any time and anywhere	0	0	4	27	11	73

Table 2. Using mobile phone in school (N=15)

4.1.6 Students' attitude and perception about the use of podcasts

Data presented below refers to the second questionnaire that inquired about students' attitude towards the use of podcasts on the study of Baroque style.

4.1.6.1 Possession, location and frequency of mobile devices use

Thus, in what concerns possession, location and frequency of mobile devices use, all students have a mobile phone, 87% of students have MP3 player and 27% MP4. The street has been referred as the place where most students use their MP3 and MP4, mobile phone is used by the majority of students (80%) both at home, in the street or in school. Asked about the frequency with which they use the devices, all students reported it to be daily, in the case of mobile phones, and 56% said to use two or three times a week for MP3 players.

All students mentioned having listened to the podcasts about the Baroque Style, 53% of the students heard them through the MP3 player and 47% through the mobile phone. For 80% of the students, podcasts were heard on the street and 67% reported having done other work while listening to them. When asked if listening to the podcasts helped them to better learn the contents, 93% responded affirmatively. All students found the podcasts a useful teaching resource and would like to continue to have the curricular content in this format.

4.1.6.2 Students' attitude towards podcasts

Regarding students' attitude towards the podcasts (table 3), only 20% of students considered not needing to attend Portuguese classes with podcasts, 33% of students believed that podcasts can replace the teacher and the majority (57%) of them undecided about whether or not they preferred to listen to the teacher explaining the subjects in class or to the podcasts. This may reflect the fact that students are more used to the traditional model than with technologies, a model that gives more autonomy to students to learn. When we asked if classes are more profitable with podcasts the majority of students (53%) agreed.

When we asked them whether the podcasts have no utility, 93% of the students disagreed which shows the acceptance of this learning tool. Only 20% of students agreed that they preferred reading the contents than listening to them. This can be explained by the existence of different learning styles and because these students are the Net Generation born with the technologies and prefer sound stimuli.

Itens	Disagreement		Indecision		Agreement	
	f	%	f	%	f	%
With podcasts I do not need to attend Portuguese classes	5	33	7	47	3	20
The podcasts replace the teacher	6	40	4	27	5	33
With this podcasts classes are more profitable	1	7	6	40	8	53
The podcasts have no utility	14	93	1	7	0	0
I like to read the contents more than hear them in podcasts	6	40	6	40	3	20
I like more to hear teacher to explain the issues in class	0	0	8	57	7	43

Table 3. Students' attitude towards podcasts (N=15)

4.1.6.3 Podcasts' pedagogical value

As far as the podcasts' educational value dimension is concerned, (table 4) the majority of students (80%) believed that podcasts are a complement to the classroom, and with these podcasts students were more successful (53%), podcasts helped students prepare for the test (60%), memorize the contents (67%), stimulate students to learn (66%) and they helped students to review what they learn in class (80%). This data shows the positive perceptions that students have on the educational value of podcasts and the experience they lived during this experiment.

Itens	Disagreement		Indecision		Agreement	
	f	%	f	%	f	%
The podcasts are a supplement to the classroom	0	0	3	20	12	80
With these podcasts students get more success	1	7	6	40	8	53
The podcasts helped me to prepare for the test	0	0	6	40	9	60
The podcasts helped me to remember the contents	0	0	5	33	10	67
The podcasts encourage students to learn	1	7	4	27	10	66
The podcasts help me to review what we learned in class	0	0	3	20	12	80

Table 4. Podcasts' pedagogical value (N=15)

4.2 Second Study

4.2.1 Sample characterization

This study is being held with 18 students of grade 10 (only girls) in a Vocational School of Braga. They were 17 or 18 years old.

4.2.2 Data collection

For data collection one questionnaire was developed about the activities supported by mobile phones in the classroom as an educational tool and a complement of teaching and learning process. The questionnaire was filled in at the end of the study online in Survey Monkey.

4.2.3 Mobile phone used as a learning tool

The potentialities of mobile phones can be considered in three aspects: repository of information, productivity tool (audio, video and photo) and writing tool. We have presented to students some activities building on these three aspects.

To transform a mobile phone into a repository of information and to enrich vocabulary, we have proposed the creation of a dictionary in which each student will add the unknown words to their phones. In each class three or four difficult words and its synonyms were presented to students for writing on the mobile phone. The students could consult them whenever and wherever they wanted. We have encouraged students to use the mobile phone as a notebook to take notes, store concepts, definitions or relevant topics.

4.2.3.1 Mobile phone ownership, model and brand

Table 5 shows that all students have mobile phone and Nokia is the preferred brand (71%), going aligned with the world trends in this age.

Number of participants	Average age	Mobile phone ownership	Mobile phone model and brand
18	17,4	100%	Nokia - N73, 7610, Xpressmusic, 5000, 6111, 5200, 6630 (2), N81, N82, 2600, 6220 Sharp, Vodafone 527 Sony Ericsson Motorola BT50 Sagem Vodafone 226

Table 5. Sample mobile phone ownership, model and brand (N=18)

4.2.3.2 Students' age of getting the first mobile phone

Regarding the age at which students got the first mobile phone (table 6), we may realize that most of them (56%) said to have been between 9 and 11 years old and 44% between 12 and 13 years. A study conducted by the Personal Finance Education Group shows that the average age for the first mobile phone is 8 years of age in the UK.

Age	9	10	11	12	13
Percentage	16%	20%	22%	18%	24%

Table 6. Students' age of getting first mobile phone (N=18)

The reasons for having a mobile phone are mainly for mobile communication needs with friends (SMS), contact with family and listening to music.

4.2.3.3 SMS messaging

Table 7 presents the messages (SMS) sent weekly. We found that the most used number is 300 SMS or over messages per week (66.7%). All students said that they do not need to look at the mobile phone screen when writing SMS and they send SMS daily. This data is consistent with data previously mentioned.

Number of SMS text messages sent weekly	**Students**	**Percentage**
	f	**(%)**
0-99	0	0
100-199	2	11,1
200-299	4	22,2
300 or more	12	66,7

Table 7. Number of SMS text messages sent weekly (N=18)

4.2.3.4 Uses of mobile phones

Students use mobile phones to send and receive text messages, listen to music, take pictures, play games, write stories and to be in touch. They use mobile phones without restrictions and they use them in all possible locations, home, street, school and even in classroom if authorized.

Most students (83%) agreed with the permission of using mobile phone in the classroom. When asked to justify why the cell phone should be allowed in the classroom, the responses were equivalent to those presented in Table 10, with 61% considering it very useful to help in learning and 39% considering it favourable to distraction.

4.2.3.5 Mobile phone addiction

We asked students if the mobile phone is a worship object among youngsters and if they depend on it (table 8).

Itens	**Disagreement**		**Indecision**		**Agreement**	
	f	%	f	%	f	%
I have always my cell phone on	0	0	1	6	17	94
When cell phone rings I answer	4	22	6	33	8	45
I only answer important calls	11	61	2	11	5	28
I can not live without mobile phone	4	22	3	17	11	61

Table 8. Mobile Phone addiction

The majority of students (94%) is always connected to mobile phone, which means 24/7 (24 hours during 7 days) connectivity. The need to be in connection with their peers and family is one of the strongest motivations for student mobile phone use. Only 22% indicated not to answer whenever mobile phone rings, and 45% does. They felt unable to control their compulsion and felt distressed when they were unable to use it. For calls, only 28% said to answer important calls, 61% disagreed. Most students (61%) are unable to live without mobile phone. Walsh et al. (2007) found some mobile phone addiction between Australian youth, aged 15 to 24 years. For psychologists mobile phone addiction in teenagers may cause severe psychological disorders and represents a real problem for four in ten young adults in Spain. These are the conclusions reached by Francisca Lopez Torrecillas[3].

4.2.3.6 Mobile phone use in Portuguese lessons

When asked why they like using the phone in the Portuguese class, they made the following statements (table 9):

I like the way we have used the mobile phone in Portuguese classes because ...	
- I have a faster access to the contents - I find interesting - I learn more - Because it helps us to learn and motivates us - It make available a common dictionary - It help us - It facilitates writing a dictionary and it is very helpful to enrich my vocabulary	- Facilitates the access to information - Learn a lot better - Let me have notes in my cell phone - Is useful to have the matter on the phone - Can have easy access to the demos in the classroom - We can do different things in relation to learning - I work better with it - I like to take notes and they are quick to access.

Table 9. Students opinions about using mobile phone in Portuguese class (N=18)

These statements show that the mobile phone receptivity into classroom is positive and the actions carried with it have interest and are helpful in learning (take notes, create a dictionary, quick access to specific information, writing stories, listen podcasts, etc.).

4.2.3.7 Advantage of using mobile phone in the classroom

On the edge of mobile phone as a tool for learning, (table 10) the majority of students (61%) considered it good for learning and 56% said mobile phone helps in learning. When inquired if the mobile phone is an element of distraction, the majority (61%) disagreed, only one student mentioned it is a cause of distraction and 33% indicated some indecision about it. It could be because cell phones are neither more nor less distractive that other non-digital tools.

[3] http://prensa.ugr.es/prensa/campus/prensa.php?nota=3624

Itens	Disagreement		Indecision		Agreement	
	f	%	f	%	f	%
Using mobile phone in the classroom is good for learning	0	0	7	39	11	61
Mobile phone helps me in learning	0	0	8	44	10	56
Mobile phone is cause of distraction	11	61	6	33	1	6

Table 10. Advantage of using mobile phone in the classroom

These results provide some evidence on the relevance of using educational activities supported by mobile phone inside and outside the classroom. Ownership of mobile phones as an educational tool was not immediately accepted or recognized by some students. However, with the systematic use and awareness of its usefulness students will recognize it as a tool for learning.
School needs to take advantage of the mobile devices students have and make the best educational use of it.

5. Conclusion

Starting from the idea that education will change because computers can help teachers to teach better through the use of appropriate software (Bennett, 2001), it's urgent to continue to investigate the implications of mobile technologies in learning as a new model. The mobile technologies are tools, increasingly powerful and can help teachers create mixed educational opportunities (blended learning), extending the space of classroom, giving students more options about time and place to learn, helping to develop other kinds of methods and resources of information accessibility.
The mobile phone is popular among young people. All of our students own a mobile phone. This allows us to have the minimum conditions necessary for the completion of the experiments reported. The already widespread possession of mobile phone by students and brand preference for Nokia, show us the penetration of these devices and brand among young people. Despite the fact that students are still in the beginning of the use of mobile phones in educational contexts the data presented already shows positive perception about its utility and its value as a tool to support learning process. We highlight the fact that students use easily all services available in their mobile phone, especially the newer (Internet, MSN, GPS, e-mail).
The term "thumb generation" requires new thinking in educational settings and they are open to interaction, collaboration and learning in innovative ways. With our project, we explore the potential of mobile technologies, the skills of students, and create a learning environment capable of promoting the development of skills necessary for the demands of the working world of the twenty-first century. School needs urgently to prepare students for work in an increasingly competitive society and mobile technologies can help.
We intend to continue to investigate the potential of mobile technologies by conducting experiments to help understand some significant aspects of its application in educational contexts and to develop content for mobile phones with appropriate copyright software.

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Designing Collaborative Authoring Tools for Mobile Learning

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1. Introduction

According to the constructionist pedagogical paradigm, learners should play an active role in their learning process as they build their own knowledge. Learning can be viewed as a state change that results from past experiences and from interaction with others. It is strongly based on the "learning by making" idea, so learners should continuously create things to express their vision. Collaboration is also pointed as a key component of this learning process, one can learn from the interaction with teachers or with peers.

Collaboration is not only important for Education, it improves people's productivity. Many applications focused on collaborative working have appeared in the past few years. This phenomenon is very common in Web 2.0. People can use web-based applications to collaboratively write documents, manage projects, share files, and so on. Some of these applications allow people to work simultaneously on distinct computers. This kind of empowerment of collaborative working can be only achieved with technology mediated situations.

Moreover, mobile technologies such as laptops, PDA and mobile phones enable teachers and learners to create different learning settings, which are not restricted neither to classrooms nor to desks. The physical mobility provided by these devices created a new study area called Mobile Learning. It focuses on learning across spaces, learning across contexts and learning with mobile devices, in learners' point of view. Mobile technologies can enrich how learners collaborate by providing devices capable of moving with learners, making technology available anywhere and any time.

Most of the collaborative applications require an Internet connection. Those applications use client-server architectures as they are web-based. New communication standards such as the Mesh networks allow distributed architectures when building collaborative software. This architecture enables us to tackle the problem of collaboration without Internet connection.

In this chapter we analyze design differences between authoring tools for regular computers (desktop) and for mobile platforms. We also discuss some advantages and drawbacks of Mobile Learning platforms and how they can enhance collaborative working. We focus on the synergy provided by a mobile platform and a non centralized network architecture. The Sugar graphical interface – designed for the OLPC initiative – is taken as an example of a collaborative software set with distributed network architecture.

2. Background

From the Pedagogical perspective, authoring is the process to make students use media to produce content. In technology-enhanced environments, digital authoring tools are means to allow learners to express their ideas. Naismith and colleagues (2004) have classified learning activities into six categories: Behaviourist, Constructivist, Situated, Collaborative, Informal and lifelong, Learning and teaching support. They did not considered this taxonomy mutually exclusive; categories are briefly described bellow.

- *Behaviourist paradigm*: learning is a result of a stimulus-response process, it is shaped through positive reinforcement or negative reinforcement in responses. When authors apply the taxonomy to educational technology, problem presentation is considered the stimulus and learner's solution is the response in computer-aided situations. Theorists: Ivan Pavlov, Burrhus Skinner.
- *Constructivist paradigm*: this approach states that learning is an active process. People are viewed as information constructors as both current and past knowledge are used to construct new concepts. Thus past experiences are important to the understanding of new situations. In a constructivist learning environment, students should be stimulated to discover new concepts. Authors consider participatory simulations a very good implementation example of technology-enhanced environments based on the constructivist theory. Theorists: Jean Piaget, Jerome Bruner, Seymour Papert.
- *Situated paradigm*: learning is viewed as a part of social interaction processes; this theory requires learners in authentic contexts and culture (can be unintentional instead of deliberate) and their participation in a community of practice (a group dedicated to do something and learning how to improve their practice through interaction). Instructors working with this paradigm should provide situations where learners can get in touch with real problems even before they have a complete understanding of it. Authors consider mobile technologies can enhance context because they can be present in different situations. Theorists: Jean Lave, John Seely Brown.
- *Collaborative paradigm*: learning is also emphasized as a part of a social participation process; interaction is a key component of this learning paradigm. Learning is a reciprocal experience that can be described as conversations between learning agents (students, teachers, technology devices), learners could converse with another agent to share an understanding. This paradigm includes CSCL (Computer-support Collaborative Learning); technology has to support these interactions and enhance communication possibilities. Theorists: Lev Vygotsky, Andrew Gordon Speedie Pask.
- *Informal and lifelong paradigm*: learning is considered not to be confined to the classroom, it takes place throughout life. This learning is often informal, specially for adults. Technology should support people to learn anytime and anywhere, assisting them in intentional and unintentional learning episodes. Theorist: Michael Eraut.
- *Learning and teaching support*: these are activities related to administration, classroom management and reviewing and assessment. Authors argue that technologies are not restricted to support learning activities.

From these paradigms, we detach the constructivist, the situated, the collaborative and the informal and lifelong ones. They share some principles such as learner-centric approach and importance of interaction between learners. A learner-centric approach suggests technologies should be *personal*, and supporting interaction between learners requires *network capabilities* from these technologies.

Sharples (2000) analyzed the requirements for lifelong learning technologies. Their design should consider new variables:

- *portability*: available wherever a learner needs;
- *individual use*: able to support personal learning and adaptable to personal abilities and needs;
- *unobtrusiveness*: technology should not obtrude on the situation;
- *availability*: provide communication with learners and teachers;
- *adaptability*: technology should be context sensitive and evolute according to learner's knowledge;
- *persistence*: learner's productions should be available despite of changes in technology;
- *usefulness*: suited to everyday needs for communication, reference, work and learning;
- *intuitiveness*: easy to use even if one has no previous experience.

In the next sections, we will analyze how authoring and collaboration are related to these requirements and educational paradigms.

3. Authoring, Collaboration and Digital Tools

Authoring is a key component of Constructivist activities. Papert argues that part of the learning process is about collecting information, by reading books, listening to teachers or visiting websites. Another part of learning “is about doing things, making things, constructing things” (Papert 1999); if doing so, students are constructing their knowledge. In school context, instructors should stimulate students to discover principles.

This attitude change transforms learners from information recipients to “active constructors of knowledge” if provided with the appropriated tools (Naismith et al. 2004). Papert uses the word Constructionism to refer to this idea of “learning by making” when learners play an active role in the learning process (Papert 1999). This is a rationale for producing relevant digital authoring tools.

The ability to create things using computers is a important issue for the future society. Resnick (2002) considers computers are the most powerful creation tool invented. Nowadays, people have daily contact with digital technologies in office environments and also in everyday activities. Computers decreasing costs are making they available to a wider public, reducing the digital divide in terms of access to technology.

But access itself does not warranty the digital fluency needed to face some of the future challenges. Education through lifetime and continuous self improvement are considered fundamentals to improve oneself in a knowledge-based society (Magalhães et al. 2009). Digital fluency is not about using the computer, but knowing how to express oneself using it (Resnick 2002).

The Computer Clubhouse project aimed to address the problem of digital fluency for young people. While frequenting those clubhouses, people are encouraged to create things such as games, simulations, music or websites using computers. This project stimulates authoring to make youth more confidence as learners; Resnick (2002; 2003) provide a more detailed description of the project and its strategies.

Collaborative learning takes place when a learner converses with another learning agent to exchange learning experiences. Sharples (2002) argues successful learning is a constructive process, where conversation takes a central place. Conversation is the communication between knowledge systems (students, teachers or technologies) about what one knows. In this point of view, the importance of collaboration in the learning process is to question and to be questioned about one's concepts and interpretations. Collaboration can be defined as the “co-construction of knowledge and mutual engagement” of peers, configuring a “special form of interaction” (Lipponen 2002).

Dillenbourg (1999) sees similarities between individual and group cognitive systems. He does not considers people “learn from collaboration”. A single person does not learn simply for being an individual; and similarly, peers in a group cognitive system do not learn from the simple fact they are more than one person. Dillenbourg points the activities performed by learners (such as reading) are actually responsible for triggering “learning mechanisms” (like induction and deduction). When in a group, peers still perform some of the activities they performed individually, also triggering the learning mechanisms. But the interaction with others brings new activities (like explanation and discussion) and activates new learning mechanisms (such as knowledge elicitation, internalization and appropriation).

Computer-supported collaborative learning (CSCL) studies how “technology can enhance peer interaction and work in groups, and how collaboration and technology facilitate sharing and distributing of knowledge and expertise among community members” (Lipponen 2002). CSCL is a collaborative situation and it triggers these learning mechanisms since it can be viewed as a contract between the peers, or between peers and the teacher (Dillenbourg 1999). Dillenbourg also highlights that we expect a particular interaction to occur among people in collective situations, but there is no warranty they really will nor the corresponding learning mechanisms will be triggered.

4. Mobile Learning

Mobile technologies enable teachers and learners to create different learning settings, which are not restricted formal learning environments. From learners' point of view, learning can be classified as mobile in three ways (Vavoula & Sharples 2002):

- across contexts: one could learn from a work demand or from leisure;
- across spaces: learning could place at home, at working offices or at theme parks;
- across time: learning could happen at different periods of the day, does not matter if it is a weekend, working day or holiday.

Mobile learning also focuses on learning using mobile technologies; making technologies available anytime and anywhere can improve learning situations. Authoring and collaboration are compatible with Mobile Learning practices (Naismith et al. 2004). By considering physical mobilities of learners we can enrich ways learning activities are performed. Learning experiences can be enhanced by allowing study in places where it would not be possible before (Bull et al. 2005).

A classification of technologies using two axis (personal-shared, portable-static) was provided by Naismith and colleagues (2004, p.7); this classification is shown at figure 1.

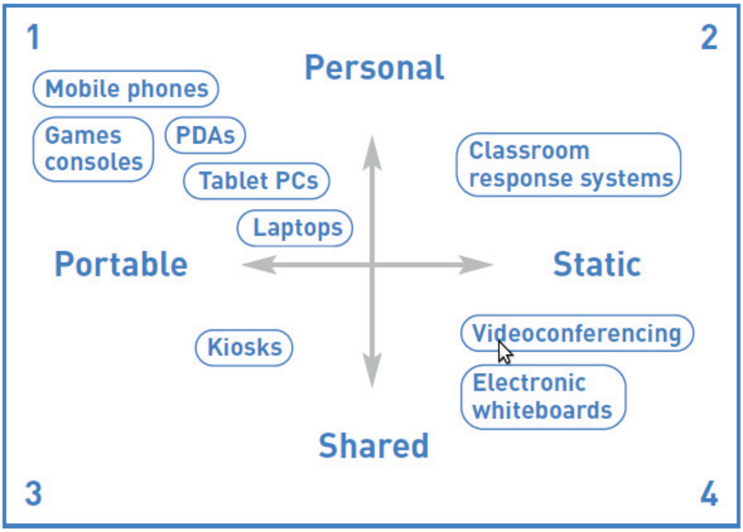


Fig. 1. Classification of mobile technologies (Naismith et al. 2004).

This classification helps us to identify how platform mobility, learner mobility and device sharing affect learning experiences. The 1st quadrant shows personal and portable devices, such as mobile phones, laptops and hand-held video games; these are the mostly common devices associated with the term “mobile technologies”. The exemplified devices are usually networked, allowing communication among other devices and information sharing. Although these portable devices are strongly personal, their information can follow a more shared fashion (Naismith et al. 2004).

Quadrant 2 shows personal static technologies, such as classroom response systems (students can answer multiple choice questions using these devices). Interaction still personal as it is destined to a single user , but technology could not be carried out classroom, so it is static.

Third quadrant represents technologies that provide learning experiences to moving learners using non-movable devices, as “being physically moved from one place to another is not the only way in which mobile technologies can be portable” (Naismith et al. 2004, p.8). Interactive museum displays are an example of those; they provide access to information to a changing audience. Thus the portability refers to the learners not to the technology. Still, these devices are typically used by more than one person at time, which classify them as shared.

The fourth quadrant shows devices with more sharing characteristics for their larger sizes.

An example would be a video-conference facility, that can be used by many people at the same time and cannot be moved around. Naismith and colleagues (2004) consider mobile technologies as those included in quadrants 1 to 3 and those from quadrant 4 that are not extremely static.

Sharples and colleagues (2002, p.233) consider mobile learning resources “should, ideally, fit seamlessly into this complex pattern of learning opportunities and resources”. There are some key issues for technology developers and educators on planning successful mobile learning environments (Naismith et al. 2004):

- Context: gathering and utilizing contextual information may clash with the learner’s wish for anonymity and privacy.
- Mobility: the ability to link to activities in the outside world also provides students with the capability to ‘escape’ the classroom and engage in activities that do not correspond with either the teacher’s agenda or the curriculum.
- Learning over time: effective tools are needed for the recording, organization and retrieval of (mobile) learning experiences.
- Informality: students may abandon their use of certain technologies if they perceive their social networks to be under attack.
- Ownership: students want to own and control their personal technology, but this presents a challenge when they bring it in to the classroom.

Context is one the most important issues, as mobile learning is intrinsically more driven by context than classroom (Sharples et al. 2002). Moreover, mobile technologies are primarily computers but the characteristics outlined above suggests they support different activities that desktop (typically shared and static) computers currently do. Mobility of learners and devices encourages new practices, also supporting new interactions between learners and the environment (Naismith et al. 2004). These mobile technologies can also lever learners' to connect different contexts, helping to “form bridges between formal and informal learning” (Kukulska-Hulme et al. 2009).

There are many Mobile Learning initiatives around the world. The MOBILearn was a 33 months-long project to propose and evaluate an architecture for mobile learning. The ENLACE project designed and implemented a technical infrastructure to support collaborative learning activities inside and outside school. The *Mystery at the Museum* project used mobile devices to improve students engagement in museum activities using a game-based approach. Kukulska-Hulme (2009) and colleagues provide more details in those initiatives. The next section will present the OLPC project in a mobile learning perspective.

5. OLPC and Mobile Learning

The One Laptop per Child project (OLPC) aims to create a laptop inexpensive enough to be sold to children around the world. This would allow the creation of opportunities for “world's poorest children by providing each child with a rugged, low-cost, low-power, connected laptop with content and software designed for collaborative, joyful, self-empowered learning” (OLPC 2009b). As an Education project, this is clearly a Mobile Learning initiative.

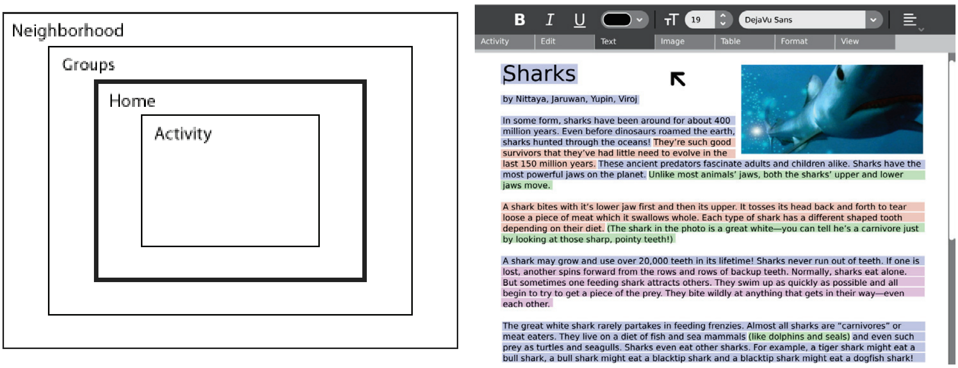
The OLPC project began in the late of 2005 and has levered the development of the today's Netbooks (Bajarin 2008). The OLPC initiative is probably the first large-scale effort to design this new class of laptop focused on low-cost and low-power consumption. Another highlight of this initiative is to be completely based on open source solutions; the openness is such that even the user is able to see the source-code.

The OLPC laptop is called XO and the graphical interface was named Sugar. The hardware was designed to be inexpensive and reliable even under adverse environments conditions. The Sugar environment is based on the Constructionist theory, so Sugar the software set is mainly composed of collaborative authoring tools (Martinazzo et al. 2008; Sugar Labs 2009). The applications are called “activities” in the Sugar interface; they use verbs instead of nouns such as “Write” for the text editor, “Paint” for the drawing application and “Record” when referring to the activity that accesses camera and microphone.

The XO hardware provided some innovations such as Mesh Network (IEEE 802.11s) compliance, low consumption and a sun-light enabled display. As pointed by Syvänen and colleagues (2005), the uncontrolled places learning can happen affects availability an quality of online services and tools. This can be a constraint for network sharing and computer-mediated collaboration, although it could encourage learners to establish their own learning places.

XO's hardware specification combined with Sugar's interface guidelines has forced application developers to rethink some design decision such as architecture and interface. Sugar activities are free software; some of them were built from scratch but most of them are actually desktop applications re-designed to fit Sugar's requirements. This is mainly due to the collaboration supporting and adaption to the Journal system. This Journal system is an innovation proposed in the OLPC project that allow learners to access the files created without referring to the file system directly. Instead of that, one does not handle with files, but with objects and people. The Journal records every interaction with the laptop keeping a history of the things the child has done and the activities he or she has participated (Martinazzo et al. 2008; OLPC 2009a).

Sugar also uses a new metaphor to organize the graphical interface and display information. The Desktop metaphor is not appropriated for learning environments (Sharples et al. 2002) and other metaphors and system images must then be created to make interaction more recognizable. Sugar is based on the Zoom metaphor, which reflects the collaboration idea (Martinazzo et al. 2008).



(a) (b)

Fig. 2. (a) Sugar's Zoom metaphor; (b) the Write activity.

Figure 2 shows the Zoom metaphor proposed in Sugar and one of its activities. The zoom has four levels named Neighborhood, Groups, Home and Activity, from the broader level to the closest one.
The Neighborhood shows other XO connected to the network, and what activities they are participating. Groups view represents learner's friends, classmates and other groups he/she belongs to.
Home level allow activity switching, check network connectivity and laptop status, for example. This is the view that most resembles a Desktop environment. Activity is the latest level and it display the current performed activity. Not displaying any other activity was a design decision that allows viewing a single activity in full screen mode.
This rupture in graphical interfaces is also observed in some GNU/Linux operating systems for Netbooks. Network-oriented operating systems like Moblin[1] and Android[2] will soon be available at the netbook market.
The Sugar architecture provide a framework creating collaborative authoring software based on DBUS[3] and Telepathy[4]. This combination (also called D-Tubes) provides a Remote Procedure Call (RPC) and an event-oriented framework through the Mesh network. DBUS itself takes care of process communication and Telepathy handles friends identities and message passing through firewalls. The Telepathy features are responsible for the Neighborhood an Groups view in Sugar's Zoom metaphor. D-Tubes facilitates the integration with XO's activities and other GNU/Linux applications, since D-Tubes are available to many platforms. The Sugar framework allow the creation of decentralized collaborative software, ie, the client-server model is not necessary.

6. Design Considerations

We consider personal and networked technologies are able to support constructivist, informal and lifelong, collaborative and situated learning activities. Mobile technologies are also very well suited for context-aware applications.
A system composed of interconnected mobile devices can be modeled as an distributed memory system. In a distributed memory system, each processor can only directly access its physically associated memory (Chandra et al. 2001, p.8). To access information stored in other nodes (processors), devices must explicitly pass messages through the connecting network. The developer is responsible for managing data exchange between nodes. As commented before, the D-Tubes framework aims to provide an easier programming model using events and a distributed architecture.
Comparatively, desktop computers have more computational power and usually improved graphics; these allow more complex and CPU-intensive applications in such platform. That kind of computer also is likely to be used as a shared resource and does not provide physical mobility itself. So when designing an authoring tool for a environment with desktop computers, it is important to analyze whether there will be people on the move or settings will be in a static fashion. The later case allow us to explore mobility across time (considering a static technology with people on the move). This can help designers to develop task models.
Mobile devices usually have simpler input systems due to their small sizes, although they are not exclusive of mobile devices. Examples of these input systems are numerical keyboards, touch screens, accelerometers and voice commands. Certainly a authoring tool

for a mobile device would not have as many features as one to desktop computers could, but the mobile software can take advantage of being present in different contexts (considering learner's mobility).

The input system is a very important difference between authoring tools designed for desktop and mobile computers. Whilst desktops provide more complex inputs (such as long texts using keyboards and peripherals, like joystick, mouse and cameras) and consequently allow richer productions, mobile devices have the advantage of portability: learners can carry them out and use in everyday situations. Even though the productions made with mobile devices are simpler, they keen characteristic is to be context-aware, this is important for linking formal and informal learning situations, as highlighted by Kukulska-Hulme and colleagues (2009).

The OLPC innovations brings the Journal as a unique feature to manage one's productions. Not dealing with files and folders can be a great advantage for young kids, since it was designed to resemble human memory (OLPC 2009a). The whole OLPC project is based on the one-to-one hypothesis; in other words, the XO is a personal device. The network capability makes these devices more powerful, since learners can experience collaboration even without an Internet connection.

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1 For more information, see http://moblin.org/.
2 For more information, see http://www.android.com/.
3 For more information, see http://dbus.freedesktop.org/.
4 For more information, see http://telepathy.freedesktop.org/.

Development of InfoStation-based and Context-aware mLearning System Architectures

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1. Abstract

This chapter[1] considers the main aspects in the development of InfoStation-based and context-aware multi-agent system architectures, which facilitate the provision of intelligent mobile eLearning (mLearning) services across a University Campus area.
Generic models and approaches for the development of eLearning systems are considered, paying particular attention to the various aspects which will have a greater bearing on the adaptation and personalization of the eLearning content for the specific end user. The supporting network architecture is described both horizontally and vertically illustrating how each of the main system components collaborates in order to facilitate the delivery of mLearning services. The chosen multi-agent approach for the system implementation is justified. The approach uses some fundamental OMG-MDA ideas with additional elements, which take into account the specifics of the InfoStation network. The software architecture required to provide the needed hardware flexibility and adaptability according to the requirements of modern eLearning systems is discussed. The system architecture is being developed on three levels: scenarios level, agent-oriented middleware, and eLearning services level. The four main generic service scenarios are presented highlighting the requirements for effective distribution of service control and session management between the agents. Suitable agent-oriented system models are proposed and explained, and the interactions between agents and mLearning services in each of these models are presented. Approaches for system implementation and structuring are also considered.
Particular attention is paid to the creation of user profiles and service profiles aiding the delivery of more personalised and context-aware mLearning services and their implementation through the Composite Capabilities/ Preference Profile (CC/PP) and User-Agent Profile (UAProf). The utilization of J2ME as the architecture for the development, deployment and execution of the mLearning services is outlined. The implementation of the system by means of the Java Agent DEvelopment (JADE) framework making particular use of its Light Extensible Agent Platform (LEAP) module is also discussed in detail.

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2. Introduction

The InfoStations paradigm is a new infrastructural system concept proposed to provide "many-time, many-where"(Frenkiel and Imielinski 1996) wireless data services. In this chapter we propose an InfoStation-based system architecture operating across a University Campus area allowing registered users to access a range of eLearning services by means of mobile devices (cellular phones, laptops, personal digital assistants– PDA's). The InfoStations can essentially be thought of as portals through which the mobile devices communicate with specific eLearning services. This infrastructural system architecture provides an ideal opportunity to enhance the mobile eLearning (mLearning) experience and could be used as a platform for other supplementary communications services supporting the mLearning process. In addition it satisfies the requirements for highly adaptable eLearning architecture (Cook, Harrison et al. 2003) by providing:

- Improved ability to adapt rapidly and transparently to changes in learners' profiles and their eLearning progress;
- Better mechanisms for discovering and comparing relevant learning resources;
- An ability to specify the requirements of an instructional component and delegate the discovery of a resource satisfying it to another process (e.g. a software agent);
- Easy interoperation with both external resources and other learning management systems (LMS).

The proposed system architecture has the following distinguishing features:

- New architecture type (service-oriented), allowing more flexibility during the run-time (by the use of Semantic Web and Semantic Grid);
- Open architecture allowing multiple reuse of eLearning content, e.g. by means of the ADL SCORM standard etc;
- Multi-communication access to learning resources by means of mobile devices;
- Agent-oriented approach;
- Knowledge technologies;
- Application integration;
- Dynamic profiling.

The objective of this chapter is to introduce the architecture of the InfoStation-based eLearning system, illustrating its flexibility and intelligence, all of which are enhanced through the utilization of intelligent agents, which communicate with the systems functional modules.

The organization of the chapter is as follows. In section 3 we consider generic models and approaches for development of eLearning systems. In section 4 we present the InfoStation-based network architecture and its functional entities. Section 5 describes the proposed multi-agent system structure and considers two possible agent-oriented system models. Sample mLearning services used in our system are considered in Section 6. Section 7 is dedicated to the implementation issues. Finally section 8 concludes the chapter.

3. E-Learning Systems: Models and Approaches for Development

While it is important to ensure that an eLearning system operates and functions efficiently from a technological point of view, we must also be sure to consider the system from a purely educational standpoint. In the past, the primary role of this type of technology in education was to facilitate remote learners with the capabilities to learn as though they were campus-based. In this case, the enhancement was more pragmatic than pedagogic, enabling a greater access to learning rather then a greater understanding of a particular concept. However, in recent years the view of what constitutes eLearning and where its value lies has most certainly shifted. ELearning has become a cheaper, easier and far more accessible alternative to the traditional face-to-face learning paradigm. Of course while providing a viable alternative, it has also become and invaluable aid to accompany the traditional teaching approach and as such create a more blended learning environment (Ganchev, Stojanov et al. 2006). Essentially we must think of an eLearning system as the utilization of technology to achieve greater learning outcomes as well as a cost-efficient method for the delivery of the learning environment to the learners.

Biggs (Biggs 1999) describes the task of good pedagogical design as one of ensuring that there are absolutely no inconsistencies between the curriculum we teach, the teaching methods we use, the learning environment we choose, and the assessment procedures we adopt. Therefore in the design of this system, we must first carefully specify the learning outcomes we wish to achieve, and as such design various teaching activities which will enable the students to achieve these desired outcomes. Indeed the assessment tasks need to be designed so as to genuinely test whether or not a particular learning outcome has been achieved. Essentially, while the technology available to us continues to develop at an astounding rate, we must never lose sight of the educational aspects. Indeed by concentrating on using newer technologies to their greatest potential, we run the risk of drawing a student's attention away from the learning content and the educational goals we wish to achieve.

3.1 Conceptual Model

In general each eLearning system consists of five components (Figure 1) the main two of which are:

- *eContent generator* – used by educators and instructors to create an electronic content (eContent) needed for the learning process;
- *eContent interpreter* – used by learners for the interpretation of the created eContent.

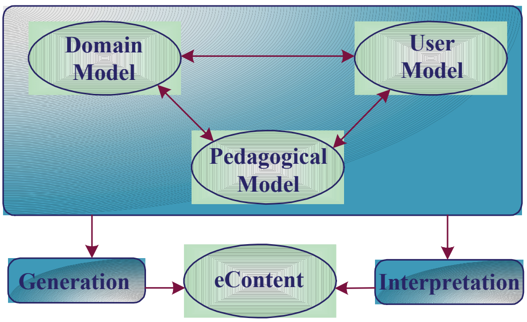

Fig. 1. The Conceptual Model of an eLearning System

The creation and interpretation of the eContent depends on some important circumstances and limitations, which could be generalized in the following three (sub) models:

- *Domain model* – represents the knowledge of a particular learning area/field; usually contains basic (atomic) concepts and different semantic links between them;
- *Pedagogical model* - contains information about possible didactical solutions used by the learning management system (LMS), e.g. to explain how to study a particular eLearning material/content. The possibility for presentation and control of learning tasks plays an important role in this model;
- *User model* – usually stores specific information for individual users, which could be used for personalization of their eLearning process. Depending on the chosen approach this information could represent the preliminary degree of learners' preparation, preferences, affinity to a particular course/module, type of mobile devices in use, ID data etc. The following main approaches could be used for the implementation of this model:
  - Stereotypes – the simplest way of modeling by user categorization in groups (categories). For each group the system supports corresponding description called *stereotype*. Each user is categorized/assigned to one or more stereotypes (e.g. beginner, middle level, advanced, expert). Each stereotype has predefined properties inherited by corresponding users;
  - Overlays – the user knowledge is considered as a subset of the expert knowledge. This way it is possible to use the same presentation for the domain model and the user model;
  - Mixed – a combination of the previous two approaches.

In order to meet the eLearning requirements, these models must be explicitly present with relevant possibilities for support and control at the architectural level. An essential problem here is the explicit presentation, processing and control of their intrinsic semantics.

3.2 Approaches for Development

ELearning systems could be developed by employing:

- *Standardized architectures* – multi-usable, independent of the application area, these architectures can easily adapt to control different types of business functionality. Their main disadvantage is the low efficiency during the run-time;
- *Specialized architectures* – developed for concrete applications these architectures provide better run-time efficiency for a particular functionality but with low adaptability and portability;
- *Hybrid architectures* – a hybrid between the first two types; an adaptation (my means of reengineering, additional modules etc.) of a specialized architecture for the purposes of a particular domain.

Our approach for the development of the proposed eLearning system architecture could be categorized as a *hybrid* one. A standardized (service-oriented) architecture expanded with some adaptable components for the three models (domain-, pedagogical-, user-) is used for the eContent generation, whereas the *domain-based approach* is used as more suitable for the eContent interpretation. Special attention is paid to the architectural solutions for InfoStation-based mobile access to the system due to its inherent features such as "many-time, many-where" eLearning. Besides this the chosen approach offers enough adaptability and flexibility to the architecture, which could be controlled as:

- *Adaptable process* – with possibility for parameter control during the process of eContent generation;
- *Adaptive process* – with dynamic parameter control during the system run-time.

4. InfoStation-Based Network Architecture

The proposed InfoStation-based network architecture provides mobile access to eLearning services, for users equipped with wireless devices, via a set of InfoStations deployed in key points around a University Campus. The InfoStation paradigm can be considered as an extended wireless Internet, (Adaçal and Bener 2006), where the mobile clients interact directly with the Web service providers (i.e. InfoStations). This architecture is built upon a number of wireless communication standards [IEEE 802.11 WLAN (WiFi), IEEE 802.15 WPAN (Bluetooth), and IEEE802.16 WMAN (WiMAX)] utilized to deliver these services to the mobile devices of registered users. A three-tier network architecture is proposed with the following basic building entities (Figures 2 and 3): user mobile devices, InfoStations, and an InfoStation Center. The users request eLearning services (via their mobile devices) from the nearest InfoStation via available Bluetooth, WiFi, or WiMAX connection. The InfoStation-based system is organized in such a way that if the InfoStation cannot fully satisfy the user request, the request is forwarded to the InfoStation Center, which decides on the most appropriate, quickest and cheapest way of delivering this eLearning service to each user according to his/her current individual location and mobile device's capabilities (specified in the user profile).

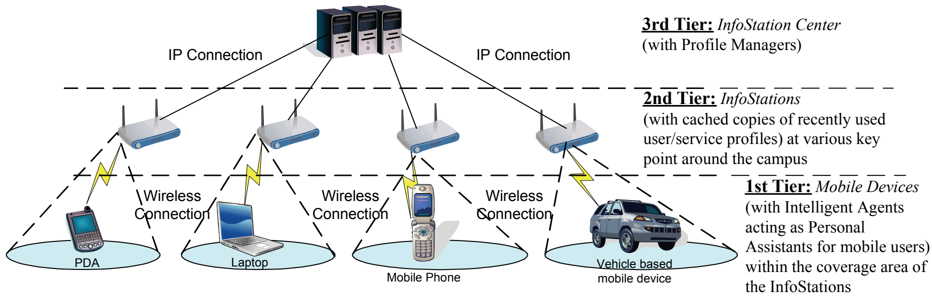

Fig. 2. The 3-tier InfoStation-based network architecture *(vertical plan)*

The First Tier of the network architecture encompasses mobile devices (cellular phones, laptops and PDAs), equipped with intelligent agents that act as personal assistants for the users. The intelligent mobile agents onboard these mobile devices can function autonomously to accomplish tasks without human interaction.

The Second Tier consists of InfoStations, deployed around a University Campus, and facilitating the mobile users' access to the eLearning services through high-speed, geographically intermittent connections. In order to provide sufficient access for a great range of mobile devices, the InfoStations are equipped to support multiple communications protocols (as illustrated in Figure 3). The InfoStations can be envisaged as mobile web service agents, which act for mobile clients like gateways to services. As web service agents they receive input parameters required to execute a service, and in return could provide the desired service. In doing this, the agents take into account the individual users' preferences and context information as specified in their profile.

The Third Tier is the InfoStation Center itself. Its main functions are to: control the InfoStations, update and synchronize information across the system, manage different types of profiles. The profiles contain information pertaining to a specific user or service in a way facilitating the delivery of these services in a more personalized and context-aware manner to a wide variety of devices:

- *User profiles* allow educators to monitor the progress of learners through the material, direct their learning process (ensuring the correct material will be covered), keep track of learners' test scores, and monitor their possible problem areas. The user profiles also contain information about the users location and the device they are currently using (this allows for more efficient and faster delivery of eLearning services), and information regarding the users' personal preferences (e.g. the format in which the user wishes to receive information). The preferences could also specify acceptable cost (if any) of each service, i.e. the user may wish to receive information in the cheapest way possible (Stojanov, Ganchev et al. 2003) (Ganchev, Stojanov et al. 2005) (Ganchev, Stojanov et al. 2004).
- *Service profiles* allow for easier discovery of services by the users. They also ensure that the users will not end up receiving a service not requested by them.
- *User service profiles* maintain the service status of each particular service when used by a particular user.

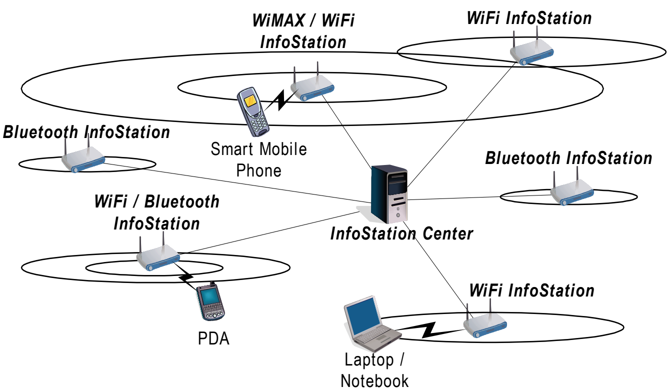

Fig. 3. The InfoStation-based network architecture *(horizontal plan)*

Before being distributed to the relevant InfoStations the services and their content are created/deployed in the *InfoStation Center*. It is here that the operations and maintenance of these services take place. In the case where an update of a service or a service profile is required, it is here within the InfoStation Center that this initially occurs. This update is then forwarded onto the InfoStations within the campus. The InfoStation Center also houses a repository of all profiles relating to both users and services alike. This repository maintains up-to-date copies of all profiles. Any changes made by individual users to their own user profiles are forwarded on from the user mobile device, through the InfoStation to the InfoStation Center, and the repository is updated. There are some common support functions that each service requires when initially created, for example device management,

profile management, service catalogue etc, as illustrated in Figure 4. These common functions not only act as service facilitators, but also enrich the service provision. The InfoStation Center also houses the Business Support Domain, (Andersson, Ljung et al. 2006), with a number of components relating to the billing of users, User Relationship Management (URM), and Resource Planning (RP). The URM entails all aspects of the interactions that eLearning system has with its users, whereas the RP is a management system, which integrates all facets of the business side of the service provision.
The *InfoStations* are deployed throughout the University Campus area and provide wireless access to eLearning services. When a user mobile device comes within the range of an InfoStation, both mutually discover each other. Then the InfoStation authenticates, authorizes and accounts (AAA) the user. To do this the InfoStation must maintain up-to-date copies of all user profiles, as well as a catalogue of all services. Once the users profile is analyzed, the InfoStations discerns which services from the service catalogue are applicable to that specific user, taking into account the user preference and mobile device capabilities. The InfoStation then forwards an updated list of the relevant services to the intelligent agent working as a personal assistant on the user mobile device. When this assistant forwards the user request for a particular service to the InfoStation, the InfoStation instantiates the service, allowing the user an access to it. If the InfoStation is unable to facilitate the user service request, it forwards this request to the InfoStation Center to deal with this. Figure 4 visualizes in more detail the 3-tier architecture of the system by utilizing some of the components proposed in (Andersson, Freeman et al. 2006).

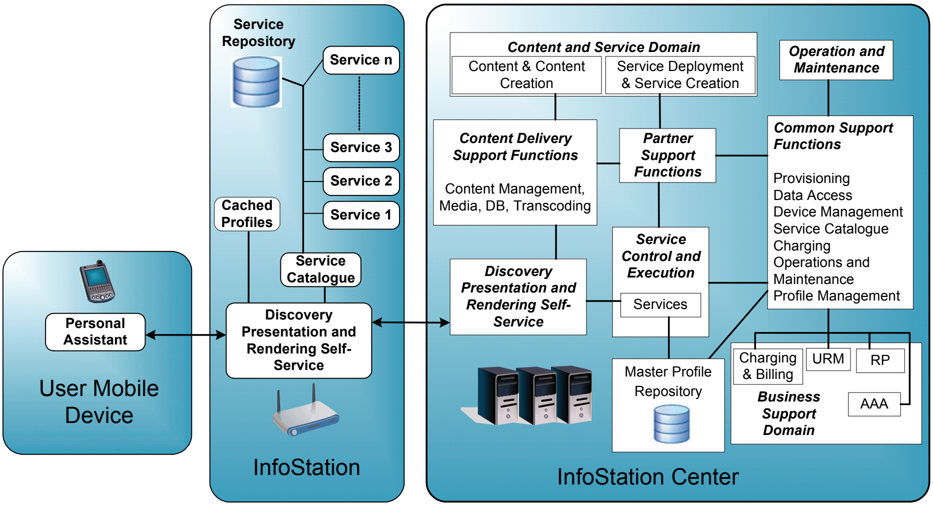

Fig. 4. The InfoStation-based network architecture

Within the mobile user domain (i.e. the user mobile device), the personal assistant (agent) allows the user to utilize the service, by migrating the service to the users device. This is down to the agent-oriented approach to the implementation of the system, which is discussed in the next section. With the service migrated onto the users mobile device, the user may utilize the service even when out of range of the InfoStation. The personal assistant may make a service request while within the range of an InfoStation, and then pass out of its coverage area. The personal assistant however will continue to work autonomously, adopting the functionality of the service until the user has completed his/her task (e.g. an eTest). Once the mobile device comes within range of another InfoStation, the service instance is updated and synchronized to reflect any eLearning work completed by the user while out of range.

5. Multi-Agent System Structure

In the previous section we described the generic (conceptual) InfoStation-based network architecture and presented its common functionality for the provision of eLearning services within a University Campus. In this section we discuss the software architecture required to provide the needed hardware flexibility and adaptability according to the requirements of modern eLearning systems. The software architecture could be considered as a singular mapping of the *conceptual model* (section 3.1) over the InfoStation network architecture. Subsequently the software could be written as a system of cooperating *agents* and electronic services (*eServices*) – a solution justified in this section. As a starting point for a step-by-step definition and specification of the software architecture we first consider the possible scenarios in the InfoStation infrastructure.

5.1 Scenarios

Due to the inherent mobility afforded by the InfoStation, it is quite possible that not only will the users move from one geographically intermittent InfoStation cell to another (*device mobility*), but also from one mobile device to another (*user mobility*). The main problem here is the distribution of the session control across the three tiers of the InfoStation architecture (by taking into account the possibility of changing mobile devices and InfoStations during the session execution). The following main scenarios are possible:

- *No change* – the simplest scenario in which the user mobile device and the serving InfoStation are not changed during the eLearning service session (i.e. the user is relatively stationary);
- *Change of InfoStation* – the serving InfoStation is changed during the eLearning service session (i.e. the user is on the move), but the user mobile device remains the same;
- *Change of user mobile device* – the user mobile device is changed during the eLearning service session, but the serving InfoStation remains the same (e.g. the user service session is switched from a mobile phone to a laptop; the user may move around but remains within the range of the same InfoStation);
- *Change of InfoStation and user mobile device* – the most complicated scenario where both the user mobile device and the serving InfoStation are changed during the user service session.

In general the user service session may start with one set of devices, may continue with another, and may finish with a third set of devices, for example a user driving to work may begin a session using an onboard computer or mobile device, then whilst on foot s/he may continue the session on her/his mobile device, and finally once the user arrives at the office, s/he may choose to complete the session using a desktop PC. The possibility of such scenario sets a requirement for an effective distribution of session control across the agents.

5.2 Control & Management

Proper solutions for service control and user management are of high importance for any eLearning system architecture. As stated earlier, specialized components for explicit control within and between the three models (domain-, user-, pedagogical-) need to be envisaged. The *user model* and the *pedagogical model* are directly related to user management and could be used also for parameterization of eLearning services. The *domain model* is used primary by the eContent services and could be used also for user management in the *hybrid architecture* approach. These problems are treated in detail in this section.

5.3 Service control

Means for proper service control are needed in every software architecture. In our proposed architecture the concept of service control is developed around a service classification model presented in Figure 5. This model serves the development of the system managing the service invocation, which is part of the system run-time module. The service model is open for extensions including new values of already specified dimensions or entirely new dimensions. In order to separate the architecture from the offered services, the service classification model is developed as independent from the infrastructure. The model consists of two main components: service characteristic space (*meta-model*) and *subject models*. The meta-model classifies services within an ***n***-dimensional discrete hyperspace.

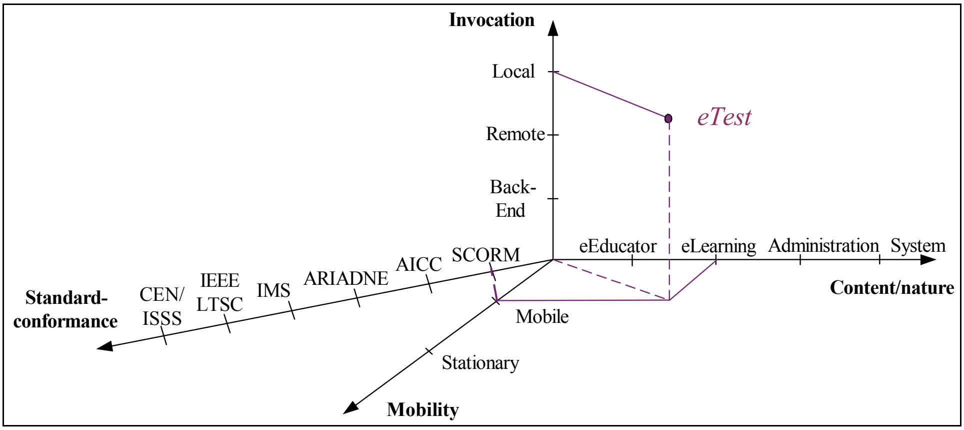

Fig. 5. The service classification model

For the moment four characteristic dimensions are defined:

- *Content/nature* – a classifier of services according to their content/nature, i.e. eLearning, eEducator, Administration, and System services;
- *Invocation* - a classifier of services according to the activation option provided in the infrastructure, i.e. Local, Remote, and Back-End services;
- *Mobility* – specifies whether the service is a mobile one or a stationary one;
- *Standard-conformance* – whether the service is conformant (or not) to an eLearning standard, e.g. SCORM(SCORM 2006), ARIADNE(ARIADNE), AICC (AICC), IEEE LTSC (LTSC), IMS (IMS), CEN ISSS (CEN/ISSS) etc.

The subject models specify the functionality of the offered eLearning services. Besides this classification for control purposes each service is considered as consisting of two parts:

- Service's user part (SUP) – an interface used for service control during initialization (searching, discovering, identification...) and finalization (in case of device change). SUP is deployed in the mobile devices and the InfoStations;
- Service's server part (SSP) – deployed and executed by the only non-changeable component - the InfoStation Center. It is in the SSP that the functionality provided by a service is realized..

This logical (conceptual) service structure could be mapped to different models and protocols for service control. Some services (mainly eLearning and eEducator services) directly use knowledge presented in the *domain model*. From an architectural point of view the possibility for dynamic switch/change (during the run-time) from one learning area to another is very important. Today's approaches for the implementation/realization of eLearning models usually use *ontologies*. Besides this, depending on their nature, some services could be parameterized by retrieving the parameter values from the *user model* and the *pedagogical model*. This increases the possibilities for architectural support for one of the main characteristics of the eLearning systems, namely service personalization. The possibility for parameterization, parameter types, their allowable values, the time needed to assign these values (during service development or dynamically during the run-time) are defined in the corresponding subject models.

5.4 User management

As a basis for the development of the concept of user management we use the *stereotype approach*, presented in section 3.

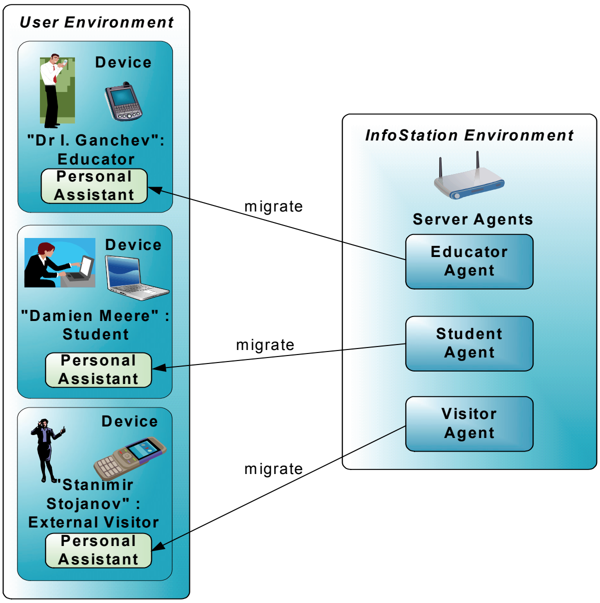

Fig. 6. Agent-oriented approach for user support

An essential problem, which needs to be taken into account when implementing the architecture, is that the users of particular services would be known only at the run-time. Hence for real personalization, the architecture must have enough flexibility in order to support both aspects of adaptability – being adaptable and being adaptive:

- *Adaptable* – server reference agents, corresponding to a particular user model, are configured and deployed a priori in the server part of the architecture (InfoStations, InfoStation Center). These agents present given stereotypes to the potential users;
- *Adaptively* – an appropriate stereotype agent will be chosen for each new user during his/her first access to the system. From the chosen stereotype and the user personal profile a corresponding personal assistant will be generated as an agent-instance of the server agent. Then the personal assistant will be transferred in the user-operating environment. Subsequent efficient and adaptive user accesses to the system are possible through the use of the personal assistant, Figure 6.

The proposed approach for user management could be used also for the implementation of the *mixed user models*. In this case 'more intelligent' agents, aware of the users' background knowledge, are needed (so as to reflect the actual knowledge level of learners in particular area of study). For the management of mixed models corresponding *domain models* could be also used.

Another important problem is related to user session management. Known client-server management mechanisms cannot be used in our architecture due to difficulties in tracing the user sessions in mobile scenarios discussed previously. For user session management we propose to use a goal-driven approach, whereby in correspondence with the used pedagogical model the actual learning tasks/goals are defined during the learning process itself. These goals are recorded in the actual user profiles and their fulfilment could be traced by the server part of the architecture and/or by the learners' personal assistants. With the help of their assistants these users could interrupt/suspend their service sessions (e.g. without achieving particular learning goal, if allowed).

5.5 Agent control models

An analysis of the expected behaviour of all components is needed when designing eLearning system architectures. The architectural components could be categorized as follows:

- *Passive* – only offering particular functionality without being able to activate services and control their execution;
- *Reactive* – can activate and control a particular functionality/service as a response to an external request;
- *Proactive* – can make self-dependent autonomic decisions for activation and execution of a particular functionality/service.

Careful analysis of the previously considered scenarios and the resulting distribution of functions and responsibilities between the different tiers of the proposed architecture suggests that it is reasonable to implement the software for passive and reactive components as electronic services (*eServices*), whereas for the software implementation of the proactive components *agents* are required.

For implementation of the proposed InfoStation-based eLearning system architecture as a combination of agents and eServices we have developed two possible models: *'thin agent'* model (Figure 7) and ***'thick agent'*** model (Figure 8). For effective software support of the proposed architecture the mobile devices (clients) and the InfoStations should be implemented as proactive components. For the InfoStation Center we envisage all three options. The main difference between the two models lies in the interpretation of the InfoStation Center.

In the *'thin agent'* model the InfoStation Center is a proactive component. This way it could take the initiative and the responsibility (in some scenarios) to activate particular services. Besides this the Center could take control over the service execution and could make corresponding decisions with regards to the operation of the entire system. This way the InfoStations software is relieved from many tasks and thus can be implemented as a light (*thin agent*) version. As a result the interoperation between an InfoStation and the InfoStation Center is 'agent-to-agent' (e.g. based on the ACL protocol). Inside the InfoStation Center the communication between agents and eServices is supported, e.g. by the OWL-S protocol.

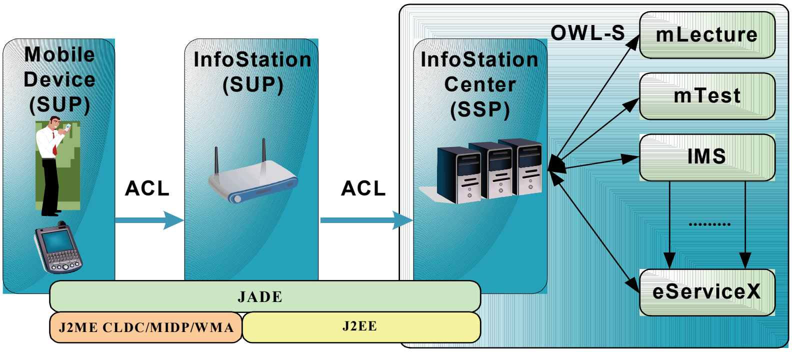

Fig. 7. The *'thin agent'* model

In the ***'thick agent'*** model the InfoStation Center is a passive or reactive component. The entire control over requested service processing is performed by the InfoStations. The InfoStation Center acts only as storage of eServices; in some cases it could support services execution but cannot take part in the control of service processing. The InfoStations' software is loaded with many tasks for the purposes of control (***thick agent***).

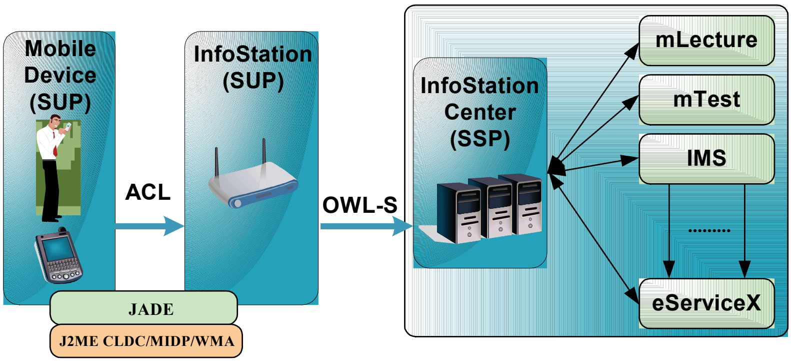

Fig. 8. The ***'thick agent'*** model

As a result the interoperation between an InfoStation and the InfoStation Center is 'agent-to-eService' (e.g. based on OWL-S protocol), i.e. the InfoStation agents see the InfoStation Center as a set of different eServices. The main disadvantage of this model is the substantial load on InfoStations with regard to control tasks. The reduced coordination between the InfoStation and InfoStation Center is certain advantage of this model. Independently of the model chosen for the actual system implementation (*thin-agent* or ***thick-agent***) it is necessary to solve the problem of communication between the agents themselves on one hand, and between the agents and eServices on the other. This type of communication could be realized:

- By using the existing communications standards/protocols, or
- By choosing (and mixing) suitable subsets of given communications standard/protocol;
- By developing a new communication protocol.

Each of these three approaches has its own pros and cons thus the choice must be carefully thought and based on detailed comparing analysis. For communication between agents currently we are analyzing the communication capabilities of the Agent Communication Language (ACL) (FIPA 2002), developed as a part of the Foundation for Intelligent Physical Agents' (FIPA) specification, or its limited subset. The ACL defines the messages used in the communication between intelligent agents within this system. Abstract messages passed between intelligent agents within the system consist of 2 components: an envelope (containing information utilized in the transportation of the message) and the message payload. The ACL is not concerned with the envelope or specifying how a message is disseminated throughout the system, but rather it defines the payload or representation of the information contained within the message itself. The ACL defines a number of parameters which are utilized to provide effective agent communication. Depending on the type of communication, which parameters are utilized will vary. Only one of the parameters is mandatory in all ACL messages, this being the *performative*. This parameter defines the type of communication that particular message performs. The performative signifies if a message is a *request*, a *proposal*, or indeed a *query*.

As well as a *performative* parameter, most messages passed between the agents within the system will also contain parameters which are utilized to specify the various participants in a communication. The *sender* parameter, for example, will be contained within most messages passed between agents in this system. This parameter refers to the agent who initiates the communicative act. The *receiver* parameter denotes one (unicast) or more (multicast) destinations for a message. The *reply-to* parameter could prove most useful within this system. During a 'conversation' between agents, by specifying an agent within the *reply-to* parameter, subsequent message are sent on to this agent instead of the agent specified with the *sender* parameter So far we have detailed parameters which outline the type of ACL message and the parties involved within a particular communication. However, ACL parameters can also be utilized to specify the content of the message, as well as a description of the content. The *content* parameter denotes the actual content of the ACL message itself. Within these ACL messages, this content could refer to any of the information passed back and forth between the PA and the InfoStation and depending on the agent model chosen, the intelligent agent operating within the InfoStation Center. For example, profile update information, user service requests, service content information etc.

For communication with eServices the agents need computer-understandable description of the eServices, and instructions of how to interoperate with the eServices. A good option here is offered by the Ontology Web Language (OWL-S) protocol (Ankolekar, Burstein et al.). To use an eService, the OWL-S provides a set of constructs used to create *ontologies* (i.e. specifications of concepts and relationships with the agent), which are machine-understandable descriptions of the service. The ontology structure is divided up into three separate sections, each dealing with a different aspect of the agent:

- Service Profile - advertises the abilities of the service (i.e. what it can do) by providing a concise high-level description of a service to a registry. Up-to-date copies of service profiles are kept in the InfoStation Center. The InfoStation Center periodically delivers copies of the service profiles to all InfoStations. The service profile is used for populating service registries, automated service discovery, service selection etc;
- Process Model - gives a detailed description of the service operation and tells a user how and when to interact with a service (read/write messages). This model is used for service invocation, planning, composition, interoperation, monitoring etc;
- Grounding - provides details of how the agents can interoperate/interact with a service, e.g. describes message formatting, transport mechanisms, protocol types, serializations etc. When combined with the process model, the grounding gives everything required to utilize a service.

Agents utilize the information contained within the Service Profile to ascertain whether or not a service meets its requirements, and adheres to certain constraints such as security, and quality etc. While the Service Profile provides all the information needed for an agent to discover a service, the Process Model provides the information necessary for the agent to use the service. The Process Model allows the agent to perform a more in-depth analysis of the service and its capabilities, and determine if it can be utilized. As well as this, it enables the agent to compose new service descriptions through the composition and interoperation of previous existing services, to perform specific tasks. The Service/Process Model also allows agents to monitor the execution of tasks performed by a service (or a set of services), and to coordinate the entities involved in the service execution. The Service Grounding details how agents can communicate with, interoperate with, and invoke a service. The relationships between the various service components are modelled using properties such as *presents* (Service to Profile), *describedBy* (Service to Process Model) and *supports* (Service to Grounding), as illustrated within Figure 9.

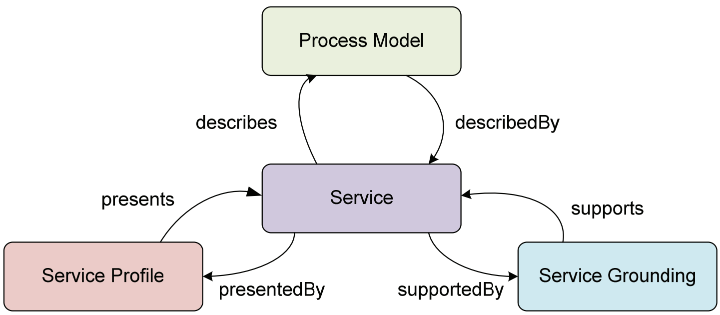

Fig. 9. OWL-S component relationships (Martin, Burstein et al. 2004)

These three parts altogether create and ontology/description, which allows intelligent agents to discover, invoke, compose and monitor eServices. The OWL-S protocol offers a good opportunity for the realization of flexible software architectures and offers a suitable environment for the support of the intelligent mobile services envisaged in our architecture. We treat the OWL-S specification in a distributed fashion, where the exact scheme of distribution depends on the chosen model – *thin-agent* or ***thick-agent***.

5.6 Agent types

The agents we use in our eLearning system architecture are divided in two groups:

- *Personal Assistants* – mainly used to support users when using the system. These agents are visible to the users. Particular attention is paid to the development of intelligent, effective and user-friendly GUI;
- *Server Agents* – mainly used to support the operation of the InfoStations and the InfoStation Center, by assuring proper communication between personal assistants themselves on one hand and activation of the desired eServices on the other. These agents are transparent to the users. Main attention paid in their implementation is related to their effectiveness during operation. They do not have user interfaces of any kind.

Besides this classification the agents may have different level of intelligence:

- *Goal-oriented agents* – used to support the *pedagogical model* and the *mixed user model*;
- *Mobile agents* – for support of the proposed implementation scheme of the *user model*.

6. mLearning Services

Some examples of services used in our system are considered in the following subsections, illustrating the sequences of events which take place during service execution.

6.1 mLecture

The mLecture service exists as the very core service within this system. While initially this service would be used as a supplementary aid to the traditional learning experience. In a traditional learning environment, it is often the case that a lecturer will make available various ancillary learning resources in order to aid the students understand the presented information. Usually this would consist of a set of notes to accompany the lecture. In this case, a lecturer could upload these learning resources (e.g. text, diagrams, images) pertaining to the lecture, or indeed supply a pod-cast or possibly even a video-cast of the lecture itself. This would greatly assist the student's assimilation of information. As students would be able to regulate the pace at which they proceed through the information and if necessary re-cycle back through the lecture. This ensures the material be more accessible for learners of varying learning styles. For some time now pod-casts have been utilized around the world in third level institutions to aid students. Building on these examples the mLecture service seeks to adopt a more multimedia approach to course delivery (where possible), incorporating audio, video and elements of interactivity to the process. Indeed while this service would greatly aid the success of the traditional learning paradigm, the ultimate goal of employing a service such as this would be the eventual presentation of a standalone distance learning course. Indeed this seems more then feasible when we consider the delivery of video-cast lectures. In the mean-time this technology serves to greatly enhance the traditional teaching/learning environment.

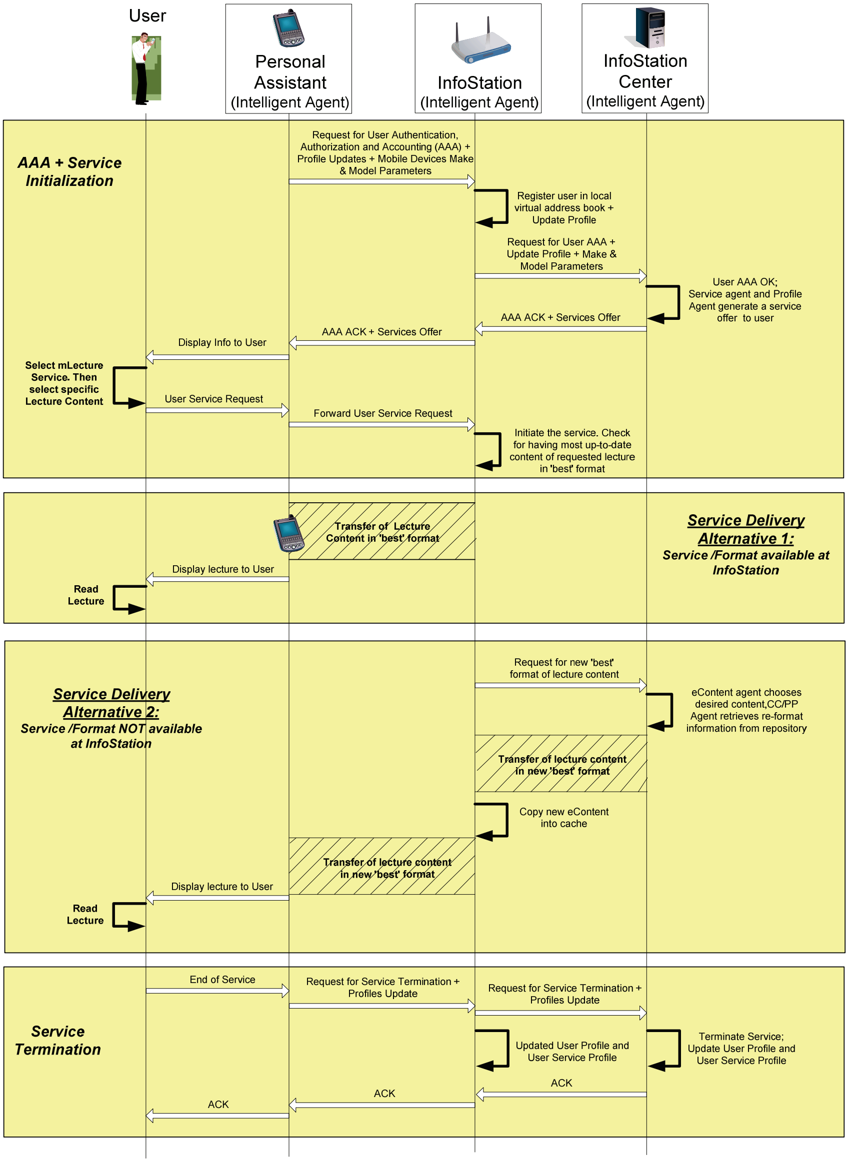

Fig. 10. *mLecture* service provision

The sequence diagram Figure 10, visualises these various entity interactions, including the situation which arises if the local InfoStation does not have a copy of the most appropriate service format within is service repository. The initial interactions, when the mobile user first enters within the range of an InfoStation, are concerned with the processing of the user's AAA request, and subsequent selection of service. In this case the service chosen is the *mLecture* service. The PA forwards the users service request to the InfoStation. If the

InfoStation does not have an up-to-date cached copy of the required mLecture, it forwards the request onto the InfoStation Center, which in turn instantiates the service and sends back to the InfoStation a full copy of the requested lecture. The InfoStation examines the user and user service profiles and customizes the service accordingly. The users current device may not possess the capabilities to accessing the full range of media formats available as part of a service. For this reason, the InfoStation will adapt the service content to a format which 'best' suits that particular device (i.e. accounting for both the device and the access network) according to the specifications within the User Profile.

6.2 mTest

A key component for a successful eLearning process, mTest provides a means to evaluate the students acquired knowledge and provides valuable feedback to students concerning their progress. mTest also allows the educator to shape the learning experience of the students, ensuring the student remains engaged in the correct material. Indeed the main benefit of using quizzes is the motivation of the students engagement in the material, without the stress of associated with traditional exams (CAA). The utilization of short quizzes throughout the duration of a course can also have the added benefit of providing great motivation to students. By providing feedback on their progression, student can be made aware of how well they are assimilating the presented course content. Educators may also benefit from such information. By monitoring the progression of a group of students, the educator may actively modify their approach to conveying the course content and as such, optimize the performance of the group, and enhance the overall learning experience. Indeed this process can be even further enhanced through the use of pervasive technologies such as Short Messaging Service (SMS). SMS quizzes have proved over the last few years, to be a very useful tool in education (especially within third level institutions). For example (Markett, Arnedillo Sánchez et al. 2004) discusses the uses of SMS to support interactivity within the classroom. With this, the students used their personal mobile phones during class to send SMS in real-time to a modem accessible by the lecturer in real time. So during the course of the lecture, the lecturer can dynamically address the SMS content as it arrives. This allowed the students to become more actively involved in the class, without disrupting it.

The sequence diagram, Figure 11, depicts sample interaction between entities involved in this service. As outlined previously, when a mobile user enters within the range of an InfoStation, s/he goes through the normal AAA procedure, and selects the relevant service. In this case the *mTest* service is chosen. Once the user/student gains access to the service, s/he may choose a particular assessment. The PA on the user's mobile device forwards a service request on to the InfoStation, specifying the user's choices. The InfoStation in turn, having analysed the capabilities of the target device, discerns the optimal format in which to present the assessment. This service content is then made available to the PA. As the student progresses through the test, his/her user service profile is maintained to reflect this progress. Furthermore we consider the possibility for the student to do the test whilst on the move and out of range of an InfoStation. Due to the geographically intermittent nature of an InfoStation connection, the student's mobile device may leave the contact range of the initial InfoStation (InfoStation 1). However the PA facilitates the users continued utilization of the service while at the same time maintaining the user service profile. Thus the student may complete the test whilst outside the signal range of any InfoStation, with the user service profile reflecting the student's progression through the material. InfoStation 1, the last

InfoStation in contact with the PA, sends user profile and user service profile updates to the InfoStation Center, ensuring it has the most up to date information.

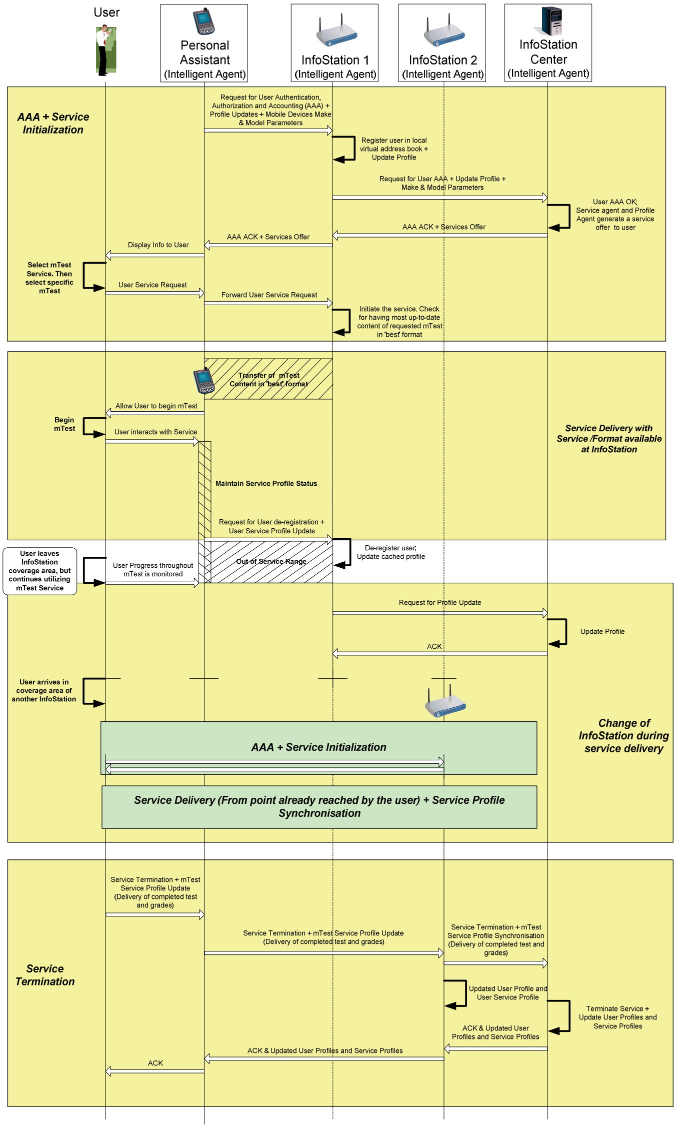

Fig. 11. *mTest* service provision – Change of InfoStation

Once the PA eventually does enter back within range of an InfoStation (i.e. InfoStation 2), the PA will again go through the process of authentication, authorization and accounting. The PA forwards on a user service profile update which reflects the progress of the student through the service content, whilst out of range of the InfoStation network. These updates are disseminated through to the InfoStation Center so as to ensure all information across the system is up-to-date. To the user, this transition between InfoStations should appear seamless, with the user not experiencing any loss of service. Once the user has completed the mTest, the PA displays the results of the assessment to the user, providing valuable feedback on their own progress and performance. A notification of service termination is forwarded on by the PA to the local InfoStation, along with the user profile and user service profile updates. Contained within these updates is information relating to the various grades achieved by the user in any assessments undertaken by the user in that particular service session. This information is in turn accessible by the lecturer/educator, allowing them to monitor the performance of the students.

7. Implementation

7.1 Composite Capability/Preference Profile (CC/PP) & User Profiles

One of the main issues concerning the implementation of the eLearning services is related to the creation of user- and service profiles. As we have mentioned previously, the Ontology Web Language (OWL-S) is utilized in the creation of the service profiles, which facilitate the advertisement of the services and interoperation between the agents and these services. We propose to use the "Composite Capabilities/ Preference Profile" (CC/PP) (Tran, Butler et al. 2003) as an uniform format for the implementation of the user and mobile device profiles. Recommended by the World Wide Web Consortium (W3C) (W3C) this platform-independent format is based on the Resource Description Framework (RDF) (Manola and Miller 2004). The CC/PP basically provides a standard way for to make known devices capabilities and user preferences. When a mobile device sends a service request to an InfoStation / InfoStation Center using the CC/PP, the latter can tailor the content of the service to suit the requesting device. In essence the content is adapted to suit the individual user. Therefore, eLearning services can be provided to users, regardless of mobile devices currently in use. As such, the eLearning service developers can create device-independent code and not worry about the mechanisms users will utilize to gain access to these services.

The majority of CC/PP-enabled devices utilize the User-Agent Profile (UAProf) (UAProf-working-group 1999). This concrete implementation of the CC/PP, developed by the Open Mobile Alliance (OMA), enables the flow of capability and preference information between an Internet-enabled mobile devices and a requesting server. The UAProf is aimed at WAP-enabled mobile devices, and defines a profile vocabulary that describes the hardware and software characteristics as well as the WAP-specific features of the mobile device and associated transport network capabilities. CC/PP and UAProf represent the devices capabilities in the form of a two-level hierarchy consisting of components and attributes. Components are a grouping mechanism for attributes, therefore in essence, CC/PP or UAProf profiles are organised as structured sets of attributes and value pairs. When a user's mobile device enter the range of an InfoStation, they will mutually discover each other and the intelligent agent on the users device will forward a UAProf to the InfoStation. From this profile the InfoStation can dynamically adapt and customize services to suit that device. However to customize the service to suit the preferences of the user, the profile must be extended to specify these preferences. This is achieved through the extensibility of the CC/PP vocabulary, which defines the format/structure of the profile information exchanged between a client and a server. This information can be extended to describe some important attributes of the user too. The user preference components can specify anything from the user's name and the languages s/he speaks, to her/his location and the preferred format in which the user wishes to receive information. An important attribute within the user profile, especially within the educational domain, would be to specify the role of the user, whether the individual is an educator or a learner.While these pre-defined UAProf attributes allow a service to be adapted and tailored to suit the operating environment on a particular device, it's also necessary to express our own additional components and attributes in order to allow the right services to be offered to the right users. Fortunately the use of RDF allows for the extension of UAProf schemas to suit the requirements of this system. As such, Profiles will be composed not only of components and attributes from a base vocabulary, but also from our own specific schema extensions. Within these extended schemas, we can specify a multitude of attributes relating to a wide variety of user's. As we've mentioned, the role of a specific user is very important, depending on whether the user is an educator, a student, or indeed a visitor to the campus will have a bearing on the levels of access the user has to services and service content. This information allows the services to provide a more personalized and higher quality of service to users. Figure 8 is an example of how a component and group of attributes relating to a particular user may specify vital information about that individual.

```
<prf:component>
<rdf:Description rdf:ID="UserPlatform">
  <rdf:type rdf:resource="http:// www.ece.ul.ie/trc/profiles/UAPROF/ccppschema-1#UserPlatform" />
<prf:Name>John Doe</prf:Name>
<prf:StudentID>0123456</prf: StudentID >
<prf:Faculty>ECE</prf:Faculty>
<prf:Course>Electronic Engineering</prf:Course>
<prf:Year>4</prf:Year>
<prf:Classes>
    <rdf:Bag>
            <rdf:li>CE4517</rdf:li>
            <rdf:li>CE4607</rdf:li>
            <rdf:li>CE4717</rdf:li>
            <rdf:li>CE4817</rdf:li>
            <rdf:li>CE4907</rdf:li>
            <rdf:li>EE4607</rdf:li>
    </rdf:Bag>
</prf:Classes>
<prf:Advisor>Dr. Ivan Ganchev</prf:Advisor>
<prf:email>0123456@STUDENT.ul.ie</prf:email>
<prf:QCA>3.47</prf:QCA>
<prf:FYP>JD09</prf:FYP>
<prf:FYPSupervisor>Dr. Ivan Ganchev</prf:FYPSupervisor>
<prf:FYPTitle>Design and Implementation of an Animated Interactive Tutorial</prf:FYPTitle>
</rdf:Description>
</prf:component>
```

Fig. 12. Example of a CC/PP User specific Component

Within this sample profile component, we can see some attributes which will prove essential in order to properly advertise services to the most applicable users, and indeed adapt them to suit this particular user. In the given sample component, Figure 12, an attribute such as 'Faculty' can have a major bearing on the type of services being offered to a particular user. For example the services utilized by members of the Business faculty will generally differ greatly from those being utilized by members of the Electronic and Computer Engineering faculty. Indeed by allowing for the specification of the various classes being taken by the user, services can be directed at even more specific ranges of users. It's essential for these factors to be taken into account in order to avoid unnecessarily advertising irrelevant services to users. In the case of charging and billing, the user may request access to services in the cheapest manner possible or indeed with the highest possible quality. As the preferences of the individual will be as varied as the individuals themselves, a mechanism within the Intelligent Agents (Personal Assistants), on-board the mobile devices, will allow the individual users to alter their own preferences.

7.2 J2ME & Device Independence

In the modern mobile environment, there are many diverse device types characterized by different screen sizes, input (keyboard, touch, keypad etc.) and other characteristics. A standard, platform-independent architecture is required for the creation of mobile applications across these diverse devices. The standard architecture we use for development, deployment and execution of the intelligent mobile services is the Java 2 Micro Edition (J2ME) (JSR-Groups). J2ME provides a modular, scalable architecture that allows for the flexible deployment of Java Technology on a multitude of different devices with different features and functions. J2ME is basically a collection of building blocks and frameworks that can be combined to suite particular devices sharing similar characteristics. J2ME's device independence stems from its use of profiles, configurations and other optional packages.

A J2ME "configuration" targets devices with a specific range of capabilities and defines the minimum elements required by those devices (i.e. a given JVM specification, a core API). A J2ME "profile" selects a configuration, and then defines a specific set of API's aimed towards a specific set of services/abilities that support a certain category of devices, within the framework of that configuration. By selecting the appropriate configurations and profiles, applications can be developed and deployed regardless of the device onto which they're to be deployed. The Connected Limited Device Configuration (CLDC) (JSR-139 2003) is a fundamental part of the J2ME architecture. It provides the most basic core set of libraries and virtual machine features that must be present within each implementation of a J2ME environment, i.e. it provides a reduced JVM implementation. This ensures low memory and CPU consumption, which are especially important factors when developing applications for mobile devices with limited resources.

The Mobile Information Device Profile (MIDP) (JSR-118 2002) defines a platform for dynamically and securely deploying of applications and services on mobile devices. It provides support for a graphical interface, networking and storage of persistent data for mobile device applications called MIDlets (similar to applets). When these profiles and configurations are combined they provide a complete Java application environment for a specific device class. J2ME provides a number of optional packages, one of the most useful of which is the Wireless Messaging API (WMA) (JSR-120 2003). This API provides platform-independent access to wireless communication resources such as the Short Messaging Service (SMS). The WMA is used on top of CLDC and MIDP that provide the core functionality required by mobile applications.

7.3 J2ME & Device Independence

Our proposed agent-oriented system is implemented by using the Java Agent DEvelopment (JADE) framework developed by TILAB (Bellifemine, Caire et al. 2005) (Bellifemine, Caire et al. 2003). This allows flexible development of multi-agent systems and applications for management of networked resources in compliance with the FIPA specifications. "JADE is an enabling technology, or middleware for the development and run-time execution of peer-to-peer applications which are based on the agents paradigm and which can seamlessly work and interoperate both in wired and wireless environments" (Bellifemine, Caire et al. 2003). JADE has been fully implemented in Java, as Java provides many features geared towards object-oriented programming in distributed environments, such as Remote Method Invocation (RMI) and object serialization. JADE provides a set of APIs completely independent of the underlying network and the Java version (the same APIs are provided for each different edition of JAVA - J2EE, J2SE, J2ME). This illustrates JADE extreme versatility for being able to be integrated into complex structures such as J2EE; it can also be tailored to fit the constraints of environments with much greater limitations on resources. For example, the JADE run-time memory footprint in a MIDP 1.0 environment can be as between 50 - 100KB. This limited memory footprint allows JADE to be installed on any Java-enabled mobile devices. This versatility also allows developers to re-use the same application code, whether it is deployed on a PC, a PDA, or a Java-enabled phone.

Each instance of the JADE run-time is called a *container*, which may contain a number of agents. A group of active containers together is called a *platform*. A single *main container* must always be active on every platform. The first container to become active on a platform assumes this role, and all other "normal" containers must register to this main container as soon as they become active on the platform. The main container also differs in that it contains two special agents, which automatically start when it is launched: the Agent Management System and the Directory Facilitator agents.

As with Java architecture, the JADE architecture is completely modular. By utilizing specific modules, JADE can be configured to adapt to the requirements of the deployment environment (e.g. processing power, memory, and connectivity). For our implementation of JADE, one of the most important modules is the Light Extensible Agent Platform (LEAP) module (Caire and Pieri 2006). This module replaces some parts of the JADE kernel providing a modified run-time environment for enabling FIPA agents to execute on a wide range of Java-enabled devices. It allows for the optimization of communication mechanisms when dealing with mobile devices (with limited resources) connected through wireless networks. A container is split into a *FrontEnd* (running on the mobile device itself), and the *BackEnd* (running from a fixed network entity called a *mediator*), as illustrated in Figure 13.

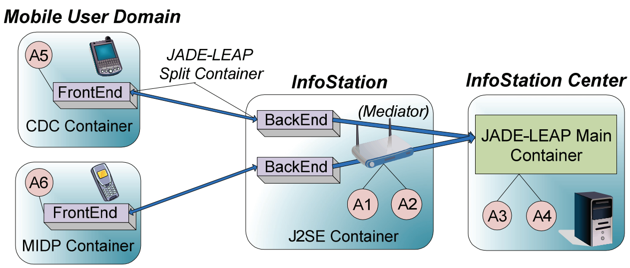

Fig. 13. FrontEnd and BackEnd of a "JADE powered by LEAP" implementation

This mediator is charged with instantiating and maintaining the BackEnds. In our system, the InfoStations deployed throughout a University Campus take on this mediator role. Each FrontEnd is connected to each BackEnd through a wireless bi-directional connection. The splitting of the container into two separate, yet connected entities is particularly useful in the realm of resource constrained devices, as the FrontEnd of the container is of far more lightweight in terms of the required memory and processing power then the entire container. Due to the geographically intermittent nature of the InfoStation connection, the FrontEnd and the BackEnd may undergo a loss of connection; however the front-end can detect this and re-establish the connection as soon as possible. Any messages not transmitted due to this temporary disconnection can be buffered and delivered when the connection is re-established. This store and forward mechanism is implemented in both the front-end and the back-end, and is vitally important for the InfoStation-based eLearning system architecture.

This splitting of the container has no bearing on the application developers, as the same functionality and set of APIs is available to an agent, whether it is contained within a full container or the front-end of a split container. The JADE framework also serves to shield the developers from the complexity of the distributed environment, allowing them to concentrate their efforts on developing the application logic, rather then worrying about middleware issues such as discovery and communication of entities within the system.

Within JADE, communication between the agents is facilitated through the use of the Agent Communication Language (ACL).

8. Conclusion

The realization of InfoStation-based system architecture for the provision of intelligent mobile services in a University Campus area has been outlined within this chapter. A detailed description of the 3-tier InfoStation-based network architecture along with its functional entities has been presented. A step-by-step multi-agent approach for the definition and the specification of the software architecture has been used by first considering the main scenarios in the InfoStation infrastructure, followed by the proposed solutions for service control and user management, and finishing with a justification for the software implementation of the passive and the reactive components of the architecture as electronic services (*eServices*), and as *agents* for the proactive components. Two examples of mLearning services supported by this underlying architecture were presented; highlighting the interactions between the main system entities during a service session The Composite Capabilities/Preference Profile (CC/PP) standard has been adopted as a uniform format for the implementation of the user/service profiles. The Java 2 Micro Edition (J2ME) has been used as the standard architecture for the development, deployment and execution of the proposed intelligent mobile eLearning services. The proposed system is organised according to a multi-agent structure, and is implemented by means of the Java Agent Development (JADE) framework, making particular use of its LEAP module.

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An Interactive Simulation Game to Enhance Learners' Experience on Ubiquitous Computing Devices

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1. Introduction

Advocating the constructive uses of digital games to motivate and/or enhance learners' experience, digital game based learning (DGBL) (Prensky, 2002) has been revolutionizing the latest educational technology or training methodologies in many industrial applications including the training of military officers in tactic planning or resource management in a simulated combat environment. In addition to such specific training, there are numerous successful examples of commercially developed simulation games including the SimCity (SimCity, 2007) or Sims™ 2 Open for Business (SimBusiness, 2007), originally developed for fun and later seriously adopted by the business schools of different universities in North America to motivate or sustain the students' learning interests in specific fields. In many cases, it was shown that the appropriate use of simulation games not only avoids the indispensable costs of human lives or money lost in the hostile combat or investment field, but also effectively motivates and/or raises the learners' interests that may have positive impacts on their actual performance attained in handling the real-world situation, and more importantly reaffirming the important value of simulation in education or training. As clearly described in (Wikipedia, 2007), "Simulation is used in many contexts, including the modeling of natural systems or human systems in order to gain insight into their functioning. Other contexts include simulation of technology for performance optimization, safety engineering, testing, training and education.". In many such applications, simulation can be used to clearly demonstrate the eventual effects of alternative conditions and course of actions.

In general, most educators agree that the use of interactive simulation tools can help students better understand the underlying working principles of many biological or physical systems, and thus at least motivate the learners' interests for further investigation that may lead to improved performance in a specific subject. For example, the use of a computer-aided simulation game named "The Incredible Machine" (Ward, 1998) was found

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to enhance the mechanical reasoning capabilities of transition year students, including 17 females and 27 males with their age between 15 and 16 years, to a certain extent in an exploratory study conducted in a vocational school in Ireland. The study strictly followed the pre-test/post-test control group design, with the students' mechanical reasoning skills evaluated by the Differential Aptitude Test for Guidance. There were significant differences in favor of male students in the experimental group with training using "The Incredible Machine" simulation game as shown in the t-test analysis of their pre-test and post-test raw scores. Besides, there are many other successful applications of simulation tools or games in other sectors of education (Kent, 2007; SCS, 2007; SuperKids, 2007).

In Hong Kong, where commercial and financial activities are overwhelmingly active in recent years with a lack of long-term development infrastructure for Engineering related disciplines, many tertiary educators in Engineering are faced with the core problems of motivating the students' learning interests and more importantly helping students realize the real values of the professional training in their own specific field. Therefore, in a Teaching Development Project, we proposed to develop an interesting simulation game inside a virtual university campus containing game rooms with different missions for students to fulfill on wireless mobile devices so as to enhance the learners' experience after classes. All the missions are focused on engaging players to exercise their logical thinking or problem-solving skills relevant to specific Engineering disciplines in a virtual environment without the limitation of many physical factors. For instance, the students can be free from the worries of damaging many digital circuit boards before successfully building a working digital device such as a digital computer or network modem. To promote the spirit of teamwork as in (Ward, 1998), each team of 3 to 4 students will work together to complete all the missions within the virtual campus. The team that obtains the highest score after completing all the missions is the winner. Since our simulation game can be accessed through wireless mobile devices such as pocket PCs, the teams can continue their missions in the game anytime and anywhere. To demonstrate the feasibility of our proposal, we used the Nebula Version 2.0 toolkit to build a prototype of our simulation game containing various game rooms inside a virtual campus that can be accessed through Window-based pocket PCs. When the prototype is completed, a detailed evaluation will be conducted to analyze the effectiveness of our simulation game on motivating and/or enhancing the learners' experience in relevant Engineering disciplines. After all, there are many interesting directions for further investigations. The integration of our simulation game with existing e-learning systems or powerful search engines is worth researching. Besides, any feasible mechanism to increase players' involvement in proposing new missions or acting as mentors to guide other teams after the team has finished its own missions should be thoroughly studied

This chapter is organized as follows. Section 2 reviews some previous works relevant to our proposal including the use of computer simulation games in education and training, and the Nebula toolkit. Section 3 details the system architecture design of our interactive simulation game to enhance learners' experience on mobile devices. We give an empirical evaluation of our proposed system on various criteria in Section 4. Lastly, we summarize our work and shed lights on future directions in Section 5.

2. Related Works

In this section, we will consider some related works including the use of interactive computer simulation games for learning, and also the Nebula toolkit that we used to develop an interactive simulation game for our Teaching Development Project.

2.1 Interactive Simulation Games for Learning

Among the theories of learning, constructivism (Moll 1990, Piaget 1963, adsworth 1979) proposed that learners need to construct their own understanding of new ideas likely developed in the course of "active involvement with the environment", by individuals who must assimilate and accommodate experiences into existing schemata**.** Piaget (Piaget 1963, Wadsworth 1979) accorded a special role to cognitive conflict in which when an individual is confronted with different points of view, he/she must reflect on his/her own sets of beliefs, compare his/her idea with those of others. As a consequence, the individual restructures and refines his/her own schemata. Vygotsky (Moll 1990, Vygotsky 1978) proposed that cognitive change involves internalisation and transformation of what was created. Essentially, Vygotsky focused on what an individual could achieve with help, through interaction with others. While working within this zone of proximal development, the learner can actively construct knowledge based on his/her personal experiences. After all, both theories highlighted the importance of "interaction" with the environment or other people, flexibly provided in many computer simulation games nowadays, for learners to assimilate experiences into existing schemata in order to construct new knowledge.

As defined in (Wikipedia, 2007), a simulation game, also known as the sim game, a game of status or mixed game, is a game that contains a mixture of skill, chance, and strategy to simulate an aspect of reality, such as a stock exchange. In the industry of computer games, simulation games simply represent a wide super-genre covering many successful titles including the MS Flight Simulator (FSim, 2007), SimCity (SimCity, 2007), Civilization, and the Sims (Sims, 2007). Among these computer simulation games, there were many like the Sims or Sims™ 2 Open for Business (SimBusiness, 2007) that were originally developed for fun and later seriously adopted by different business schools or academic institutes for training their students in specific fields. In many cases, it was shown that the appropriate use of simulation games not only avoids the indispensable costs of human lives or money lost in the real-world combat or investment field, but also effectively motivates and promotes the learners' interests, thus likely producing positive impacts on the actual performance attained when handling the real-world situation. Besides, there have been various institutions that tried to develop their own computer simulation games for training or research. For instance, an exploratory investigation (Wade, 1998) about the effectiveness of a computer simulation game named "The Incredible Machine" for the mechanical reasoning skills was conducted in a vocational school in Ireland. In a control experiment with groups of 3 or 4 students working in a collaborative environment, it was revealed that no significant improvement was found between the experimental group and control group based on an analysis of pre-test and post-test results. However, interesting gender differences were found. Significant differences biasing towards male participants were discovered in the t-test analysis of pre-test and post-test raw scores, demonstrating the effectiveness of such computer simulation game on the mechanical reasoning ability of the male participants. Furthermore, the students' feedbacks collected in this study also suggested different patterns of mouse usage, reactions to the game, interaction styles, and strategies used by the groups.

2.2 The Nebula Toolkit

Being motivated by relevant investigations as described in Section 2.1, we started a Teaching Development Project aiming to develop an interactive simulation game mainly to motivate and sustain students' learning interests in the use of Information Technology in Engineering related disciplines. After spending a few months in literature reviews and information search, we decided to adopt the Nebula toolkit to develop our interactive simulation game.

Basically, the Nebula Device 2, namely the Nebula2, toolkit (Nebula2, 2007) is one of the leading open source 3D game and visualization engines used in many commercial games and professional visualization applications. It offers a complete abstraction layer from the underlying host system for the needs of real-time 3D games, thus providing a more realistic environment for most computer simulation games. One can think of Nebula2 as an operating system for games with the following features:

- an object model which integrates scripting, persistency, and safe referencing through smart pointers;
- wrapper classes for file-system access;
- wrapper classes for multithreading;
- wrapper classes for networking and inter-process communication across machines;
- an accurate time source (milliseconds or better);
- a collection of mathematical classes (vector, matrix, line, bounding box, etc.);
- a flexible scripting subsystem with support for several scripting languages (currently Tcl, Lua and Python);
- a 3D graphics subsystem with support for the D3D9 HLSL shaders;
- a 3D audio subsystem on top of DirectSound with support for static and streamed sound
- an input subsystem on top of DirectInput;
- a graphical user interface (GUI) subsystem for creating 2D user interfaces;
- a complete resource (including textures, meshes, shaders, fonts, animation data, etc.) management subsystem, with support for loading resources in a background thread;
- virtual file-systems (file archives) for faster loading;
- a flexible scene graph subsystem;
- a statically linked, stripped down Tcl version (called MicroTcl), featuring 36 core Tcl commands which does not require any additional runtime files.

3. The System Architecture of Our Interactive Simulation Game

Based on the Nebula2 engine and libraries for their supported features as mentioned previously, we carefully designed the system architecture of our interaction simulation game to enhance the learners' experience on mobile devices. The system architecture is depicted in Figure 1 below.

Essentially, the whole software system of our interactive simulation game is composed of two major parts: the game engine which deals with high-level game logic, and the Nebula2 kernel which handles low-level functions such as graphics, keyboard/mouse inputs, etc.

The game engine has three components: game entity, scenario loader and message pump. Each game entity represents an object in the game. By attaching different properties to a game entity, the game entity can behave differently. For example, with a physics property, the game entity can collide with other entities whereas without it, the game entity could simply go through. When events arrive, a message dispatcher of game entity is responsible for passing them to an appropriate property handler. Game entities in a particular scenario are managed by an entity manager created by the scenario loader. When switching the scenario, all the entities in this scenario will be read from the SQLite database by the scenario loader, created by the entity manager, and ultimately stored back to the SQLite database by the entity manager for the future retrievals. The game engine is event driven. Events can come from the nebula2 kernel, such as keyboard/mouse input, or from the network, such as actions of other players. The message pump dispatches all these messages to the appropriate entity handlers in order to keep the game running. In addition to such high-level game logic as handled by the game engine, all the low-level input functions are implemented by the Nebula kernel. For specific details about the Nebula2 kernel, refer to (Nebula, 2007).

Basically, our interactive simulation game consists of several game rooms that try to emphasize relevant subjects in Information and Communication Technology (ICT) that should be of interests to Engineering students in general. The relevant subjects in ICT we chose for the game rooms include Computer Architecture, Database Management and User Interface Design. Clearly, given the flexibility of our system architecture, other relevant subjects can easily be integrated into our simulation game. Inside the simulation game, each group of 4 students will enter into a different game room, one after another, to perform some designated tasks and then earn a score after accomplishing the tasks. For example, in the game room for Computer Architecture, students will be asked to pick up the correct components out of a diverse range of computer devices lying on the floor, and then configure such components to build a working desktop computer. During the game, the chosen leader of each team will act as a coordinator as well as the ultimate decision-maker to perform the actual actions such as the steps to compose a desktop computer in the simulation game room for Computer Architecture. Each member of the team, possibly located in different corners of the campus and being connected by the WiFi networks, can discuss what to perform next via the online chat-room facility provided on the mobile devices. After all, the scores obtained by going through various game rooms will be accumulated for each team, and can be checked via the web interface. And the team with the highest score will be selected as the winner of the simulation game.

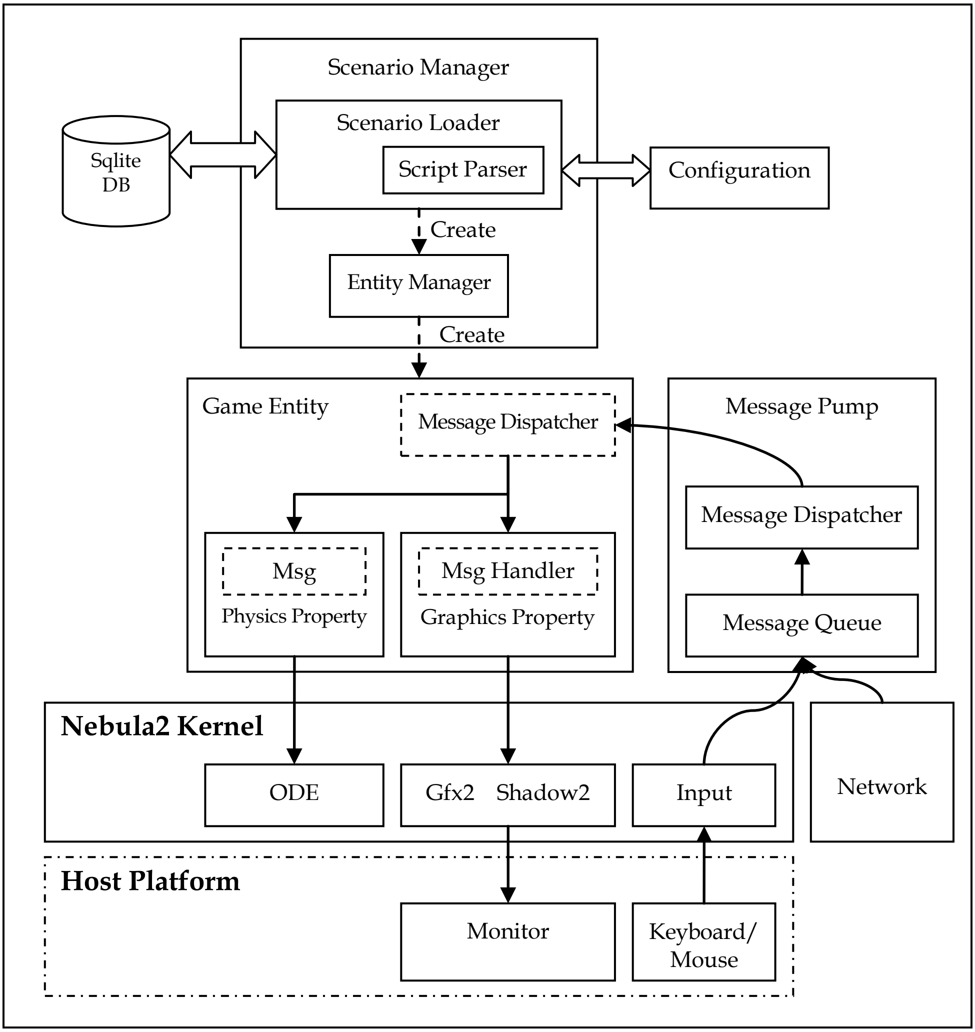

Fig. 1. The system architecture of our interactive simulation game

4. Prototype Implementation and Evaluation

We used the Nebula2 toolkit (Nebula, 2007) and its supporting technologies such as the SQLite, MicroTcl scripts, and several C++ programs to build a prototype of our interactive game containing several mini-game rooms inside a virtual campus that can be accessed through Windows-based desktop or pocket PCs. The use of mini-games like robot-shooting or duct/path connection are aimed to introduce some fun and also the flexibility in the design of each game room that can be an individual game component by itself, or combining with other mini-game rooms in an adventure to focus on some specific subject/topic. In our prototype implementation, we built an adventure of 3 mini-game

rooms inside the virtual campus, that try to emphasize relevant subjects in Information and Communication Technology (ICT) for Engineering students in general. The relevant subjects in ICT we chose for the mini-game rooms include Basic Organization of Computers, the (more advanced) Structure of Microcomputers and lastly Application Programming on Computers. Clearly, given the flexibility of our system architecture, relevant subjects in ICT such as Database Management and User Interface Design, or other different topics can easily be integrated into the virtual campus of our simulation game.
To play the simulation game, each team of 2 to 3 students should "individually" log in the game server via a networked PC and then select to enter into a game room of a virtual campus to perform some designated task. Among the team members, the players should nominate one student as the team leader to submit the final decision to each question/task. The team members are allowed to use the text-based voting mechanism or voice using the peer-to-peer Session Initiation Protocol (SIP) to communicate with each other before making any decision so as to encourage teamwork. After completing a set of questions/tasks, each team will be given a score, based on their time and accuracy, which will be added to their overall score. The team with the highest overall score is the winner. Figure 2 shows the user interface of the "virtual campus" for players to navigate among the game rooms available in our simulation game.

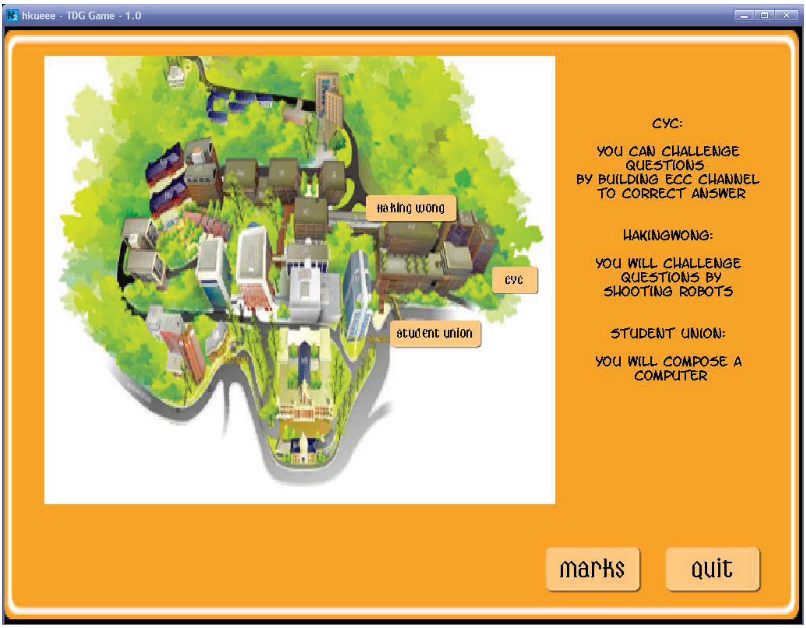

Fig. 2. The user interface of the virtual campus displayed in our simulation game

As shown in the diagram, the overall scores of all the participating teams can be checked by clicking on the "Marks" button inside the virtual campus from time to time to encourage constructive competition among the teams. For example, in the mini-game room for Basic

Organization of Computers as shown in Figure 3, each team of students will be asked to select the right components out of a wide range of computer devices including the processor, memory or network card, and also put such components into the correct slots to build a working computer. Each team leader will act as a coordinator to collect opinions from other team members via voice communication over the SIP server, and then make the necessary decisions to obtain a computer configuration for online submission. Our Nebula2 game engine will proceed to check if it contains all the essential components such as the processor and RAM for a working computer. Accordingly, it will send a message to congratulate the team for their good work. Otherwise, an error message will be displayed to allow the whole team to revise their configuration for later submissions.

Fig. 3. The user interface of the mini-game on the basic organization of computers displayed in our simulation game

Besides, to promote our TDG game through "trials" to be played on mobile devices anytime and anywhere, we ported our TDG game using embedded Visual Basic to run on (standalone) pocket PCs. This will allow us to study the performance attained by different teams with and without the "trial practice" of our TDG game, and more importantly the possible impact(s) of revisions on mobile devices over the retention period of the knowledge/skills covered in our TDG game. Figure 3 shows the similar interface of our TDG game ported onto the Dell™ Axim X41v pocket PC installed with an Intel(R) processor of 624 Mhz, and the Windows Mobile 5.0 operating system.

Fig. 4. The user interface of the pocket PC version of our simulation game

After the above prototypes was completed with extensive testing, a thorough evaluation was conducted to analyze the effectiveness of our simulation game on motivating and/or enhancing the learners' experience in relevant Engineering disciplines. In particular, we have carefully prepared a set of questionnaires and invited individual students from different classes/programmes in the Department of Electrical and Electronic Engineering (EEE) to try out our pocket PC version, that is mobile and can be tested anywhere, and then complete the questionnaire for our detailed analysis.

Essentially, after the (standalone) pocket PC version of our simulation game was built in early January 2007, it was distributed to various (around 8) EEE students, randomly selected from different classes/programmes, to try out the game with their feedbacks collected through the above-mentioned questionnaire to evaluate the potential benefits of employing simulation game to stimulate and also engage the students' learning interests in different EEE or possibly other courses. It should be noted that due to the "limited number of mobile devices" (only 1 pocket PC) available for this teaching development project, it was impossible to perform the system evaluation on a class scale. Therefore, we had to randomly select students to try out our game and then conduct survey on an individual basis. Table 1 summarizes the evaluation results obtained from our survey with the average score displayed out of a scale of 1 (lowest) ~ 5 (highest), the higher the score, the better the impression/impact of our simulation game, for each question.

Questions	Avg. Score
A. Do you think the simulation mini-game on pocket PC is easy-to-play ? **1.** Strongly disagree **2.** Disagree **3.** Neural **4.** Agree **5.** Strongly agree	**3.9**

B. Do you think the use of simulation game in our EEE or other courses can help to initiate the students' interest in learning? **1.** Strongly disagree **2.** Disagree **3.** Neural **4.** Agree **5.** Strongly agree	**3.5**
C. As compared to the conventional revision exercise, can the use of simulation game in our EEE or other courses simulate and also engage more students' interest in learning? **1.** Strongly disagree **2.** Disagree **3.** Neural **4.** Agree **5.** Strongly agree	**3.4**
D. Do you consider the use of simulation game in our EEE or other courses can provide a more funny and relaxing way to learn basic concepts in specific areas? **1.** Strongly disagree **2.** Disagree **3.** Neural **4.** Agree **5.** Strongly agree	**4.0**
E. Do you consider the use of simulation game in our EEE or other courses can increase the effectiveness of learning from student's perspective ? **1.** Strongly disagree **2.** Disagree **3.** Neural **4.** Agree **5.** Strongly agree	**3.4**
F. Do you consider the use of simulation game in our EEE or other courses can provide a more relaxing way to revise about basic concepts after classes? **1.** Strongly disagree **2.** Disagree **3.** Neural **4.** Agree **5.** Strongly agree	**3.8**
G. If such a simulation game is available freely in our EEE or other course website, how likely will you use/play such a game for learning/revision ? **1.** Definitely will not use **2.** Will not use **3.** Difficult to decide **4.** Will use	**2.9**

5. Definitely use	
H. If such a simulation game is available freely in our EEE or other course website, how often will you use/play such a game for revision/learning? **1.** Difficult to decide **2.** 0 **3.** once a week **4.** twice a week **5.** 3 times or more a week	**2.0**

Table 1. The evaluation results of our survey about the effectiveness of our simulation game to motivate and/or enhance the learners' interests in specific Engineering discipline

Basically, the feedbacks from these students are fairly positive, with the average score as 3.5 out of a scale of 1 ~ 5 supporting that simulation games can help to initiate students' learning interest. Over 87% of the students consider the use of simulation game as providing a more funny and relaxing way to learn about concepts in specific areas, and around 50% of the students plan to play the simulation game once or twice each week when such a game is available from our EEE or other course websites. Besides the formal survey, our team also communicated informally with other EEE students after classes to collect their views and feedbacks on the possible use of simulation games in promoting their learning interests. Most students expressed interests in using our simulation game for learning/revision in the future.

5. Concluding Remarks

Undoubtedly, interactive simulation games, with many successful examples to come, will form an important part of the digital game-based learning that aims to enhance or reshape the learners' experiences. In a Teaching Development project, we proposed to develop an interactive simulation game inside a virtual university campus containing game rooms with different missions for students to fulfill on wireless mobile devices so as to enhance the learners' experience after classes. All the missions are focused on engaging players to exercise their logical thinking or problem-solving skills relevant to specific engineering disciplines. Through wireless mobile devices such as pocket PCs, the teams can continue their missions in the game anytime and anywhere. To demonstrate the feasibility of our proposal, we used the Nebula Version 2.0 toolkit to build prototypes of our simulation game containing various game rooms inside a virtual campus that can be accessed through both Window-based desktop and pocket PCs. When the prototypes were completed, a detailed evaluation was conducted through a carefully designed survey to analyze the effectiveness of our simulation game on motivating and/or enhancing the learners' experience in relevant engineering disciplines. From the survey results, some initial and encouraging feedbacks are collected.

There are several interesting directions for future investigation. First, the integration of our simulation game with existing e-learning systems or powerful search engines is worth researching. Besides, any feasible mechanism to increase the players' involvement in proposing new missions or acting as mentors to guide other teams after the team has finished its own missions should be thoroughly studied.

6. Acknowledgements

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10

Augmented Reality and tangible interfaces for learning

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1. Introduction

Recent advances in hardware, software, and methods are changing the way of learning for many students. These new methods include games and video games (Mayo, 2007) as well as Augmented Reality (Kaufmann, 2004). As just mentioned, Augmented Reality (AR) has already been applied for learning, entertainment, or edutainment. It has also been used in other fields such as: military; medicine; engineering design; robotic; telerobotic; manufacturing, maintenance and repair applications; consumer design; psychological treatments, etc. (Azuma, 1997; Azuma et al., 2001). In an AR system, users see an image composed of a real image and virtual elements that are superimposed over it. The most important aspect in AR is that the virtual elements add relevant and helpful information to the real scene. AR can be a successful tool in many fields since it can be applied anywhere where the information superimposed on the real world can help the user; learning is one of these fields.

In this chapter, we present a new AR game for learning about exotic animals that are not very well-known. The game uses tangible, magnet cubes as the user interface. Since the game uses AR, images as well as explanatory videos about the exotic animals can appear on the surfaces of the cubes. The main objective of this work was to develop an innovative AR system to allow people to learn about exotic animals in a fun way. The system is fun because it is played as a game. It is innovative because as far as we know there is no other AR system that has been developed for this purpose. Another objective was to evaluate different aspects of the AR game. Taking into account the multidimensionality of learning as well as AR as a field, there are a number of aspects that can be considered in the evaluation. In our study, we have evaluated different aspects of the AR game such as: enjoyment and fun, perceived value, usability and sense of presence.

The rest of the chapter is organized as follow. Section 2 presents related works. Section 3 presents the AR game and includes the software and hardware requirements as well as a description of the AR game and the real game. Section 4 presents the results of the game evaluation. Finally, section 5 presents the conclusions, suggestions for improvements and future work.

2. Related work

2.1 Augmented Reality for learning

This is not the first AR system that has been reported for learning, but AR systems have rarely been extensively evaluated. One of the few works that does include an evaluation is Kaufman's thesis (Kaufmann & Schmalstieg, 2003; Kaufmann, 2004). He developed and evaluated Construct3D. It was designed to teach mathematics and geometry. Construct3D was tested with 14 students from two high schools in Vienna. All were 12th grade students. Half of the students were taught geometry using traditional paper and pencil construction methods ("The first group"). The other half ("The second group") used CAD programs regularly in classes to make most of the constructions. Both groups of students (7 students each) used Construct3D for 6 hours in total. The results from two evaluations showed that Construct3D was easy to use, required little time to learn, and encouraged learners to explore geometry.

A research group that has developed several AR systems for learning is the Mixed Reality Lab of Singapore (www.mixedrealitylab.org) (e.g. the Magic Story Cube, the sun system or how plants grow). The Magic Story Cube used a cube as a tangible interface that was folded or unfolded and, depending on the markers that were visible, the story was different. The Magic Story Cube presented the story of Noah's ark. In the sun system, several concepts that are related to the solar system were explained. In the plant system children learned how plants germinate, disperse, reproduce and perform photosynthesis.

Another research group that has also developed several AR systems in this field is the HIT Lab NZ (www.hitlabnz.org). The first one was The Magic Book (Billinghurst et al., 2001). It looked like a normal book, but there were markers on the pages, when the system recognized a marker, an image was shown or a story was started. A second work presented by this group was the AR Volcano. It was a system for learning about volcanoes, which included details on subduction, rifts, the Ring of Fire, volcano formation, eruptions and tectonic plates (Woods et al., 2004). A third work that is worthy of mention is the S.O.L.A.R system. It was an AR system for learning the position of each planet in the Solar System (Woods et al., 2004). Another work developed by this group is the BlackMagic. It was a MagicBook that told the history of the America's Cup (Woods et al., 2004).

Other groups have also been working on the development of different AR systems. For example, Shelton & Hedley (Shelton & Hedley, 2002) developed an AR system to teach the relation between the earth and the sun to geography students. Organic chemistry can also be taught using an AR system (Fjeld et al., 2007). Bimber et al. (Bimber et al., 2001) presented the Virtual Showcase. It placed virtual objects on real artefacts. One of the most outstanding applications was to place skin and bones on the skull of a Raptor dinosaur. Larsen et al. (Larsen et al., 2005) presented an AR system for learning how to play billiards. The most outstanding characteristic of this system was that the game was played on a real billiard table. The purpose of this system was to learn how to play billiards following sequences of exercises that were organized according to the user's level of ability. In 2006, Motokawa & Saito (Motokawa & Saito, 2006) presented an AR system for learning how to play the guitar. The system showed how to correctly hold the strings by overlaying a virtual hand model and lines onto a real guitar.

In 2007, two AR systems were included as activities in the Summer School of the Technical University of Valencia. The first AR system taught children the anatomical structures of the human body. Specifically, the children were able to 'open' the abdomen of a virtual human body using their own hands. They could see the areas where the stomach and the intestine were placed in the human body (Juan et al., 2008a). Forty children aged 8 to 10 years old took part in this activity. The children liked the system and were interested in using it for other educational purposes. The second system was an AR storytelling system for interactive stories where the children could choose how the story developed and the ending (Juan et al., 2008b). A story based on the Lion King was created in this system. The story had eight different endings. The story was shown on two different cubes, one that showed the story over all six faces of the cube and another where the story was only shown over one face of the cube. Forty-four children aged 6 to 8 years old took part in this activity. As in the above case, the children liked the system and were interested in using it for other educational purposes.

2.2 Games and video games

Games and video games have a great potential for learning. Several works have been reported for this purpose. McClean et al. (McClean et al., 2001) studied learning outcomes by comparing traditional lectures, web-based experiences and immersive games. They used a virtual-world-based geology game called Geography Explorer and a virtual-world-based biology game called Virtual Cell. The lectures produced the lowest learning outcomes. In comparison with the lecture method, the games increased learning outcomes by 15%-40% (Geography Explorer) and 30%-63% (Virtual Cell).

For teaching electrostatics, Squire et al. (Squire et al., 2004) used the Supercharged. They compared traditional teaching with teaching using the Supercharged game. They conducted a study with two different groups. In the first group, 32 students learned electrostatics through interactive lectures, teacher demonstrations, observations and experiments. In the second group, 58 students mostly played the Supercharged game during class time while also receiving lectures and handouts. The 32 students in the first group improved their understanding by 15% over their pre-test scores; those who played the game improved their understanding by 28%.

A commercial developed algebra game, called Dimenxian (2005) was used in a study to evaluate the game's learning effectiveness (Mayo, 2007). In the study, the 75 students who played Dimenxian increased their algebra knowledge by one grade (i.e., from B to A). Underachieving students increased their test scores by as many as three grades by playing the game.

Virvou & Katsionis (Virvou & Katsionis, 2008) used the VR-ENGAGE game to teach students geography. They conducted a study of usability and likeability of VR-ENGAGE.

3. Material & methods

To capture the video we used different Logitech cameras: QuickCam Pro 5000, QuickCam Pro 9000 and QuickCam Pro for Notebooks. We used the QuickCam Pro 9000 camera for the tests with the following features: Carl Zeiss lens; captured image size - 1600 x1200 at 30 fps; autofocus system and ultra-high resolution 2-megapixel sensor with RightLight 2 technology. A 5DT Head-Mounted Display (HMD) (5DT Inc., 800 Hx600 V, High 40º FOV) was used as the visualization hardware. Using a screen, the person in charge of the tests could see the same scene as the participant saw on the HMD. The camera was firmly

attached to the HMD on the front part of the HMD. Figure 1.a shows the camera, and Figure 1.b
shows the camera attached to the HMD. To develop the system, we used the OsgART library developed by HITLab NZ (www.artoolworks.com/community/osgart). It is a C++ library that allows developers to build AR applications using the rendering capabilities of Open Scene Graph (OSG) and the tracking and registration algorithms of ARToolKit. OSG is a set of open source libraries that primarily provides scene management and graphics rendering optimization functionality to applications. It is written in portable ANSI C++ and uses the standard OpenGL low-level graphics API. ARToolKit is an open source vision tracking library that allows a wide range of AR applications to be easily developed (Kato & Billinghurst, 1999). The required elements for the application are: a USB or FireWire camera, and a marker. A marker is a white square with a black border inside that contains symbols or letter/s.

(a) (b)

Fig. 1. a) QuickCam Pro 9000. b) Camera and HMD

In the AR game, the virtual elements that appeared over the markers were images and videos of exotic animals. The videos of the animals described the physical characteristics of the animal, its habitat and food. In order to be able to extend the game to other themes with minimum changes, we included as much information as possible in XML external files. We used three different kinds of XML files. The first XML file contained a collection of all the available questions, creating a kind of question database. This file contained a common part for each question which included the following: what the participant has to do when s/he has found the right animal; what to show when the animal is right or wrong; etc. All the questions were stored below the common part. The information required for each question was: the question identifier, the number corresponding to the correct image, the 8 images (possible answers) that appeared over the cubes with their identifiers and image paths, the video path, and the question to ask in order to find the animal. This file also included the textual content in different languages. Part of this file is shown in Figure 2. The second XML file contained the real set of questions to be used in the execution of the game. This file only stored the identifier of the questions that would be asked in the order established in the file. The third XML file was used to store the participants' scores. For the game, we had a total of 10 animals. These animals are: a guanaco, a calao, a cone, a corocoro, a lacewing, a mantis shrimp, a lycaon, a scaly anteater, a sawfish, and a ray. The cubes have a magnet in their interior. This magnet facilitates that two cubes can be held together in an easy way.

```
<questions>
        <common>
                <en>
                        <text type="question"> Select '*' when you find </text>
                        <text type="correct1"> Correct!!! You found </text>
                        <text type="correct2"> Do you want more information? </text>
                        <text type="wrong1">You are wrong.</text>
                        <text type="wrong2">This is not the picture of </text>
                        <text type="start">Select 'SI' to start next question.</text>
                        <text type="end">Select '*' to pass to next question.</text>
                        <text type="quit">Select 'NO' to quit.</text>
                        ….
                </en>
                <sp>
                        // idem for the Spanish version
                </sp>
        </common>
        <question id="1" ok="1">
                <image id="0">images\corocoro\cannareccione.jpg</image>
                <image id="1">images\corocoro\corocoro.jpg</image>
                …
                <image id="5">images\corocoro\ capovaccaio.jpg</image>
                <image id="6">images\corocoro\ grifone.jpg</image>
                <image id="7">images\corocoro\upupa.jpg</image>
                <avi>video\corocoro.xml</avi>
                <en>
                        <text type="question">a corocoro.</text>
                </en>
                <sp>
                        <text type="question">un corocoro.</text>
                </sp>
        </question>
</questions>
```

Fig. 2. Part of the first XML file

The basic steps in the AR game are:

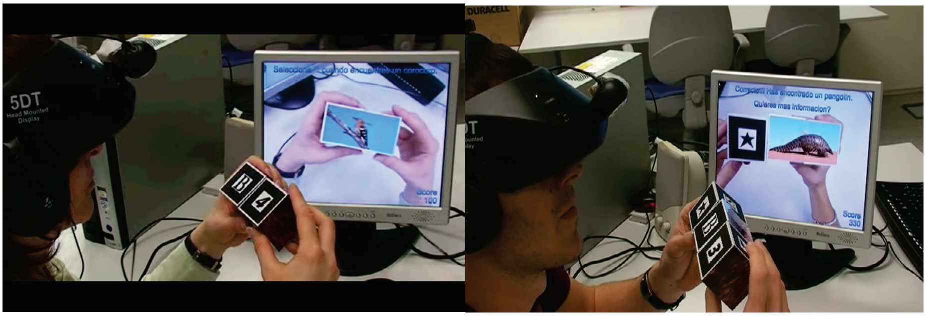
1) Initialization of the video entry and download of the files that contain the pattern and camera data; the XML files containing information related to questions about the animals that are going to be asked about.
2) The game asks the participant to find the first animal by showing the question in the upper area of the screen. The participant turns both the center cube and the cube on the right. The center cube has two markers in two opposite sides (A and B). The cube on the right has four markers in four continous sides (1, 2, 3 and 4). As a result of the combination of the markers of these two cubes, eight different combinations can be used. Therefore, eight different animals can appear over the two cubes. Figure 3 shows the three cubes used in the game.

3) The system identifies the areas where the markers are located (center cube, A/B; right cube, 1/2/3/4). It recognises the visible markers and shows the related animal over them (e.g. Figure 4.a and Figure 5.a). If the participant thinks s/he has found the right animal, s/he has to select the side of the cube on the left that depicts the "*" symbol (e.g. Figure 5.b).
4) If the participant does not find the right animal, the game shows a message indicating this situation and the participant has to try again. If the participant finds the right animal, the game asks if s/he wants to know more about the animal. The participant has to select the side of the cube on the left that depicts "SI" for Yes and "No" for No. If the answer is no, the game goes to next step, 4. If the answer is yes, the game shows a video over the front sides of the center cube and the cube on the right (e.g. Figure 6.a). It explains the characteristics of the animal, its habitat and food. The participant can skip the rest of the video by using the cube with the "*" symbol at any point.
5) The game asks if the participant wants to search for another animal. The answer is selected using the cube on the left as in previous step. If the answer is yes, the game repeats step 2; if the answer is no, the game ends.
6) At the end of the game, the participant receives a score that depends on the number of animals successfully found and the amount of time. The greater the number of found animals and the lower the time, the higher the score. The participants' score is then compared with the ten best scores that are stored in the XML file.

Fig. 3. The three real cubes used in the game

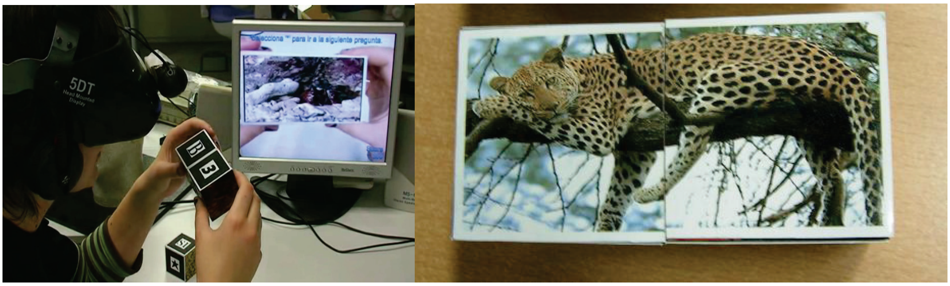
(a) (b)

Fig. 4. a) AR game. A scaly anteater appears on the cubes as an augmented image.
b) The same cube as in Figure 4.a., but without an image



(a) (b)

Fig. 5. a). A woman is trying to find a corocoro. b) A man has found a scaly anteater



(a) (b)

Fig. 6. a). A woman is watching the video about the mantis shrimp. b) Cubes of the real game

In order to validate the AR game, it has been compared with a real game. The basic steps in the real game are:

1) The person in charge of the validation asks the participant to find the first animal (using his/her voice). The participant uses two cubes to find the right animal. The images of four different animals appear as a combination of the faces of the two cubes. The images are real pictures that have been sticked over the cubes. Figure 6.b shows two cubes of the real game.
2) The participant turns the two cubes to find the right image. If the participant thinks s/he has found the right animal, s/he has to select the side of the cube on the left that depicts the "*" symbol (as in the AR game). The person in charge of the validation tells if s/he is right or not.
3) If the participant does not find the right animal, the person in charge of the validation tells the participant to try again. If the participant finds the right animal, the person in charge of the validation asks if s/he wants to know more about the animal. The participant has to use the left cube to interact with the game (as in the AR game). If the answer is no, the game goes to next step, 4. If the answer is yes, the person in charge of the validation shows a page with images and text. The text is the same that the video reproduces. It explains the characteristics of the animal, its habitat and food. The participant can go to the next step by using the cube with the "*" symbol at any point.
4) The person in charge of the validation asks if the participant wants to search for another animal. If the answer is yes, the game repeats step 1; if the answer is no, the game ends.

4. Results

The study included 20 adult participants, 12 males and 8 females (aged from 16 to 44 years old, mean=24.1, SD=5.70). Thirteen participants were Computer Science professionals. None of them was expert in AR. Five participants were employees at the Technical University of Valencia. Another participant was a physical therapist. The youngest participant was a high school student. The study was carried out at the Technical University of Valencia. The participants did not receive any compensation for their time.

Participants were counterbalanced and assigned to one of two conditions:

a) Participants who used the real game first and then the AR game.

b) Participants who used the AR game first and then the real game.

The protocol was the following. Before using either game, the participants were shown an explanatory video about how to play the games. The participants then played the first game. After the game, the participants were asked to fill out a post-game questionnaire and an adapted version of the presence questionnaire by Slater et al. (Slater et al., 1994). After filling out the two questionnaires the participant played the second game. After playing, the participants were again asked to fill out the post-game questionnaire and the same presence questionnaire. Finally, they were asked to fill out a final questionnaire. The participants played with the AR game at about 15 minutes and with the real game at about 10 minutes. The post-game questionnaire had to be answered on a scale from 1 (not at all) to 5 (very much). The post-game questionnaire contained the following questions and statements. The questions are grouped by the aspect to evaluate.

Enjoyment and fun

AG1. Does the game seem fun to you?

AG2. Did you like seeing the questions/images/videos over your hands and the fact that you could move them?

Perceived value

AG3. Would you like to use this game for other subjects, e.g., plants, monuments of the world, etc.?

AG4. Do you think your friends would enjoy playing this game?

AG5. Would you like to play again another day?

Usability

AG6. Has it been easy to play?

AG7. Did you like using the cube for communicating with the game?

AG8. Was it easy to perform selections using the cube?

The presence questionnaire contained the following questions. The scoring was on a scale of 1-7.

P1. Describe on a scale of 1 (none)-7 (total) the level of sensation of reality that you had when the images and videos (in the AR system) appeared on the cubes?

P2. Were there moments during the game when you thought that the images on the cubes were real pictures?

P3. When you think back to your experience, do you remember the game more as a film you saw or more as a game you played?

P4. Think about your memory of "playing with cubes on which images and videos appeared". How similar is this memory to your memories of playing with other similar games?

P5. During the experience, did you often think that you were actually playing with cubes on which images and videos appeared?

The final questionnaire contained the following questions:

A2P1. Which game did you like the most?

A2P2. Did you feel comfortable wearing the HMD?. The scoring was on a scale of 1-5.

A2P3. What did you like the most?

A2P4. What did you like the least?

This work evaluated different aspects of the AR game: enjoyment and fun, perceived value, usability and sense of presence. To do this, we compared subjective measures taken in a real game and in the AR game. Table 1 shows Student t tests for the scores given to the post-game questionnaire after playing both games. The last row indicates whether there was a statistical difference between the two games for the related question. As this table shows, there was a statistical difference for questions 1-5, 7. For enjoyment and fun (AG1, AG2), the results indicate that participants perceived the AR game as being more fun than the real game (AG1). They liked the AR game more than they liked the real game since they could see the questions/images/videos over their hands and they could move them (AG2). For the perceived value (AG3), the results indicate that participants preferred the AR game for its use for other purposes. They also thought that their friends would enjoy playing the AR game more than playing the real game (AG4). In addition, they would prefer to play with the AR game again (AG5). For usability, we have included AG6-AG8. There were no statistical differences between the two games for AG6 and AG8, indicating that the perceived level of easiness was similar for the two games. There was a statistical difference between the two games for AG7, indicating that participants liked to play using the cube for communication with the AR game more than they liked to play using the real game.

In order to determine whether or not the order of play had an effect on the scores in the second game, the sample was divided into two groups (participants who used the real game first and participant who used the AR game first) and Student t tests for the scores given to all questions were applied. No significant statistical differences were found using the AR game (see Table 2). This indicates that the order of play did not influence the participants' scores for the post-game questionnaire. With regard to the real game, no significant statistical differences were found for questions 1-4, 6-8 (see Table 3). This indicates that the order of play did not influence the participants' scores for the post-game questionnaire. The only question that presents a significant statistical difference was AG5. This indicates that the participants liked the real game for playing again if it was played first.

Questions	**AG1**	**AG2**	**AG3**	**AG4**	**AG5**	**AG6**	**AG7**	**AG8**
AR	4.05± 0.76	4.75± 0.44	4.05± 0.83	3.7± 1.03	3.6± 0.75	4.15± 0.99	4.35± 0.81	4.05± 0.89
Real	2.4± 0.82	2.95± 1.05	2.75± 1.07	2.2± 1.11	2.35± 0.99	4.2± 1.15	3.1± 1.17	4.00± 1.03
Stat. t	8.43	8.01	5.38	6.10	6.14	-0.18	4.63	0.18
Critical t	2.09	2.09	2.09	2.09	2.09	2.09	2.09	2.09
Statistical difference	Yes	Yes	Yes	Yes	Yes	No	Yes	No

Table 1. Student t test for scores given to the post-game questionnaire after using both games, $\alpha=0.05$

Questions	AG1	AG2	AG3	AG4	AG5	AG6	AG7	AG8
AR First	3.90± 0.88	4.70± 0.48	4.10± 0.74	3.40± 1.27	3.70± 0.68	4.20± 1.03	4.40± 0.70	4.10± 0.88
AR Second	4.20± 0.63	4.80± 0.42	4.00± 0.94	4.0± 0.67	3.50± 0.85	4.10± 0.99	4.30± 0.95	4.00± 0.94
Stat. t	-0.88	-0.49	0.26	-1.33	0.58	0.22	0.27	0.25
Critical t	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10
Statistical difference	No	No	No	No	No	No	No	No

Table 2. Student t test for scores given to the post-game questionnaire after using the AR game, α=0.05

Questions	AG1	AG2	AG3	AG4	AG5	AG6	AG7	AG8
Real First	2.70± 0.82	3.4± 0.84	3.10± 1.20	2.60± 1.27	2.80± 1.14	4.20± 1.14	3.00± 1.16	4.20± 0.79
Real Second	2.10± 0.74	2.50± 1.08	2.40± 0.84	1.80± 0.79	1.90± 0.57	4.20± 1.23	3.20± 1.23	3.80± 1.23
Stat. t	1.72	2.08	1.51	1.70	2.24	0.00	-0.38	0.87
Critical t	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10
Statistical difference	No	No	No	No	Yes	No	No	No

Table 3. Student t test for scores given to the post-game questionnaire after using the real game, α=0.05

For the sense of presence, table 4 presents the data for the presence questionnaire. It shows Student t test for the scores given after playing the two games. The analysis of the data indicates that there is no significant statistical difference between the two games. This implies that participants perceived the AR game as being real. In order to determine whether or not the order of play had effect on the scores in the second game, the sample was divided into two groups (the group of participants who played the real game first and the group of participants who played the AR game first). Student t tests for the scores given to all questions were applied. No significant statistical differences were found (see Table 5). Therefore, the order of play did not influence the participants' scores for the presence questionnaire.

Presence questionnaire	P1	P2	P3	P4	P5
AR	5.90±0.91	5.75±1.45	5.70±1.66	3.55±2.16	6.05±1.43
Real	5.75±0.79	5.80±2.04	5.90±1.83	4.25±1.97	4.95±2.28
Stat. t	0.55	-0.09	-0.33	-0.97	1.79
Critical t	2.09	2.09	2.09	2.09	2.09
Statistical difference	No	No	No	No	No

Table 4. Student t test for scores given to the presence questionnaire after playing the two games, α=0.05

Presence questionnaire	P1	P2	P3	P4	P5
AR First	6.00±1.05	5.70±1.70	5.20±1.87	3.30±2.31	6.50±1.08
AR Second	5.80±0.79	5.80±1.23	6.20±1.32	3.80±2.10	5.60±1.65
Stat. t	0.48	-0.15	-1.38	-0.51	1.45
Critical t	2.10	2.10	2.10	2.10	2.10
Statistical difference	No	No	No	No	No

Table 5. Student t test for scores given to the presence questionnaire playing the AR game, α=0.05

With regard to the final questionnaire, we included the question: Which game did you like the most? (A2P1). All the participants (100%) liked the AR game most. For the question: Did you feel comfortable wearing the HMD? (A2P2), the participants' score was 3.50±0.95 on a scale from 1 to 5. For the question: What did you like the most? (A2P3), several answers included:

- Communicating with the computer using the cubes
- Watching the videos on the cubes
- Using the HMD
- The system ran very well
- The person in charge of the test was very professional
- The animals were very rare and I had not previously heard about hardly any of them
- The game was very different to the games I have seen until now.

For the question: What did you liked the least? (A2P4), several answers included:

- The HMD was big and heavy
- The theme of the game
- The system was not comfortable
- I got dizzy
- The style and size of the letters because they were not easy to read
- Some of the questions were difficult to understand.

5. Conclusions

We have presented an AR game that uses magnet and tangible cubes as the user interface to learn about different exotic animals. AR systems for learning have been cited in the related work section, but these systems have rarely been extensively evaluated. In this work, twenty participants took part in a study in which different aspects were evaluated (enjoyment and fun, perceived value, usability and sense of presence). First, for the fun aspect, the results indicate that participants perceived the AR game to be more fun than the real game. All the participants (100%) liked the AR game most. Second, for the perceived value, the results indicate that participants preferred the AR game for its use for other purposes. They also thought that their friends would enjoy playing the AR game more than playing the real game. In addition, they would prefer to play with the AR game again. Third, we evaluated usability. The perceived level of easiness was similar for the two games. The participants liked to play using the cube for communication with the AR game more than they liked to play using the real game. Usability is considered as an important technical factor that affects educational effectiveness (Jones et al., 1999; Squires, 1999). For example, Kaufman

(Kaufmann & Schmalstieg, 2003; Kaufmann, 2004) evaluated usability using a question similar to ours: ‘It is complex/easy to use’. Kaufman’s results were 2.36±0.50 on a scale from -3 to +3. His result is not comparable to ours because the two systems are very different. However, we consider this question and the identification of usability to be important factors in AR systems. In our case, the score assigned to the real game was nearly the same as the AR game score, the participants did not report significant differences between the two games. This implies that the participants consider the AR game to be easy to use. Fourth, the sense of presence was evaluated. The presence questionnaires indicated that the AR game induced sense of presence in participants and that this sense of presence was similar to what they felt in a real environment. The main objective pursued in any VR or AR system is that the feeling of presence in a VR/AR environment be similar to the real world. These results are in accordance with those obtained by Usoh et al. (Usoh et al., 2000). These authors found nonsignificant differences in presence measures between real and virtual environments.
An aspect to highligth is that the interaction with the system is achieved using the tangible interface (cubes). The user does not touch the keyboard or the mouse to interact with the system. The partipants liked to play using the cube for communication with the AR game (AG7) more than they liked to play using the real game. Moreover, this interaction was one of the aspects of the AR game that participants like the most as several answers to this explicit question (A2P3) corroborate.
Although we have not evaluated our game as a pedagogical tool, we think it could be a good alternative for learning. Therefore, an exhaustive pedagogical evaluation could be performed. This would provide a more significant contribution to educational systems, particularly AR educational systems. The game can also be improved in several ways. First of all, we used monoscopic visualization. A stereoscopic visualization would be desirable. Second, the picture of animals could be substituted by 3D animals so that the participants could see the animals from different points of view. Third, with this game, it could be possible to teach/learn other subjects, such as plants/monuments of the world/etc. using different methods for classification. Changing these features is especially easy in our game because of its structure. The game could be used for other purposes and the results could be compared with the ones obtained in this work. Finally, several participants were of the opinion that the HMD was heavy and uncomfortable. It only weighs approximately 600 grams. Nevertheless, lighter HMD or other visualization systems could be considered.
To sum up, this system and other AR systems aimed for learning developed by the research group and other groups demonstrated that AR can complement successfully traditional teaching in a ludic way. However, more work has to be done in order to consolidate AR as a tool for learning.

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11

New Ways for Learning and Knowledge Transfer Using Social Semantic Technologies

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1. Introduction

The history of technology enhanced learning has started about 15 years ago. But it kicked off far earlier if we consider early learning machines such as the one developed by F.B. Skinner as technology. All technology developments have been accompanied by conceptual developments. In the beginnings, the notion of technology enhanced learning was to provide standardized learning material using monolithic systems, referred to as learning management systems. But this was just a one way provision with an author on the one side and a consumer, the learner, on the other. Sometimes technology enhanced learning consisted of simple websites containing content intended for learning. Today we find service-based collaborative modular systems. But not only technologies have changed. Also the concept of learning has gone through various changes. Originally, learning was very much dominated by its formal character, while in the meantime informal learning has evolved as a more promising way to learn. It was the paradigm shift from behaviourism to cognitivism and to constructivism which has triggered this change, which was further accelerated through the new technology developments (Tochtermann & Granitzer, 2008).
The importance of technology enhanced learning is also well documented by European Research Programmes (Framework Programmes 6 and 7). One of the reasons why corresponding research has been heavily supported by the European Commission lies in the fact that *the change of working condition and the high-speed evolution of information and communication technologies, peoples' knowledge and skills need continuous up-dating*[1]. For the current 7th Framework Programme, challenge 4 Digital Libraries and Content explicitly mentions in its working documents that *the challenge, therefore, is to harness the synergies made possible by linking content, knowledge and learning*[2].
Both statements support our notion that learning is more than consuming defined content in order to reach a pre-defined learning goal. Instead, it is more about continuously acquiring, generating, applying and even sharing knowledge and not so much about conscious and intended consumption of content.

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[1] http://cordis.europa.eu/ist/telearn/index.html
[2] http://cordis.europa.eu/ist/kct/fp7-challenge4-excerpts.htm

Thus, the emphasis of this contribution is on supporting new ways of knowledge transfer, with a special focus on supporting knowledge activities directly at the work-place in accordance with the current needs of the employee – or as we will call them throughout the remainder of this paper – the knowledge worker. In our opinion, solutions which support the knowledge worker on demand reach from simple applications to complex systems. In chapter 2 we briefly introduce the need for workplace learning and knowledge transfer. How knowledge transfer can be supported through Social Software, Semantic Technologies, and a combination of Social Software and Semantic Technologies, is discussed in chapter 3, 4, and 5, respectively. In chapter 6 we present our conclusions.

2. Learning and Knowledge Transfer at the Workplace

One success factor for efficient knowledge work is the availability of information relevant to a specific task at the time the knowledge worker needs it. As long as knowledge workers only use resources from their local working environment (e.g. her PC), they can produce good results, assumed that her personal knowledge management is good. But real life is more complicated. Even if the knowledge worker could exactly define her information needs, which often is not the case, she will encounter problems in finding what she needs to fulfil her information need. Usually corporate information is distributed among repositories, available in the intranet, the internet, and is even held by people. Every time the knowledge worker has information need, she has to interrupt her work to spend some time for searching the required information.
To better support knowledge workers, our vision is that of software systems ob-serving the activities of the knowledge worker, deriving their information needs, mining distributed resources and finally providing the knowledge worker with information relevant for her current situation. And this vision is about to become reality: In the European Project APOSDLE such a comprehensive software system is currently being developed and evaluated [http://www.aposdle.org]. But also smaller solutions exist which could support the employee in her daily work. For example, a Wiki can help with documenting working experience and providing knowledge shared among different people. Ontologies can help to better organize workplace related information. In our notion, the optimized next-generation workplace learning and knowledge transfer solutions, be it extended systems or single applications, will have three key features in common.

- Adaptation to current information needs
- Support of informal learning
- Detection of user context

In the following sections we will further justify and explain in depth these key features (Lindstaedt & Ulbrich, 2006).

2.1 Needs Orientation

Normally, organizations are interested in maximizing the productivity of their employees. A study (Brakeley et al., 2004) with 244 executive managers showed that 69% of respondents judge measures for increasing employee productivity as the most relevant task of human resource management. Concerning training initiatives 77% of the respondents find it most important to align training with organizational goals and 75% state that learning contents match the needs of the employees. However, only 14% report satisfaction about the way how training is aligned with organizational goals and needs.

Workplace-integrated solutions can especially help concerning the orientation on learning needs, since needs oriented support is their philosophy. By providing the knowledge worker with resources matching her current requirements, knowledge acquisition is facilitated and thereby one central precondition for increased productivity is established.

2.2 Informal Learning

Another argument for workplace learning solutions comes from the role informal learning takes in working. Usually, employees apply less than 30% of the knowledge acquired in formal learning situations to their later everyday work (Robinson, 2003). About 80% of the knowledge needed for individual work is acquired in informal learning situations (Raybould, 2000), (Cross, 2007). The proportion of formal learning as opposed to informal learning is only about 10%-20% of learning at work (Cross, 2003). Obviously, informal learning is highly relevant in the context of knowledge transfer and acquisition. Hence, there should be corresponding support. These facts are also confirmed by the Business Intelligence Industry Report 2007 published in the Chief Learning Officer Magazine (CLO, 2007). Respondents estimated the percentage of informal learning to be up to 70%. With this in line, there is also the intention to place more emphasis on informal learning. Even though classroom training was said to be the most widely used method, at least 40% of the respondents reported a decrease of this method during the last 12 to 18 months prior to the survey, and 72% and 62% expected an increase in asynchronous and synchronous eLearning, respectively.

Against this background workplace learning solutions are an interesting option. They aim at supporting knowledge workers in their informal knowledge transfer activities, even though supporting measures are organized through formal structures.

2.3 Context Awareness

As Cross states human conversation is the most powerful technology for knowledge transfer (Cross, 2007). Its power is based on the fact that in communication people usually adapt to their counterparts. Knowledge transfer happens according to the knowledge and experiences of the vis-à-vis. While a novice is given basic information helping to develop understanding, an expert is given extra information widening her knowledge horizon or providing inputs for reflection.

As said before, context detection is also considered to be one key feature of work-place learning solutions. By observing the behaviour of knowledge workers in the sense of used applications, visited websites, current tasks or processes, the context is detected and supporting content can be provided accordingly. When we talk about con-text, we distinguish among three context types: the domain context representing the topic in which work is embedded, the process context representing activities that cumulate to working processes and workflows, and the user context which refers to the knowledge worker herself. Concerning these contexts – in (Lindstaedt et al., 2005) the domain, process, and user context are summarized under the term *3spaces* – various aspects such as competences, acquired knowledge, goals, roles, or tasks are distinguished. In (Jameson, 2001), (Klemke, 2002) and (Schmidt, 2004) different schemata have been described.

In the following chapters 3, 4, and 5 we would like to give an idea about how latest technologies, namely Social Software, Semantic Technologies and the combination of them, Social Semantic Technologies, might be used for supporting the knowledge worker in her daily work. Each chapter starts with an introduction to the technology in question. Chapters 3 and 5 rely on use cases which are reported in scientific literature. Since Social Semantic Technologies are not a commonly used and applied solution yet, only scenarios, and no use cases about their potential utilization are sketched. Most of the use cases and scenarios meet the key features need and informal learning. To a lesser extent they address the key feature context. Also, the solutions are not necessarily machine-aided as the description of the key features might have suggested. However, we think that because of their relative simplicity they are of particular interest for small and medium sized companies that neither have the large number of users nor the amounts of content which machine-aided solutions usually require.

3. Social Software

3.1 A Brief Introduction to Social Software

About three years ago, technologies and concepts summarized under the term Web 2.0 emerged. Since then they have attracted increasing attention, not only for the private but also for the corporate sector. The term Web 2.0 was coined by Tim O'Reilly and colleagues when they prepared a web technology conference in October 2004. It should address the next generation of the world-wide web, a social web. The Web 2.0 is made up of services and users redesigning the web as a platform for these users and services. The term architecture for participation accurately describes the idea behind this. O'Reilly tries to define the Web 2.0 through eight design patterns: the long tail, data is the next intel inside, users add value, network effects by default, some rights reserved, the perpetual beta, cooperate do not control, software above the level of a single device (O'Reilly, 2007). In general, the Web 2.0 is built upon the three pillars content, community, and services, embraced by networking.

Web 2.0 can be seen from two perspectives. One perspective – and this was the basic idea – refers to a business model. Enterprises that build upon the eight design principles belong to a new group of Internet based businesses. Web 2.0 undertakings are Xing, Salesforce, Innocentive, or 23andMe, just to mention a few. The other perspective also summarizes individual applications under the term Web 2.0. They need not necessarily make up the business model of an enterprise. Social Software is only a part of the Web 2.0 but sometimes used synonymously with it . Social Software supports and enables interpersonal communication, interaction and collaboration and it is characterized by a high degree of self-organization of the users involved. The idea behind Social Software is that users produce content and make it available free of charge and with new copyright models (e.g. creative commons) for reuse by other users. Wikis and Weblogs are the best known examples for Social Software. But Social Software goes far beyond these two applications. Also Internet Relay Chat, Internet Forum, Instant Messaging, Social Bookmarking, Social Media Sharing, Social Task Sharing, Social Networking Services and Engines, and even Massive Multiplayer Online Games can be classified as Social Software.

3.2 Social Software Applied to Learning and Knowledge Transfer

While in the beginnings companies were reluctant to integrate Social Software in their business environment, many corporate best practice examples exist today. McAfee presents the results of a survey among students of an MBA class at Harvard Business School (McAfee, 2008). 50% of the 36 students surveyed reported that they would introduce social applications such as bookmark sharing, networking or prediction markets. 44% reported that they would introduce Wikis and 22% Blogs for accelerating setting-in of new employees, fostering cross-project, cross-department and even cross-company knowledge sharing and capturing and preserving organizational learning. In the following we outline three real-world examples. In each example the challenges are described and a Social Software solution addressing these challenges is introduced.

Training

Distributed sales organizations, e.g. in the automotive industry, face the challenge of holding their staff up-to-date on new car models, special campaigns or new technologies and of course related customer questions. Continuous training is needed but often not possible. Training requires travelling which means that employees are absent from work for some time. Sometimes costs for this absence even exceed training costs. Further problems consist in the well known fact that only fractions of the knowledge acquired in training are transferred to work. And even if transfer is successful, it is not sustainable.

For meeting these challenges the car manufacturer Opel (Magnus & Hatz, 2008) decided to use Podcasts. The procedure of Podcast production was as follows. The Podcast team gathered information by calling sales staff, by analyzing training and seminars, or through media research. All the gathered information was documented in a Wiki. Important topics were selected for Podcast production which happened every two months in advance. The MP3 files were made accessible on a server for consumption on MP3 players, laptops, CD-ROM, or mobile devices. This most innovative idea for training was widely accepted among the participants. After the pilot phase 89% of participants judged the project as success; 83% found the medium appropriate. 94% listened to each Podcast. Podcasts were consumed briefly after publication, and users listened to the Podcasts during work, at home, on their way to work, and some even during sports. Because of the great success of the pilot project a company-wide roll-out started in May 2007.

Leveraging employee knowledge

Today companies are under pressure to react immediately to upcoming trends and challenges. Since a wealth of knowledge lies inside their staff, an ambitious task is to leverage this knowledge, which of course is not that easy. Even though a lot of knowledge is documented explicitly, a huge amount remains implicitly in the heads of the people. Therefore it is often not clear who is an expert and thus can be asked for advice. And even if experts are known, their knowledge would be also interesting for all colleagues and not just the one who had the related knowledge deficit.

Namics AG, an IT and Web Service provider, applied the following approach (Hain & Schopp, 2008) in order to leverage the knowledge of their employees. When someone had a question, she sent an email to all. People who could answer the questions replied there answer to all too. This of course resulted in a flood of emails out of which only a fraction was relevant and interesting for the employees. To meet this problem it was decided to introduce multiple Weblogs addressing different topics to which employees could subscribe. Weblog posts could be written within the Weblog software or an email could be sent to the

Weblog. The employee who had a question could decide whether all colleagues should be informed by email about the post or if only subscribers should receive an email. Also the answer could be given by email which was sent to the Weblog and attached to the initial blog post. Since questions and answers were collected within one Weblog and related to each other, highly relevant and sustainable knowledge could be easily exported to a knowledge database for long term utilization. The main advantage of this solution was the introduction of the pull principle meaning that employees could decide which information they wanted to receive. Moreover, because of the easy assignment of provided information, author and experts could be better identified. A lesson learned from this project was that a solution should be attached to existing processes and that user acceptance and not technology should guide the selection of the solution.

Documenting and distributing key knowledge

Usually companies store their knowledge across various systems such as knowledge or content management systems, file systems, or other repositories. This results in common problems. Uploading is an additional effort for each user as is updating of the systems. Often the structures are not intuitive and might even be different for each department, not to mention information which is isolated and not linked to each other. Because of such difficulties employees tend to store their documents locally or on other systems than the dedicated system. Delays in or the impossibility of finding relevant information, decreases productivity and in turn weakens the competitiveness of a company.

The Inhouse Consulting Department of the Deutsche Bahn AG faced similar challenges (Mielke et al., 2008). Its main goal was to have a functioning knowledge management system where they could document and distribute a) knowledge relevant for the fast development of services, b) knowledge that was only available in individual employees or small groups of employees, and c) knowledge which could only be acquired with high personnel, time and financial efforts otherwise. In order to allow multiple perspectives on the knowledge base, the knowledge items should be linked to each other. Moreover, the system should be easy to use, should mimic a knowledge bazaar and not a static library, and should enhance communication among the employees. These requirements led to the selection of a Wiki as knowledge management system. In a sophisticated introduction process including change management measures the Wiki was successfully implemented.

Of course, the application of Social Software can go beyond supporting individual business processes within organizations. There are also examples where the entire business model is based on Social Software. Such an example is neurovation.net. This platform mainly supports the community based development of ideas. The individual user can post a challenge, invite other users to think about this challenge, and gets back ideas and solutions which she probably would not have been able to create her-self. How this platform works and how it was developed is outlined in (Stocker et al., 2008).

4. Semantic Technologies

4.1 A Brief Introduction to Semantic Technologies

Semantic Technologies refer, as the name suggests, to technologies which help giving meaning to data. Even though Semantic Technologies need not necessarily be tied to the Web, the first applications had their focus on Semantic Technologies for the Web for which reason we talk about the Semantic Web. Machine-processable data is at the centre of the

Semantic Web. Because of its formal and coherent description, this data can be processed by machines in a meaningful way. For these purposes data must be application-independent, composeable, classified, and part of a larger information ecosystem according to (Daconta et al., 2003). Contrary to Social Software which mostly deals with social connections and human readable content, the Semantic Web deals with formal content and its formal connections. Three problems suggest that there is a need for Semantic Web technology.

- Today information overload is a common problem. The information quantity continuously increases, but the human information processing capacity does not. For that reason, it becomes more and more difficult to select relevant data and draw well informed decisions.
- Usually data are stored in monolithic systems, also called stovepipe systems. This raises difficulties when it comes to sharing data across databases. Searching and finding remain restricted to the individual systems. It is the work of people to connect and integrate data which yields dissatisfying results. This is a problem in every day work, but much more of a problem as regards security and surveillance.
- The need for content aggregation causes the third problem. Even though it can be done on an HTML basis, it is not yet possible to aggregate content concerning its meaning.

Humans of course can handle these problems, since they are able to filter, infer, map, and combine content, but only on a small scale. Machines cannot do that, even though principally they would have the capacity. And this is exactly the vision of the Semantic Web. According to this vision, machines will process information in a meaningful way with the meaning coming from a defined structure of the data. The main technologies which will empower machines »to understand the meaning of data« are XML, RDF, the corresponding schemata, and Ontologies. For a better understanding we will briefly introduce these concepts but not go into the details, since details are out of the scope of this contribution.

XML

The eXtensible Markup Language (XML) has been recommended as a set of syntax rules for hierarchically structured data in 1998 by the World Wide Web consortium (W3C). The latest (fourth) edition of XML 1.0 has been published in 2006[3]. XML has originally been designed as a language for describing the structure and the syntactic elements of very large electronic publications such as manuals provided by aircraft manufacturers. In the meantime it has turned out that XML is at least equally well-suited for exchanging very *small* portions of information between different services on the Web.

A piece of data or document written in XML can automatically be examined if it first, conforms to a number of general construction rules for documents (i.e. if the document is 'well-formed') and if it second, conforms to a specific grammar, which has been designed for a given use case (i.e. if the document is 'valid'). XML can therefore be used for applications, which need to make sure that the information exchanged with third parties is predictable with respect to the document's structure and correct with respect to the document's syntax (cf. (Daconta et al., 2003)).

[3] http://www.w3.org/TR/2006/REC-xml-20060816/

RDF

The Resource Description Framework (RDF) is a model for expressing 'sentences' made up of subject, predicate and object[4]. Technically speaking, these sentences are referred to as 'RDF triples'. RDF triples can be used to make factual statements about the subject of a sentence and express relationships between subjects and objects. An example for this would be the following sentence: ('Gisela Granitzer' 'is an author of' 'this article'). Typically, subjects, predicates and objects are codified as unique identifiers of remote resources in the form of so-called Uniform Resource Identifiers (URIs, e.g. http://www.know-center.at). Thus, virtually anything, which can be identified uniquely by an URI, can also be a part of an RDF statement (Daconta et al., 2003). Objects as well as predicates can be used as subjects in different statements which gives a net like structure, a so-called semantic net, that allows for drawing conclusions.

Ontologies

RDF lacks basically two properties: first, it does not provide means for stating to which class an RDF element belongs. And second, it does not provide language-inherent means to control how further information is inferred from assertions made via RDF triples. Both drawbacks are taken care of by further standards of the Semantic Web namely by the Resource Description Framework Schema (RDFS[5]) and the Web Ontology Language (OWL[6]).

RDFS introduces the concept of *classes*. A class is a specification of attributes of an RDF element on an abstract level. RDF elements (subjects and objects) can be defined as belonging to a specific class. The concrete digital 'embodiment' of an RDF element, which belongs to a class, is called an *instance*. Predicates of an RDF triple can also be assigned to classes, although classes for predicates are labelled and treated differently in RDFS. The introduction of a class concept in RDFS makes it possible to conclude automatically that an instance belongs to some specific class based on the instance's properties. RDFS makes it also possible to infer what properties an instance must possess basing on the class to which the instance belongs. RDFS additionally introduces means to specify what classes the subjects (*domain*) and objects (*range*) of an RDF triple must belong to, given a certain predicate.

OWL enhances RDFS even further in that it introduces a number of new language constructs. In concrete OWL adds constructs for classes (e.g. cardinality, enumeration of instances, class membership based on the existence of certain property values), relations between classes (e.g. equivalency, transitivity and symmetry of predicates) and the construction rules of classes (e.g. classes, which are exactly the intersection of two other classes). These constructs have been designed such that they allow relating instances to each other by quantifiers and operators in a way that makes automatic *reasoning* (i.e. inferring further knowledge from existing statements) possible using tree-like logical rules. This is true for the sublanguage OWL DL, which corresponds to a field of logic labelled Description Logic (DL). The other two sublanguages of OWL are OWL Lite (less expressive than OWL

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[4] Please note that several different labels are used for the elements, which make up a triple. Since we find the 'sentence'-metaphor useful in the context of this work, we will stick to the label 'subject', 'predicate' and 'object' for the respective elements.

[5] http://www.w3.org/TR/rdf-schema/

[6] http://www.w3.org/TR/owl-features/

DL) and OWL Full (more expressive than OWL DL but statements are not necessarily logically decidable).

OWL, RDFS and RDF together are sufficient to make up an ontology upon which ontology-aware applications can be built. An Ontology in the context of this contribution is therefore a construct, which specifies how statements are made, what elements they can contain and what logical rules are defined in order to interpret statements properly for drawing further conclusions from them. A piece of software, which commits itself to a given ontology states that the outputs it produces via its computations are logically consistent with the specifications and rules of the ontology no matter how the data are represented by the software internally (Gruber, 2008).

4.2 Semantic Technologies Applied to Learning and Knowledge Transfer

This section describes examples in which semantic technologies provide a solution to challenges at the workplace. Each example includes a brief description of the challenge and introduces a solution based on semantic technologies. Details are not given, since the purpose is to give an idea and highlight that semantic technologies are meaningful instruments.

Competence matching

As it is stated in (Colucci et al., 2007), competencies held by human resources make up the core of knowledge intensive organizations. Personnel can be understood as knowledge ware-house. If required competencies are not available the organization has two options. One is to hire external personnel. The other is to build up the required competencies within the organization. In both cases the organization has to specify its needs and find resources that can satisfy the competency needs. In the understanding of that article the resources can consist in either external personnel or learning objects which help to build up the competencies in internal personnel. In order to satisfy a knowledge need, professional profiles and learning objects must be mapped to each other.

(Sicilia, 2005) introduces a very interesting approach to competency gap analysis based on ontological descriptions. Competencies are taken from established catalogues of competency descriptions such as O*Net. They are on the one hand mapped onto professional profiles of job situations (organizational needs) and on the other hand onto employees' profiles (competency model of employee). Both profiles are constructed using an integrative ontological schema, namely a taxonomy of terms used for labelling competencies. Therefore professional profiles and employees' profiles are comparable and allow for inferring an employee's competency gap with respect to a given job situation. Moreover, competencies are related to each other according to their prerequisite-dependencies, thus allowing inferring a meaningful competency gap although competencies might not explicitly be addressed in either one of the profiles involved. (Ley et al., 2008) and (Ley et al., 2007) describe an ontology-backed approach on matching professional profiles and employees' learning history profiles in the domain of work-integrated learning. They enhance the approach shown above in that they apply an Ontology in OWL DL (not merely a taxonomy of terms) as a schema used in professional profiles as well as in persons' profiles.

Personal Information Management

For enhancing productivity and competitiveness personal information management is as crucial as corporate information management. The employee is dependent on finding and recalling information within her emails, files, contacts, bookmarks, and other resources

(Sauermann et al., 2007). Of course there are categorization schemata such as file system or email folders, or tags. However, these schemata are keyword oriented, while cognitive models are more complex and not only based on taxonomies. For the knowledge worker it would be helpful to organize her information according to her individual mental model. Against this background, in (Sauermann et al., 2007) a framework for personal information models was developed. Based on RDFS as representation language multi layer Ontologies representing concepts and documents are used which are in the current attention of the user. Basic concepts such as time, place, people, organizations, and tasks are pre-modeled and can be extended by the user at will, to express their mental model. Items can be assigned to multiple concepts, extending the limitations of current hierarchical file system.

Retrieval of relevant information

Not only must organizations satisfy their competence needs or must employees organize their information in an optimal way, but also do knowledge workers depend on finding information, which match with their current information needs. According to the vision of the Semantic Web, retrieval can be optimized by the semantic enrichment of resources (Scheir et al., 2007). However, resources are sparsely annotated with semantic information. To bypass this problem semantics must be introduced differently. In (Scheir et al., 2007) associative retrieval is suggested for solving the problem. Associative retrieval comprises techniques which help to find information that is somehow associated with information already known to be relevant. It is based on the principle that starting from one node activation spreads across a network consisting of nodes and edges. Nodes that are tightly connected to the starting node are reached first and thus are most relevant compared to the starting node. In the described showcase some resources are annotated with concepts of a predefined Ontology, while others are not. Two layers were used, a document and a concept layer. Documents were connected to each other by text based similarity, and concepts were connected to each other by semantic similarity. Additionally, document nodes were connected to concepts nodes. So, if a query starts with a term matching a concept, starting from that concept the network is activated. Or if a query starts with a term only matching the text in a document, activation would spread over the network starting at that document.

5. Social Semantic Technologies

5.1 A Brief Introduction to Social Semantic Technologies

As the above descriptions show, the Web 2.0 can be associated with a human web, which in particular builds on user generated content and networks of people, while the semantic web constitutes a machine-readable web of data. In most recent years, however, one can observe an increasing convergence of social media and semantic systems to a Social Semantic Web (Pellegrini & Blumauer, 2007), often also referred to as Web 3.0. There are two variations of the Social Semantic Web: Semantically Enabled Social Software and Socially Enabled Semantic Web (Pellegrini & Blumauer, 2008). The first variation refers to the enhancement of Web 2.0 content by machine processable semantic data. The second variation refers to the collaborative creation of structured (semantic) data. Even though these two variations are conceptually different, they reflect only two sides of the same medal. In the following we will introduce some applications that can be summarized under the term Social Semantic Web.

In the case of Semantic Wikis, the content of a Wiki is mapped to a predefined structure which machines can »understand«. The structure comes from RDF or OWL and goes beyond structured text and hyperlinks. Thereby content is enriched with metadata and relations and thus becomes processable by machines. Common features of Semantic Wikis include (Schaffert et al., 2006) annotated links connecting knowledge elements with the annotations stating the type of association between the elements. Since not only links but also knowledge elements carry metadata, content can be enriched by providing related content. Annotated links can also be searched which helps revealing how information elements are connected. In contrast, when searching for knowledge elements also connections are delivered. Some Semantic Wikis also integrate reasoning support services which deduce information which otherwise would remain hidden to the user.

Also Weblogs convene with Semantic Technologies in the form of structured and semantic blogging. Structured blogging means that machine processable data such as geo-coordinates, contact information, calendar data or keywords enrich the code behind Weblog entries which makes them better searchable. One example is the Word-Press plug-in FOAF (Friend of a Friend) output which analyses Weblog entries and exports identified relationships as FOAF model. Another example is the WordPress plug-in Yahoo!Shortcuts which detects named entities such als locations, persons, organisations, or products within Weblog entries and enriches these entities semantically. User can then add materials such as photos to these entities which makes the information even richer. If an Ontology structures the additional data, we talk about semantic blogging.

Also Community Management can be supported by utilising semantic technologies. Identifying and annotating actors and relations among them and laying this information down in semantic web suitable formats helps finding people with complementary or similar competencies. This can be of interest when someone has to find a co-author or an expert for a joint project proposal. Also, suggestions for possibly interesting communities can be made on this basis. Fravity is such software. It analyses user profiles and depending on the number of common friends users are represented more or less connected to each other. Another approach is followed by Twine. This software analyzes content that a user flags important during her daily work. These contents are enriched with semantic information and are interpreted as interest profiles. These profiles are matched so that recommendations concerning content, people or topics can be generated. A well known project on this topic is Socially Interlinked Online Communities by DERI[7]. In this project an Ontology was developed including the central concepts of online communities such as user, role or post and describing the relations among them. By this coherent description various online communities, even based on different tools such as Weblogs, Chats or Forums are connected to each other. A query would span all these communities and tools yielding e.g. all community statements matching the query.

5.2 Social Semantic Technologies Applied to Learning and Knowledge Transfer

Since it is only about two years that Social Semantic Web applications have come up, according installations in organizations are not common. Just since most recently companies have become familiar with utilizing Social Software. They are not yet familiar with semantic technologies, and even to a much lesser extent with Social Semantic Technologies. This is

[7] http://sioc-project.org/

why currently we can provide only possible scenarios but no real world examples. However, research addressing Social Semantic Technologies is under way. In (Blumauer et al., 2006) the situation of Semantic Technologies has been analysed and in a former and a current research project the authors are concerned with the application of a Semantic Wiki in the context of research communities.

Supporting new employees

Consider an employee who is new to the company: in addition to demonstrating her competence by working in a project, she faces the challenge of learning about the company. A lot of questions are open at the beginning: Which topics does the company deal with? Which partners does the company have? Which colleagues are working on what topics? What kind of projects does the company usually conduct? Usually, the new employee learns about all these things in a step-wise fashion. She reads project reports, talks to colleagues, participates in meetings. Usually, it takes weeks to months until a new employee is familiar with the company concerns. However, it is in the interest of the employer to bring an employee to its full potential as soon as possible. And also the employee can be more productive if she has a complete picture about her working environment. A comprehensive overview about all this information would support this. In order to optimize that overview, in addition to information elements it should also include relations between them. These relations would state the type of connection between information elements. A sound understanding can be built on this basis. Of course, relevant information often is available in knowledge management systems or similar systems. However, these systems usually suffer from rigidity and information elements are neither connected to each other within one system nor across systems. It is a time and resource intensive task finding out which information is archived where and how information elements relate. A Semantic Wiki could be one alternative of preparing company related information in an easy to navigate way. However, the utilization of a Semantic Wiki requires underpinning content with a knowledge structure that meets the individual purpose. Concepts such as project, person, partner, area, and topic as well as relationships among them could make up such a structure. By specifying relations among these topics the accessibility of information would be enhanced. Example relations are: person *works-in* project, person *knows-about* topic, or area *deals-with* topic. A new employee who searches for a certain person would not only find the person and artefacts the person produced, but additional information about that person, namely that she *works-in* certain projects or *knows-about* certain topics would be delivered automatically.

Sharing knowledge across projects

Consider an organization which uses Weblogs for documentation of project work of course excluding legal information such as contracts etc,. Each Weblog includes information about involved partners, personnel, topics, results and publications. These Weblogs serve several functions. All people involved in the project contribute and find information about the course of the project, workpackages, deadlines, outputs, as well as people and partners involved. The executive manager uses the Weblogs for getting a quick overview about the current work progress. Concerning manager tasks such as strategic planning she uses the Weblogs for identifying common interests among partners involved in different projects or trend topics. And sales staff searches the Weblogs for information that can be used for marketing such as partner companies, software for demonstration or publications. This would help them to better understand the various topics which in turn improves the communication towards potential customers. For all of these groups searching the Weblogs for the individually relevant information is a resource intensive task. For the project staff it is difficult to find out which other projects dealt with similar topics or whether partners were involved also in other projects. Information about that could be important for overcoming knowledge deficits or difficulties with partners. For the executive manager it would be an effort to find out which partners work on similar topics within the projects and thus could be linked together for a further, more comprehensive project. This knowledge would be important for talking to the partners and convincing them about the importance of the collaboration. And sales staff would have difficulties finding out which projects had marketable results such as software demonstrations to be used for sales presentations. As introduced in the previous section the solution could lay in enriching the Weblog with semantics. This could be achieved by relating the central concepts used in the context of project work to each other. Therefore a meaningful semantic structure is required. As in the previous example, this structure could include relations such as partner *deals with* topic, project *is about* topic, or person *works in* project. Defining the structure would be less of a difficulty. First of all concepts must be identified based on instances in the entries. Part of the concepts such as person, organization, or products could be automatically identified by named entity recognition. However, the concept *result* referring to software demos, products or services cannot be found out automatically. The same is true for the concept *output* referring to publications of presentations. Such concepts would have to be indicated by the authors themselves. They are requested to enrich the text with corresponding xml tags which could be used by the machine. If then the executive manager would for example search for a topic she would also get the information which partners deal with this topic or which projects are concerned with this topic. From this information she could infer which partners are interested in the same topic and thus might cooperate in a subsequent project. Or she could identify side issues. On this basis she could further research whether these topics are emergent themes or themes which would require less attention in the future.

6. Conclusion

This article showed there are three technological streams delivering great benefits for new ways of learning and knowledge transfer, i.e. Social Software, Semantic Technologies and Social Semantic Technologies. The real world examples and scenarios contributed to a better understanding for how the technologies can support new ways for learning and knowledge transfer. Our assessment is that currently the usefulness of Social Software is highest. Its advantages are the rather simple applications which can be used to solve a variety of problems referring to development, storage, organization, and distribution of information. Semantic technologies have their strengths in the structured organization and retrieval of information. By organizing information according to coherent structures relevant information can easily be retrieved and related information can be provided which makes relations visible to users which would remain invisible otherwise. However, for benefiting from semantic technologies organizations are required to structure their business domain and to reduce information to a manageable number of concepts. Also, the idea behind semantic technologies may sound a bit complex for managers who have to decide whether a tool is used or not. Finally, semantic technologies are often considered to be in a pre-mature experimental status yet. This is also the reason, why social semantic technologies might have the same problem. However, maybe they could be exploited for evangelizing semantic technologies. Since Social Software supports the production of user generated content, it becomes clear that vast amounts of content can be produced at high speed bearing the risk of little usage unless appropriate (semantic) technologies are in place. At the same time it is clear that the produced information is of high relevance for the organizations, since it reflects employee knowledge which otherwise could not be leveraged but is very useful. Ex ante structures cannot be defined if it remains unclear who will contribute which knowledge. And the manual definition of ex post structures is a time- and resource-consuming task. But if in some way structure could be generated automatically the value of semantic technologies would be uncovered.

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12

The Use of XML to Express a Historical Knowledge Base

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1. Introduction

Although the content currently available on the Web is easy for humans to read, it is not easy for computers. To address this, W3C is working on an activity, called the Semantic Web, in which items of content will be given semantic information so that they can be easily understood by computers. The goal of the activity is to convert the "document-based Web" intended for humans to a "data-based Web" that is understandable by computers(World Wide Web consortium, 2001). One effective application of the "data-based Web" to education may be the automatic collection, rearrangement and representation of written materials. For example, in the field of history, there are many records available on the Web, such as scientific papers and databases dealing with history or chronological tables. The descriptions in these records are not designed with the aim of allowing computers to understand or collect data automatically. If information about historical events could be collected and converted into a reusable format automatically, it would be possible to develop educational materials that allow history to be analyzed from a wider range of perspectives than is possible today.

There have been attempts to develop frameworks or languages to describe historical knowledge both in Japan and abroad. In Japan, the Technical Committee on Electrical Technology History of the Institute of Electrical Engineers of Japan, created a database on the history of electrical power system technology, and developed the *Historical Space Modeling Language* (HSML) and a GUI called Mandala for browsing historical information written in HSML(Matsumoto & Yamada, 1998). Outside Japan, the *Historical Event Markup and Linking* (HEML) Project(Robertson, 2006) is developing its own XML schema designed for historical description, and a Web application that displays historical events in a variety of formats, such as chronological tables and maps. In the field of schedule management, iCalendar has been used as an event description format(Dawson & Stenerson, 1998). This resembles the idea of historical description. Now that Web-based software is widely used, there have been attempts to write iCalendar in a manner compatible with Web technology, such as RDF Calendar, which writes iCalendar in Resource Description Framework (RDF), and microformats "hCalendar", which embeds items equivalent to iCalendar in XHTML data.

(a) (b)

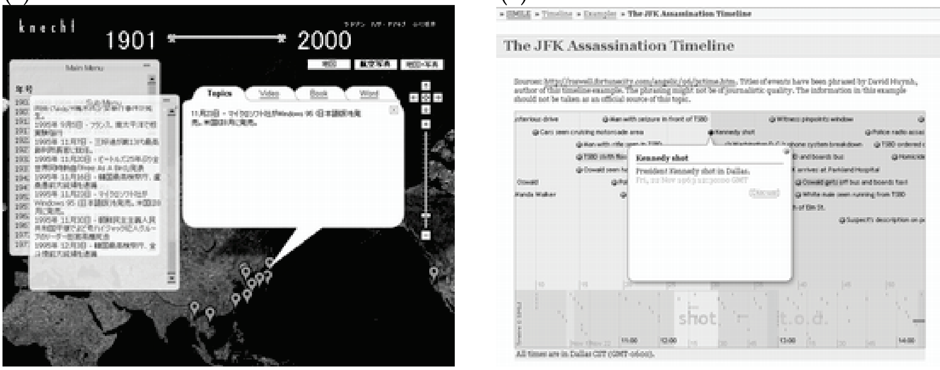

Fig. 1. (a) Knecht Chronicle (b) SIMILE Timeline

Research activities that focus on history include an attempt to liken items in a history study database to the Dublin Core[1], which is a metadata framework for bibliographic information, and to map database items onto its vocabulary(Adachi & Suzuki, 2006). In the field of historical studies, Yaegashi of the National Museum of Ethnology studied the handling of historical information in order to develop a multi-functional history study support system(Yaegashi, 1986; Yaegashi, 1989), and discussed how to process information in historical documents written in disparate formats. Akaishi et al. developed a mechanism for studying documents by accessing different types of information media in multiple databases built on different architectures (Akaishi et al., 1999; Itoh et al., 1999). All these studies pointed out the difficulties in developing an integrated tool because of the diversity of perspectives of researchers and learners of history, and difficulties in ensuring consistency in data because data is created using different architectures. To overcome these difficulties, Fujita et al. (Fujita et al., 1993) proposed a method of supporting the extraction of search information by converting historical text data into hypertext.
In parallel with the development of description formats, there have been attempts to represent historical knowledge in an intuitive, easy-to-understand manner. In Japan, Knecht has developed "Knecht Chronicle", a service that displays historical events on a map by combining different Web services, such as Google and Wikipedia (Figure 1(a)).[2] Outside Japan, in a joint project called SIMILE, W3C, MIT Computer Science and Artificial Intelligence Laboratory, and MIT Libraries have developed, using AJAX, "Timeline"[3], a tool to display a chronological table in a manner that allows intuitive operation using dragging with a mouse (Figure 1(b)). The "Cronus System" developed by the Editorial Engineering Laboratory [4] allows us to see at a glance historical events that concurred in multiple fields. It can position historical events in a 3D space, a capability which enables us to understand the sequence of events and the relationship between different events. The Cronus System can also create historical data by itself, and create relationships between events by linking

[1] http://dublincore.org/index.shtml (June, 2009)
[2] Knecht Chronicle, http://chronicle.knecht.jp/ (June, 2009)
[3] SIMILE. Timeline. http://www.simile-widgets.org/timeline/ (June, 2009)
[4] Cronos System, http://www.eel.co.jp/02_core/002_cronos/cronos.html (June, 2009)

	HSML	HEML	Timeline
Classification	Hierarchical classification is possible by inheriting classes	Possible to write this	None
Time	Specifies year (month, day)	Specifies year (month, day)	Year (month,day, time)
Location	No explicitly (however, possible to write this as part of an attribute)	Possible to write this	None
Person involved	Possible to write developer	Possible to write this	None
Reference information	Possible to write this	Possible to write this	Possible to write this
Other attributes	Possible to write many attributes	None	Display icon

Table 1. Comparison of tags in HSML, HEML and Timeline

customized historical events using lines. Inoue et al.(Inoue et al., 2007) attempted at multi-dimensional representation of information by analyzing and visually presenting historical document data, with no metadata attached, according to the time space and geographical information, and discussed the possibility of such approaches. More recently, a study is in progress to use mobile phones to present historical information visually (Yamada et al., 2009).

As described, there have been a number of attempts to establish ways of representing knowledge of historical events, either by developing description languages or by making relationships between historical events visually understandable. However, there are few tools that can handle causal relationships. Among those mentioned above, only the set of HSML and Mandala by the Institute of Electrical Engineers of Japan can handle them. However, since HSML cannot be used without an HSML interpreter, it is not as readily usable as RDF, which is now widely used. The Cronus System can handle only those data created on the System.

To develop a system that can analyze the rich information resources available on the Web from multiple perspectives, as the Cronus System does, it is necessary to determine an underlying framework for the description of historical events. This paper aims to consider such a method of knowledge representation, focusing in particular on technology history, in which it is easy to find clear causal relationships.

2. Description Frameworks

2.1 description methods

In studying the framework for describing technology history, we first studied event (historical event) description tags. As models for such tags, we studied HSML, HEML, and Timeline, and compared their tag structures. HSML allows its tag structure to be extended to suit the specific application field. The comparison is shown in Table 1. HSML provides the highest expression capability, but its tag types are classified in too much detail for the

Case	Description
Agentive	Role of the person who causes a certain action
Experience	Role of the person who experiences a psychological phenomenon
Instrumental	Role that is a direct cause of an event or that stimulates a reaction in relation to a psychological phenomenon
Objective	Moving object or changing object. Or, role that expresses the content of a psychological phenomenon, such as judgment or imagination
Source	The starting point from which the object moves, and the role that expresses the original state or shape when the state or shape changes
Goal	The goal the object reaches, and the final state or result when the state or shape changes
Locative	Role of expressing the location where an event occurs
Time	Role of expressing the time when an event occurs

Table 2. Fillmore's deep cases(Nagao, 1996)

description of general historical events. We decided that the information handled in HEML was sufficient for the description of items that appear in chronological tables. To check the expression capability of the tags and the ease of handling them, we developed a prototype chronological table using HEML for the description of historical events and Timeline for their visual presentation, and confirmed that the XML schemas of HEML are mutually interoperable.

We next studied description items. This paper uses deep cases of Fillmore's classical case grammar as our underlying framework for studying the items of description suitable for historical events. We compared existing description formats in terms of how well they correspond to the items derived from the deep cases. A deep case indicates the role an individual word plays vis-à-vis the verb. Any historical event can be associated at least with a subject and an action it takes. Therefore, we consider that the framework based on the concept of deep cases provides the widest range of description items regarding an event description. The eight cases given by Fillmore's deep case are shown in Table 2.

When the eight cases are applied to the description of historical events, they can be described as follows. The agentive case refers to the entity that caused an event. This entity may be an individual or an organization. The instrumental case corresponds to the cause of an event that occurred. The objective case applies to the object to which an event occurred, but its nature depends on the nature of the event. For example, when a new technology is being developed, the technology is the objective case. The location case corresponds to the place where an event occurred while the time case indicates the time when an event occurred. Since an event can be said to be expressed in direct discourse, the experiencer case does not exist. It is more difficult to interpret what the source case and the goal case represent. Unlike time or place, whether there are starting and goal points depends greatly on the nature of event (verb). Therefore, in this paper, we assume that no roles exist that correspond to the source or goal case for an event.

Consequently, we consider that a historical event may be defined by five elements: person, cause, object, location and time.

Deep case	Item name	HEML	iCalendar	Dublin Core	Timeline
Agentive	Person	Possible to write name and title of the person	Possible to write name and contact point of the host of the event	Possible to write this	-
Instrumental	Cause	-	-	-	-
Time	Time	Possible to write starting and ending times	Possible to write starting and ending times	Possible to write event creation time and its bounds	Possible to write starting and ending times
Locative	Location	Possible to write name and the latitude/longitude of the location	Possible to write name of the location	Possible to write name and the latitude/longitude of the location	-
Objective	Object	-	-	Possible to write this	-
	Event name	Possible to write this	Possible to write this	Possible to write this	Possible to write this
	Description		Possible to write this	Possible to write this	Possible to write this
	Reference information	Possible to write this	Possible to write this	Possible to write this	Possible to write this
	Other	Supports multiple languages	Possible to write priority and related events	Being based on bibliographical information, there are items on rights holder, etc.	Possible to write presentation-related items, such as color of text characters and icon

Table 3. Presence/absence of Fillmore's deep case items in existing event description methods

2.2 Presence/absence of items of deep cases in existing description methods

To find candidates for event description items, we compared iCalendar, HEML, Timeline, and Dublin Core. The comparison results are shown in Table 3.

When it comes to individual items that can be identified and recorded, HEML provides means for making the most detailed description, such as the geographical information of latitude/longitude and the title of the person concerned. Timeline is simpler than other description methods because it is specifically designed for the description of a chronological table. In Timeline, all the elements considered in the Section 2.1 are written in the "explanation" part.

All the description methods allow links to reference information to be written. "Explanation" does not fit any deep cases. Since "explanation" represents an event itself, it embraces all deep cases. Therefore, "Explanation" should not be included as one of the structured historical event items. Since the vast information of knowledge relating to a historical event should be described using a hierarchical structure, it is realistic to describe such details in lower layers (references indicated by reference information).

Although none of the description methods other than Dublin Core have items for describing the subject in question, their event name takes the form of "subject + verb" in most cases. Therefore, it can be considered that the event name includes the information about the subject.

Table 3 shows that Dublin Core has the largest number of description items. Since it was originally developed for bibliographic information, it includes some parts that are inappropriate for the description of an event. For example, we have assumed that the creator item can include the description of persons, but if we take "the Battle at Sekigahara" as an example of a historical event, who is the creator of the Battle? It is possible to assume that the time of the event fits either the expiration date (date) or the temporal coverage (coverage), but which of these is more appropriate? Dublin Core defines 12 elements, called DCTYPE, as a vocabulary of type elements that express resource types. One of them is "Event". When we attempt to apply this to an actual event, we encounter a variety of interpretation problems. Sometimes, it is necessary to extend the definitions. For these reasons, a detailed study is needed before applying Dublin Core to the description of an event.

All the description methods have adequate expression capability to write basic information about an event. However, none of them allows the description of causes. Since when describing history we consider causal relationships, it is necessary to develop a new description method that allows the description of causes.

2.3 Relationships between events

We investigated how to describe the relationships between events. The description of the history of technology would require not only a description of the attributes of each event but also a description of the relationships between events, such as causal relationships. Therefore, we investigated the probability of being able to find a description about the relationships between each technology and the conditions surrounding it or the social background to it in actual literature about the history of technology. This probability may

Item	Number of sentences	
	(1) Report by the Institute of Electrical Engineers of Japan	(2) A Short History of Twentieth Century Technology
Technology	50 (61%)	31 (39%)
From technology to technologh	1 (1%)	7 (9%)
From technology to environment	3 (4%)	7 (9%)
Environment	11 (13%)	20 (25%)
From environment to environment	0 (0%)	2 (3%)
From environment to technologh	4 (5%)	9 (11%)
Others	13 (16%)	3 (4%)
Total	82	79

Table 4. Distribution of description content in publications on the history of technology

vary depending on the authors or the field of each publication. We selected the report (Ishii & Arai, 1999) by the Technical Committee on the History of Nationalization of Electrical Technology of the Institute of Electrical Engineers of Japan, which is considered to focus on technological description. We also selected the Section of "Technology at Home" in "A Short Story of Twentieth Century Technology" by Trevor I. Williams as an example of literature with a heavy weight given to social background (Williams, 1987).

The result is shown in Table 4. While about 60% of sentences in the report by the Institute of Electrical Engineers of Japan concentrated on technology itself, this percentage is about 40% in the case of "A Short History of Twentieth Century Technology." In both publications, the description about the socio-economic environment accounted for 15-20%, which implies that the framework for the description of events should take non-technical events into consideration as well. The descriptions about the relationships between events amounted to 10-30%, which suggests that it is necessary to carefully consider inter-event relationships regardless of the nature of the publication. Therefore, it is important to study the framework for the description of inter-event relationships. HSML allows event attributes to describe inter-event relations, and thus has tags that indicate preceding events or subsequent events. In addition, HSML provides a "used_by" tag and a "developed_by" tag, and allows users to define new tags to describe relationships as necessary. It thus has an extremely high description capability. However, to use these tags, it is necessary to introduce non-event classes, such as person or organization, which increases the complexity of the entire description system.

3. description method

3.1 Selection of microformat vocabulary

We use RDF, which is now widely used on the Web, as the data format for historical events. However, while RDF is easy for computers to read, it is not easy for humans. Therefore, we mark up attributes, etc. in an HTML document, extract data that is easy to read for computers from the HTML document, and output this data in RDF. We use microformats as the framework for writing metadata inside an item of content. Microformats extract metadata from a document by giving names to attribute values in XHTML. Attribute values provided in the XHTML grammar are used. An advantage of this approach is that it can be applied to existing items of content with almost no requirements for modifying their structure. Since we are considering the application of our method to existing historical event descriptions, we have chosen to use microformats for their above-mentioned advantage. One specification of microformats is hCalendar, in which iCalendar is implemented as microformats. However, hCalendar does not allow the latitude/longitude information or causes to be recorded. Therefore, we have newly defined the vocabulary of microformats.

In addition, we have developed a method, based on XSLT, of extracting metadata of the defined microformats and converting it to RDF. XSLT is a conversion language that converts one XML document into another XML document. We associate an XSLT file with an item of content by specifying it in a link element in XHTML. The agent can automatically extract

Classification	Case	Element	Attribute	Value	Item	Location	Data type
Event	Objective	Not specified	class	event	event name	title attribute	character string
Time	Time	Not specified	class	start_data	Sharing date name	within element	character string
					starting date name	title attribute	date
		Not specified	class	end_date	ending date	within element	character string
					ending date	title attribute	date
Location	Location	Free	class	location	location name	within element	character string
					lat/long	title attribute	numerical
Participant	Agentive	a	rel	participant	participant's name	title attribute	character string
					participant's URL	href attribute	URL
Evidence	-	a	rel	evidence	evidence name	title attribute	character string
					evidence URL	href attribute	URL
Cause	Instrumental	a	rel	cause	cause name	title attribute	character string
					cause URL	href attribute	URL

Table 5. Proposed "microformat" vocabulary set

metadata using this XSLT file. The mechanism in which a computer associates an XSLT file with a document to extract metadata is called GRDDL (Gleaning Resource Descriptions from Dialects of Languages). As exemplified by W3C's establishment of the GRDDL Working Group[5], further efforts are expected to be taken to develop specifications, technologies and application examples of GRDDL. Against this background, we have defined the microformat vocabulary shown in Table 5.

An event is represented by one element. This element has the "event" value in its class attribute. The event name is written in the title attribute of that element. Any further information about the event is written inside this element.

The time when an event occurred is written using the content of the element that has the "start_date" value in its class attribute, and using the value of the title attribute. Examples of the content of this element are "At the beginning of the 19th century" and "At 5:56 p.m. on October 23, 2004." The content can be a numeric value or a character string. The content of the title attribute is of the date format. Specifically, it is of either the dateTime format, date format, gYearMonth format, or gYear format, all defined in XML Schema. If an event has a certain duration, the end of the duration is expressed by an element that has the "end_date" value in its class attribute. The manner in which the content is written in this case is the same as that of writing the starting time of the event.

The location where an event occurred is expressed by the content of an element that has the "location" value in its class attribute and using the title attribute of that element. The content

[5] http://www.w3.org/2001/sw/grddl-wg/ (available, June 2009).

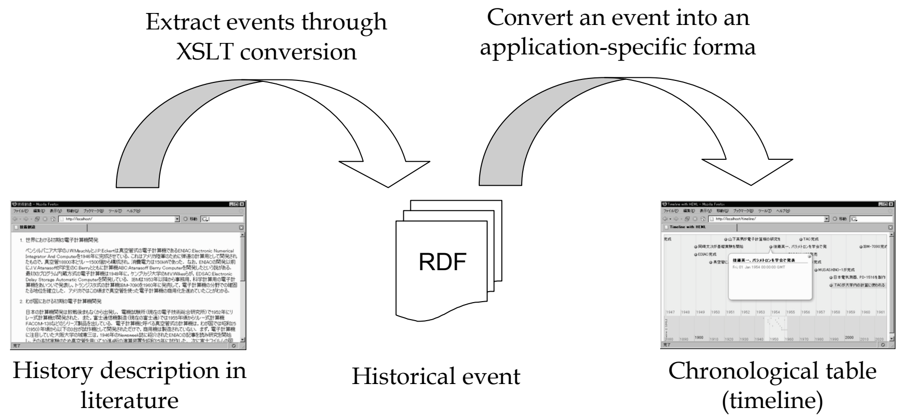

Fig. 2. Sequence of processing in the prototype

of the element indicates the location name. The latitude/longitude information is written in the title attribute in the form of "latitude, longitude", using a comma as the delimiter.
Persons, evidences and causes are written using an "a" element. Defined values of these are put in the rel attribute of the element. The name is written in the title attribute, and the URL is written in the href attribute of the element. There may not be appropriate URLs for the persons and evidences(source of information) involved in an event. In such a case, these are substituted for by putting the same value as that in the rel attribute in the class attribute of an arbitrary element. There may be many evidence that are contained in literature and thus cannot be expressed by URLs. This issue requires further study. As far as the subject of an event is concerned, we assume that it is included in the "subject + verb" of the event name, rather than newly defining a separate item

3.2 Evaluation of the compatibility of the microformat vocabulary

To evaluate the compatibility of the microformat vocabulary, we marked up documents on technology history using the microformat vocabulary shown in Table 5, and showed the marked-up events on the timeline of SIMILE. We used two reports from the Institute of Electrical Engineers of Japan: "Early development of electronic computers in the world" and "Early development of electronic computers in Japan." The general processing sequence of this experiment is shown in Figure 2. First, each report was marked up using the defined vocabulary. Events were extracted from each report using the XSLT associated with the report, and the RDFs that describe the events were obtained. These were then converted into the data format of the particular application (SIMILE Timeline in this experiment) and the events were shown.
Data in Timeline is of XML format and uses its own unique vocabulary. If we created an XSLT that directly converts the microformat format into the Timeline format, it would be possible to create Timeline data from the documents. However, we chose to first convert the microformat format into RDF, and then convert from RDF into the Timeline format. This was because we did not focus on a specific representation format but wanted to be able to handle a variety of representation formats. The result of this experiment confirmed that the extracted events can be mapped using a variety of timeline production tools.

4. Input Support Tool

Considering that the above-mentioned selection of the vocabulary enables history to be described in a unified format, we proceeded to develop a tool that supports the input of educational materials on history. Specifically, this tool mainly supports attaching markup tags to input text. An overview of the tool is shown in Figure 3(a). First, the user obtains paper documents on history written in a natural language, or retrieves history document files from the Web. Next, he or she inputs the obtained documents using the input support tool, and then, aided by the input support functions of the tool, edits data based on the framework for describing historical events. The editing basically consists in identifying keywords by using defined tags. When the input of the historical events of a document has been completed, it is saved as an XML document file. Finally, the XML document is converted into RDF and registered in the DB.

The editor was implemented by combining Word Press, which is a PHP CMS, and OpenWYSIWYG, which is an open source editor. The following functions were implemented in this tool:

A) Consistent expression of person's name: When a person's name is used repeatedly in natural text, it is often omitted, or replaced with a pronoun, etc, to make reading and writing the text easier. This omission makes it difficult for computers to comprehend the text. If data is registered with the first or last name omitted, computers cannot recognize whether the persons involved are the same person or different persons. Since this can hamper sharing of data, we added a function to complement a person's name by presenting the user's input history and thereby ensuring consistency in expression.

B) Consistent expression of location's name: Historical documents, whether written in the past or recently, include the names of locations where historical events took place. Such location names may remain the same as in the past or may have changed over time. If the location name has changed, a single location may be registered as several different locations in the database. Therefore, we added a function to allow the latitude/longitude information to be input along with the location name, by referring to geographical information.

C) Consistent expression of years: A variety of calendar systems have been in use in the past and today. To describe a historical event, it is necessary to use a unique standard calendar system. We have adopted the Christian years as the standard years. However, even the Christian years have two versions: the Julian calendar and the Gregorian calendar. Besides, the year when the Christian years were adopted varied from country to country. Since our main focus was on implementing the tool, we closed our eyes to small differences. We thus developed a function that automatically converts non-standard calendar years to the Christian years.

Considering the above, we implemented the data flow shown in Figure 3(b). The input support functions were implemented using Ajax, which is a client-side technology, and PHP, which is a server-side technology. The editor (OpenWYSIWYG) of the prototype served as the basis for the tool. Since it is written in JavaScript, it is highly compatible with Ajax. HTML_AJAX was used for the interworking between JavaScript and PHP. HTML_AJAX is a PHP PEAR package. One of its advantages is that a class existing in the PHP server can be

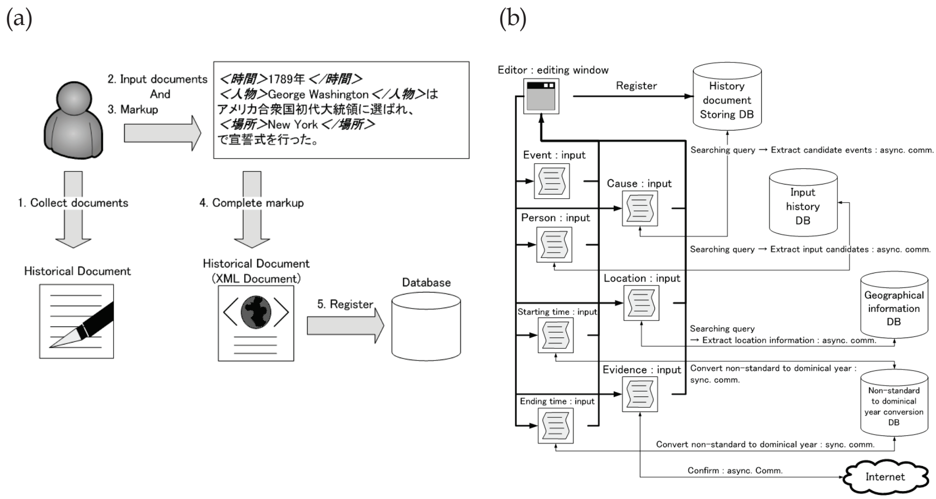

Fig. 3. (a) outline for Input/Output system, (b) Operation sequence of the input support tool

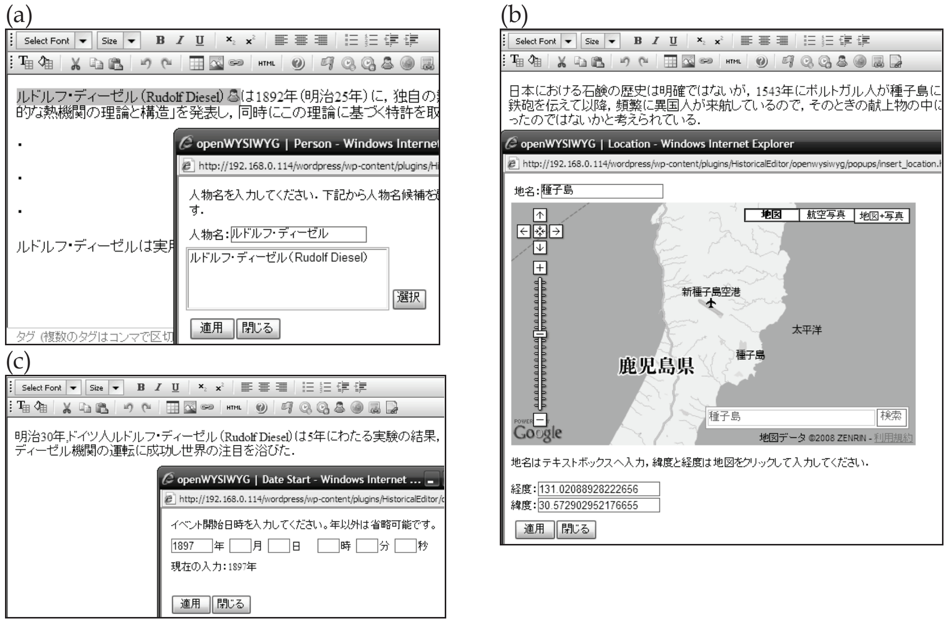

Fig. 4. Example of executing the (a)personal name complementing function, (b) location name complementing function, (c) year data conversion function

```
<SPAN class=event title=Success in the operation of a Diesel engine>
   <SPAN class=dtstart title=1897> 1897 (Meiji 30) </SPAN>,
   German
   <SPAN class=person title="Rudolf Diesel"> Rudolf Diesel </SPAN>
   drew worldwide attention by finally succeeding in the operation of a Diesel engine
   after five years of experiments.
</SPAN>
Diesels engines differ greatly from other engines in their high heat efficiency and ability
to use a variety of fuel types. They were first used for power generation and as power
sources on land to substitute for steam engines, and then their applications expanded to
drive ships, trains and cars.
<SPAN class=event title=Introduction of Diesel engines to Japan>
   Diesel engines were introduced to Japan in
   <SPAN class=dtstart title=1907> 1907 (Meiji 40) </SPAN>
   or so
</SPAN>
<SPAN class=event title=The first Diesel engine produced in Japan>
   The first domestically produced engine was built in
   <SPAN class=dtstart title=1917> 1917 (Taisho 6). </SPAN>
   There is a record reporting that event.
</SPAN>
```

Fig. 5. Example of editing using the input support tool

executed from the client. This capability was used to implement the process of sending data from the server to the client, the issuing of queries to the input history database and the calendar system conversion database, and the processing of the obtained data. The Google Maps API service was used in the geographical information database to support the input of geographical information.

The windows of the implemented functions are shown in Fig. 4(a)-(c). We used two reports on research on systematizing technologies (Sato, 2008; Nakasone, 2007) as historical data. Figure 4(a) shows an example of executing the personal name complementing function. "Rudolf Diesel" is marked up as a personal name. Once this is done, when the user tries to mark up "Rudolf Diesel" again, the personal name complementing function provides a candidate from the input history. When the user executes markup by selecting the provided candidate, no apparent change occurs in the passage but actually "Rudolf Diesel" has been registered as XHTML metadata. Figure 4(b) shows an example of executing the location name complementing function. When the user tries to mark up the location name "Tanegashima Island", the location name complementing function presents a map of "Tanegashima Island" using Google Maps. When the user clicks a point in the map, the latitude and longitude data are retrieved, and registered in the relevant metadata along with the location name. Figure 4(c) shows an example of executing the year data conversion function. When the user tries to mark up "Meiji Year 30 (according to the Japanese calendar)", the year data conversion function converts the Japanese calendar year to a dominical year, which is then registered in the relevant metadata.

The above-mentioned information was input to the input support tool. Text data that had been input using the markup function available in a GUI environment was marked up appropriately, and the data was saved as text with metadata attached as shown in Figure 5. The saved text data can be reused using a variety of tools.

5. Conclusions

To create a framework for describing historical events, we have compared and evaluated existing history description languages based on the deep cases of Fillmore's case grammar, and developed a unique description framework by adding items that are lacking in the existing languages. We have also created a microformat vocabulary set suitable for this framework. In addition, we have used an existing editor to mark up technology history to examine the usability of the editor. To further enhance the usability of the editor, we have implemented input support functions, such as supplementing persons' names, supplementing location names, and converting calendar systems. In particular, we have adopted Christian years as the standard calendar years but ignored minor differences between the Julian and Gregorian calendars in the implementation in order to allow early verification of the usability of the input support functions. When the editor is to be applied for commercial purposes, the differences between the Julian and Gregorian calendars will not be negligible. We plan to solve this problems at an early opportunity. Another issue for future study is the development of a tool that presents, in an intuitive manner, events marked up using the vocabulary we have defined.

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Free Text Response Assessment System Based on a Text Comprehension Model

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1. Introduction

Nowadays, computer scientists make efforts to develop systems based on Cognitive Psychology and its theories (Kintsch, 1992; Kintsch, 2001; Rinaldi et al, 2002; Graesser & Tipping, 1999). Such systems have as their main goal the computer-assisted assessment of free-text responses and most of them are based on the Latent Semantic Analysis Theory (Landauer & Dumais, 1997), by using vector-oriented analysis. The need of diagnosing alternative conceptions presented in a free-text response, rather than just marking it, leaded to our knowledge-based system proposal.

This chapter aims to describe this system, which could give a boost to an automated free-text response assessment, by extending its knowledge base with new assessing rules, concepts and relations among them, and by diagnosing misconceptions presented in this response, according to the *Baudet & Denhière Text Comprehension Model*; this model describes the way a text reader constructs his/her mental knowledge representations during the reading process. Additionally, the present chapter introduces Semandix, which constitutes a semantic tool implementing two of the basic modules of the proposed system upon the precious contribution of concept mapping tool and computational semantic dictionaries.

In detail, section 2 describes the *Baudet & Denhière Text Comprehension Model*, while section 3 presents the necessary semantic tools for an automated assessment system. In sections 4 and 5 we explain the design of the proposed system and introduce Semandix, respectively. Finally, in section 6 our future plans are being discussed.

2. Text Comprehension Model

For the representation constructed by learners during the comprehension process of a text, primary role should be attributed to the understanding of the cognitive categories: entity, state, event and action (Baudet & Denhière, 1992; Lemaire, Denhière et al, 2006). The term entity refers to the atoms, units or persons participating in the representation structure. The term state describes a situation in which no change occurs in the course of time. The term event refers to an effect, which causes changes but is not provoked by human intervention.

The event can be coincidental or provoked by non-human intervention, e.g. by a machine. An action causes changes but is originating by a man. Text comprehension is considered as the attribution of meaning to causal relations between occurrences in the text. Learners construct a representation of the text, which contains the cognitive categories: entity, state, event and action. For the interpretation of learners' cognitive processes their discourse is analysed, in order to trace the recognition (or not) of the cognitive categories.

Furthermore, text analysis in relation to the cognitive categories does not suffice (Baudet & Denhière, 1992). The organization and structure of cognitive representation should involve three structure types: relational structure, transformational structure and teleological structure. The *relational* structure represents a state in which there are entities of the possible world and no change occurs in the course of time, whereas part/all relations define a hierarchy in the structure of the system. The *transformational* structure represents complex events of the world or events sequences, which provoke transformation of static states. When a transformational structure is causal then it is described as a causal path among events. When it is temporal the changes are temporal and not necessarily causal. Part/all relations among events and macroevents define a hierarchy in the system. The *teleological* structure is organized in a tree of goals and/or subgoals and within a time period its initial state, defined by the present entities, their relations and the values of their properties, changes turning into a final state performing in that way the predefined goal.

The organization and structure of cognitive representation should also be examined on micro and macro-level. On the micro-level scale, the creation of a text that allows a precise description of a technical system and facilitates readers in constructing its microstructure representation must involve the description of (i) the units that constitute the system based on the causal relations which unite them and (ii) the events sequence taking place on these units in respect to causes affecting them as well as to changes that bring the system from one state to another. On the macro-level scale, the development of the macrostructure by readers is achieved through the reconstruction of the microstructure and the establishment of a hierarchical structure with goals and subgoals. The creation of a text, which facilitates readers in constructing its macrostructure representation for a technical system, must involve the teleological hierarchical structure of goals and subgoals of the various operations as well as their implications. A technical system containing a set of associated units, which are fixed by hierarchical relations of all/part-of type and can be organized as a tree of goal/subgoals is called a Functional System.

3. Semantic Tools

3.1 Concept Mapping

In educational settings, concept mapping is a teaching and learning valuable tool providing an explicit learners' knowledge structure representation and promoting meaningful learning (Novak & Musonda, 1991; Novak & Gowin, 1984; Blitsas, Papadopoulos et al, 2009). A concept map is a set of nodes, which represent concepts and relations among concepts. The concepts and relations are organized into hierarchical, circular or hybrid structures as a whole so as to represent and describe the central concept of the map, which is the root of the node. One of the key tools is the CMapTools http://cmap.ihmc.us/ (Figure 1), which enables the user to export the concept map created in the form of XML file.

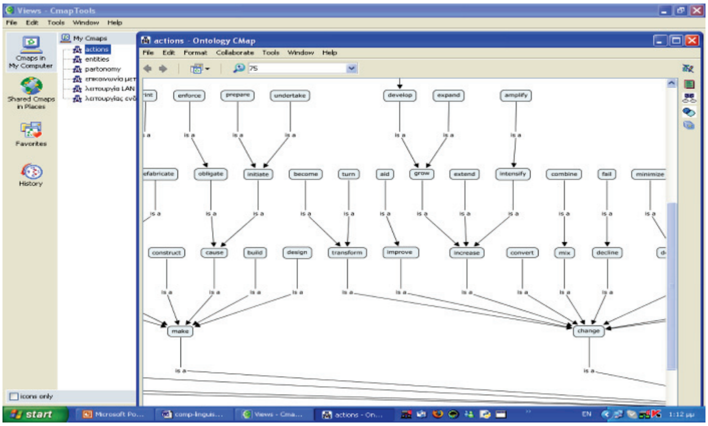

Fig. 1. CmapTools software

3.2 “Machine Readable” Dictionaries

Electronic dictionaries commonly used nowadays are in fact printed dictionaries converted to electronic form, so that they can be easily searchable through a computer. The computational lexicons or “machine readable” dictionaries have completely different function. They include, apart from definitions and examples of the words/entities use, relations among these words. Their creation is resulted by the need of use in applications in the field of Linguistic Technologies, such as “Machine Translation”, “Information Retrieval & Extraction from Corpora”, “Construction Summary” etc. Most of these dictionaries do not rely on text comprehension models but merely on language use standards (grammar rules, multilingual terms recognition etc.), statistical modeling (use of word frequency, cohesion etc.) or a combination of these two. In this section an overview of the principal computational semantic lexicon Wordnet and Visdic platform is presented.

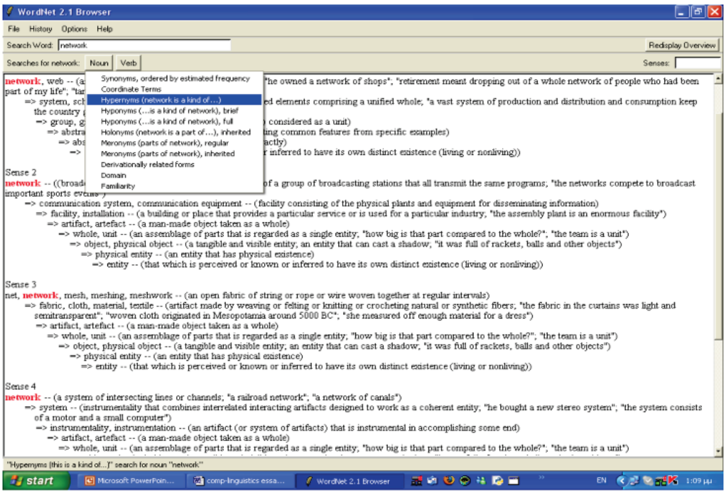

Fig. 2. English Wordnet Environment

Wordnet (Figure 2) is a computational semantic lexicon organized semantically and containing essentially verbs, adjectives and adverbs grouped into sets of synonyms (synsets). A synset is a set of words, which in a given environment may be used in place of one another. Another important feature of Wordnet is the separation of concepts in fields (domains). A word may belong to several synsets in many domains. Each synset in each domain has its own interpretation by examples and semantic correlations of hyperonym, hyponym, olonym, and meronym with other concepts. For example, the word "memory" is presented in separate wordnet synsets in Psychology & Computer Science domain.
Visdic editor http://nlp.fi.muni.cz/projekty/visdic/ (Figure 3) constitutes a graphical application for browsing, editing or linking "machine readable" dictionaries in different languages and structured in XML format.

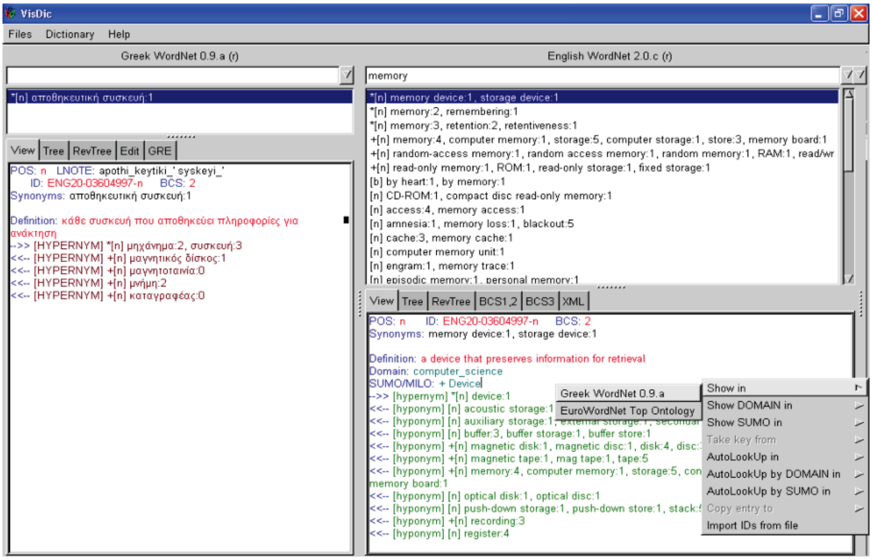

Fig. 3. Visdic Editor Environment

4. Designing a Free-Text Response Assessment System

In this section we present the design of a proposed Free-Text Response Assessment System based on Denhière-Baudet Text Comprehension Model and some examples of implementing this system in terms of Prolog facts (Blitsas & Grigoriadou, 2008). Figure 4 displays the architecture of that system.
In detail, the four basic system modules, described in the next subsections, are the following:

- Normalization Module (NoM): convertion student's free-text response into normalized response through Natural Language Processing (NLP)
- Functional System Module (FSM): ontology of the basic structures of the expert's knowledge representation, namely relational and transformational structure of microstructure, and teleological structure of macrostructure, depicted in the expository text referring to Computer Science domain.

- Enrichment Module (EnM): enrichment of the system Knowledge Base with content from expository texts, concept maps and/or wordnets (XML format).
- Assessment Module (AM): assessment of normalized response coming from NoM.

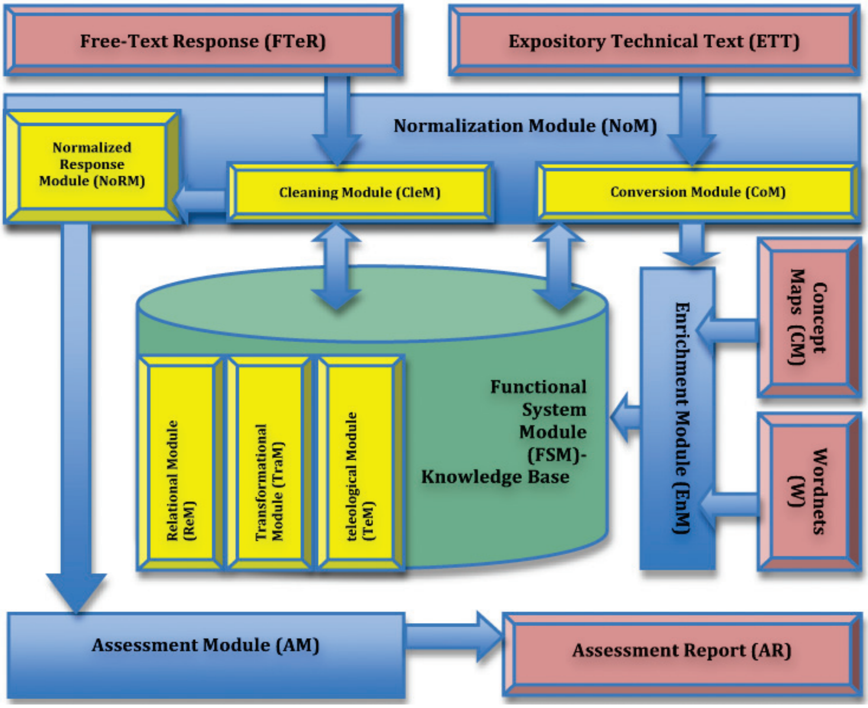

Fig. 4. Architecture of the Free-Text Response Assessment System

4.1 Normalization Module (NoM)

Its goal is converting a free-text response into normalized response referring to Computer Science domain into ontologies, describing the microstructure and macrostructure, enriching the content of FSM, which is being described in subsection 4.2.

When we use the term 'normalized response', we mean the response, which includes the entities, meaning the units, the events and the macroevents, declared explicitly or implicitly in the respective free-text response. In order to achieve the previous goals, the Normalization Module has the following three submodules:

- Cleaning Module (CleM): It is responsible for cleaning up the student's free-text response from unnecessary words. Collaborating with the FSM it can “decide” which word will be cleaned up and which one will be kept as necessary. It means that when CleM meets a word that constitute entity or relation, appeared in FSM, it will keep this word, and additionally, it will build the representation of student's response. This representation is, in fact, the 'normalized' response. The output of CleM is led, as an input, to NoRM. During this processing stage, there is a need for CleM to collaborate with computational synonym dictionaries, such as WordNet, in order to decide if a word is a synonym of an entity or relation of FSM, so that CleM keeps the word as a necessary one and does not consider it as irrelevant. This collaboration can be achived through EnM.

- Conversion Module (CoM): It is responsible for distinguishing the expository text entities, into units, events and macroevents, in order to send them to FSM where microstructure and macrostructure ontologies will be constructed.
- Normalized Response Module (NoRM): It functions as a buffer of the student's normalized response. Its output is led to AM for estimating the errors appeared in student's normalized response representation.

4.2 Functional System Module (FSM)

The Functional System Module includes three submodules, which depict the Relational Structure (ReM), the Transformational Structure (TraM) and Teleological Structure (TeM) of expert's knowledge representation. This module takes, as an input, the output of CoM, and constructs the different structures.

As an example for representing these three structures of expert's knowledge, we used a expository text, taken from the book 'Computer Science: An overview' (Brookshear, 2006). This text extract refers to the combination of bus topology networks toward forming wide area computer networks: “*The repeater is little more than a device that connects two buses to form a single long bus. The repeater simply passes signals back and forth between the two original buses (usually with some form of amplification) without considering the meaning of the signals. A bridge is similar to, but more complex than, a repeater. Like a repeater, it connects two buses, but it does not necessarily pass all messages across the connection. Instead, it looks at the destination address that accompanies each message and forwards a message across the connection only when that message is destined for a computer on the other side*”.

The expert's micro and macrostructure representations are following in subsection 4.2.1.

4.2.1 Expert's microstructure representation

At the microstructure level, there is a description of units, which constitute the system, as well as, the causal relations, which connect them. First stage of realizing microstructure representation is constructing relational structure of the text content. Relational structure has two basic ontologies (Gruber, 1993): taxonomy and partonomy.

Taxonomy is a tree-like structure, 'is a' type, which analyzes the taxonomical relations among the entities appeared in the expository text. Partonomy is a tree-like structure too, 'part of' or 'has' type, which expresses all/part-of relations among the text entities. These ontologies have to represent the knowledge, explicitly referred in the text, as well as, the implicit knowledge, which is activated during the reader's comprehending. Examples of taxonomy and partonomy are following, in form of Prolog facts:

Taxonomy:	is_a(repeater, device).	is_a(bridge, device).	is_a(bus, lan).
Partonomy:	part_of(node, bus).	part_of(lan, wan).	part_of(content, signal).

Second stage of realizing expert's microstructure is representing transformational structure (figure 5).

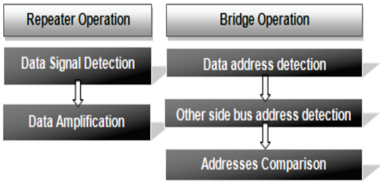

Fig. 5. Expert's Transformational Structure

4.2.2 Expert's macrostructure representation

Expert's macrostructure includes teleological structure and microstructure. Teleological structure, describing in section 2, is depicted in TeM, and an example, referred to the text, is show schematically, in figure 6.

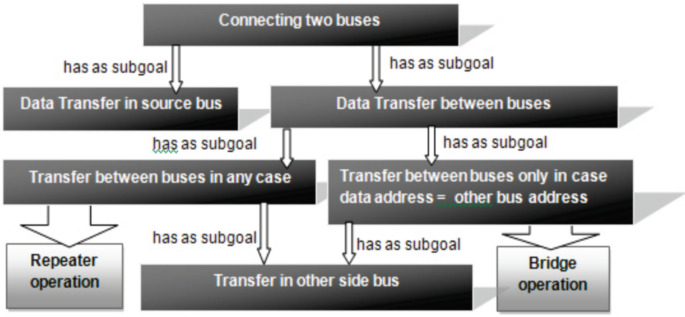

Fig. 6. Expert's Macrostructure

4.3 Assessment Module (AM)

The Assessment Module could assess three kinds of questions:

(i) Ontological questions, through ReM, such as 'what is',
(ii) Operation questions, through TraM, such as 'how does it work', and
(iii) Teleological questions, through TeM, such as 'why' or 'which one'

In order to develop the Assessment Module, we had to obtain data of errors students make, during reading expository text and answering questions on microstructure and macrostructure they construct. An experiment on secondary level students took place to estimate the alternative conceptions students have during comprehending technical expository texts.

Two question types were given to the participants:

- inference questions, examining the transformational structure students formed and
- bridging questions, examining the macrostructure they formed and the recall they achieved from different points of the text.

Forms for completing events (for the first question type), and choosing the right device for a specific goal (for the second question type) were given. So, the demanded responses had a normalized form. One example question of each type is following in the next two subsections.

4.3.1 Response assessment on microstructure questions

An example of inference question, referred to transformational structure, which belongs to microstructure, is the following: *"Describe the operation of a Router, step by step, from the first state, in which the message is located in the source node of the source network to the state, in which the message is located in the destination node of the destination network"*.
Three error types were mentioned on students' responses:

- missing events in the events sequence
- events replaced by goals
- causal errors among events

The right sequence of events of Router operation (Router transformational structure) is:

(destination network) protocol detection → *protocol control* → *protocol comparison* → *protocol conversion.*

For example, in a student's response, the next error types were appeared:

- Causal error: instead of 'protocol control' precedes 'protocol conversion', in the response 'protocol conversion' precedes 'protocol control',
- Event replaced by a subgoal: in place of 'data detection', 'data transfer' appears.

Figure 7 displays the analysis of student's transformational structure assessment process, and figure 8 displays an example of automated transformational structure question assessment, implemented in Prolog. In figure 8, AErrors are "events replaced by subgoal" errors, and BErrors are the causal errors. Finally, MEvents are the missing events.

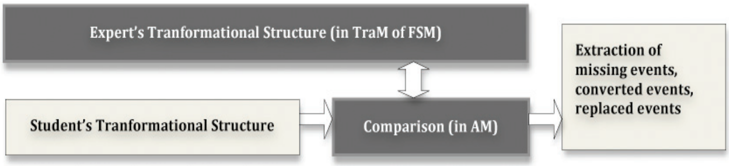

Fig. 7. Student's transformational structure assessment process

```
# 0.01 seconds to consult teleologia final.pl [c:\documents and settings\     \desktop\
| ?- seekerrors(AErrors,AErrorsAm,Right_Order,Wrong_Order,BErrorsAm,MEvents,MEventsAm).
Give the testing device:
|: router.
Give the events sequence:
|: control_protocols.
|: detect_protocols.
|: transmit_protocols.
|: convert_protocols.
|: exit.
AErrors = [transmit_protocols] ,
AErrorsAm = BErrorsAm = MEventsAm = 1 ,
Right_Order = [detect_protocols,control_protocols] ,
Wrong_Order = [control_protocols,detect_protocols] ,
MEvents = [compare_protocols] ;
```

Fig. 8. Automated transformational structure question assessment example

4.3.2 Response assessment on macrostructure questions

A bridging question demands a response after combining information from more than one point of the given text. An example of bridging question follows: *"In the case of connecting a Bus with a Ring topology network, which is the device, you have to use? Why the other devices are rejected? Justify your position"*. This question demands a position and justification for the choice of the right device and for the rejection of the others. The response is based on the macrostructure (including the microstructure of 'repeater', 'bridge', and 'router' devices). Router is not presented in the example text but is appeared in a bigger text, where the example text belongs.

The following incomplete sentences were given to the students:

"The right device is ...(1) because ...(2)"

"Device .... (3) can't be used because ... (4)"

"Neither device ... (5) can be used because ... (6)"

The right response is: (1) Router, (2) protocol conversion, (3) bridge or repeater, (4) not protocol conversion, (5) repeater or bridge & (6) not protocol conversion.

In students' responses, the following error types were appeared:

- Wrong position (1) or/and justification (2) for the choice of the right device.
- Wrong positions (3), (5) or/and justification (4), (6) for the rejection of the other devices.
- Blanks in some of (2), (3), (4), (5) and (6).

So, we have three different degrees of assessing.

- "Naïve": wrong position & justification for choosing the right device.
- "Incomplete": right position for choosing the right device and wrong response on (2), (3), (4), (5) or (6), and
- "Full": full right response.

Figure 9 displays the analysis of student's macrostructure assessment process, and figure 10 displays an automated macrostructure question assessment example, in Prolog.

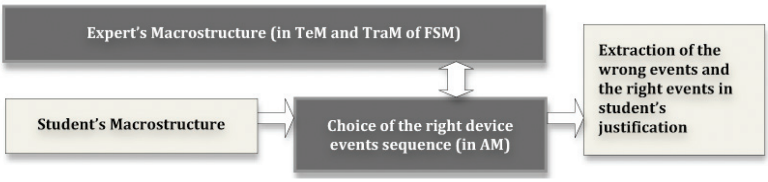

Fig. 9. Student's macrostructure assessment process

```
# 0.01 seconds to consult teleologia final.pl [c:\documents and settings\
| ?- inference_assessment(Position_Assessment,Justification_Assessment).
Give the right position:
|: router.
Give the position to be accessed:
|: repeater.
Position_Assessment = wrong ,
Justification_Assessment = naive

| ?- inference_assessment(Position_Assessment,Justification_Assessment).
Give the right position:
|: router.
Give the position to be assessed:
|: router.
Give the justification for the position:
|: convert_protocols.
|: exit.
Give the justification against the other devices:
|: repeater.
|: detect_protocols.
|: exit.
Position_Assessment = right ,
Justification_Assessment = incomplete ;

no

| ?- inference_assessment(Position_Assessment,Justification_Assessment).
Give the right position:
|: router.
Give the position to be accessed:
|: router.
Give the justification for the position:
|: convert_protocols.
|: exit.
Give the justification against the other devices:
|: repeater.
|: detect_protocols.
|: bridge.
|: convert_protocols.
|: switch.
|: compare_protocols.
|: exit.
Position_Assessment = right ,
Justification_Assessment = full ;
```

Fig. 10. Automated macrostructure question assessment

4.4 Enrichment Module (EnM)

The goal of the Enrichment Module is enriching the FSM knowledge base in three different ways: (i) inserting XML format lexical-semantic databases, obtained by semantic dictionaries, as Wordnet, (ii) inserting concept maps in XML format as well, provided by tools like CMapTools or Compass, and depicting an explicit representation of expert's knowledge structure (Novak, 1998) and (iii) inserting the content of expository texts referring to Computer Science domain. In the following section a semantic tool implementing the two first ways is presented.

5. Semandix – Constructing FSM & Implementing EnM

Semandix (*Seman*-tic *Dix*-ionary) is a semantic tool constructing the Functional System Module, meaning the knowledge base, and implementing a part of the Enrichment Module of the proposed system by using as a basis the cognitive Baudet-Denhière text comprehension model. It has been developed in Visual Basic .Net, under Microsoft SQL Server support and .Net Framework. Semandix gives also the capability of investigating concepts and relations appeared among them within a free text. Its ultimate goal is to assess automatically free-text responses by exploring alternative conceptions appearing within them always according to the text comprehension model of Denhière and Baudet.

5.1 Semandix Semantic Dictionary

Semantic dictionary of Semandix tool (figure 11) gives the possibility of searching a concept in the knowledge base of the system and presenting all relations referring to different structures of the cognitive model (relational, transformational, teleological) and the associated concepts with the searched concept.

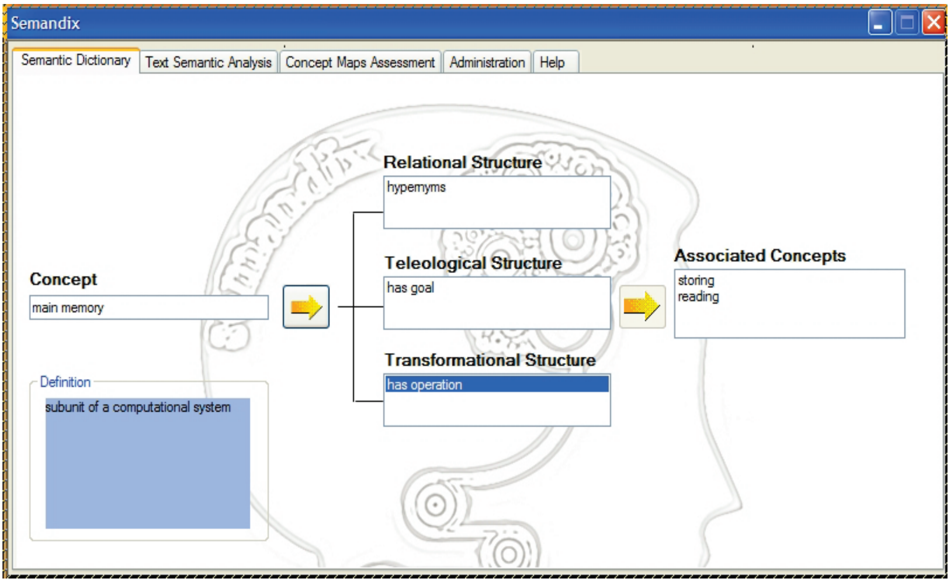

Fig. 11. Semantic Dictionary of Semandix

Selecting the transformational relation on the box of associated concepts, “storing” and “reading” appear, which are in fact two of the most important operations of the main memory of a computational system.

5.2 Semandix Knowledge Base Administration

The most important module of Semandix tool is the Administration tab (figure 12).
This module gives the administrator of the knowledge base the capability of:

- Adding individual concept and relation with other concept, identifying the type of model structure that relation refers to. In case the triad (concept, relation, concept) already exists the administrator is able to remove it or add a new definition for that concept (figure 12a). For the depicted examples we entered individual concepts in English.
- Enriching the knowledge base with content of concept maps and wordnets by adding XML format files extracted by CMapTools and Visdic, respectively (figure 12b). For the depicted examples we used a wordnet with concepts of “Computer Memory Hierarchy” domain in Greek, and Concept Maps expressing expert’s knowledge on the same subject.
- Enriching massively the system knowledge base with relations referring to every structure of the text comprehension model separately, in order for the tool to automatically categorize the incoming content to the right structure (figure 12c).
- Cleaning the whole knowledge base of the system (figure 12d).

For every new concept incoming to the knowledge base by the previous means, there is a parsing mechanism, which compares it with the existing concepts in the base, in order to eliminate wrong spelling or different case of the word expressing that concept.

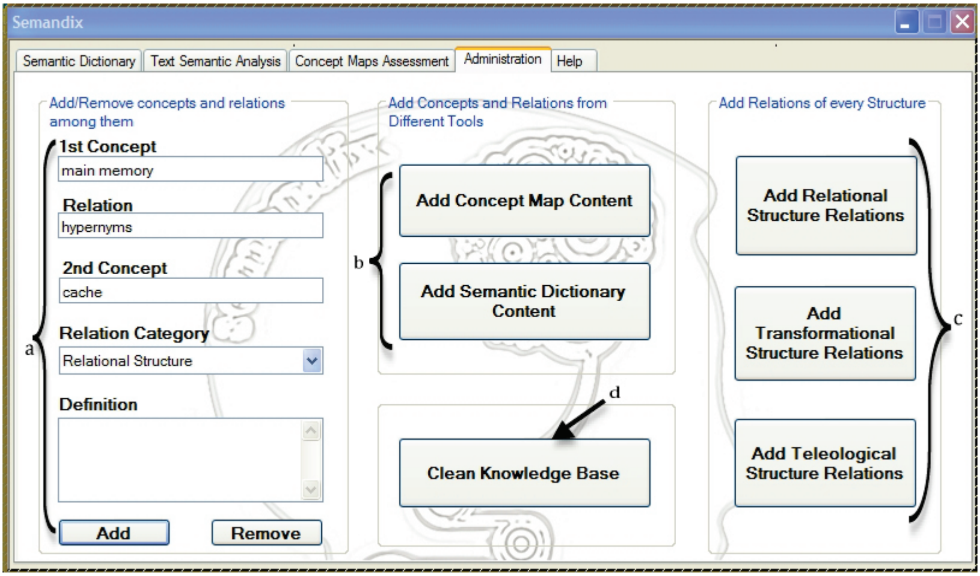

Fig. 12. Administration tab of Semandix

5.3 Semandix Text Semantic Analysis

Trying to implement the Assessment Module of the proposed system of the section 4, as a first step, Semandix gives the capability to a user of analyzing semantically the content of a short free-text response. This semantic analysis is constituted by the recognition of the concepts presented in the text and highlighting the relations among them. The Semandix enables the user to either type text or open a text file from his/her hard disk. After opening the text file the text will appear in the text field.

In figure 13 an example is presented in Greek. This Semantic Analysis could be combined with the assessment rules implemented in Prolog in section 4, in order to extract diagnosis of the alternative conceptions the user presents on the free-text response.

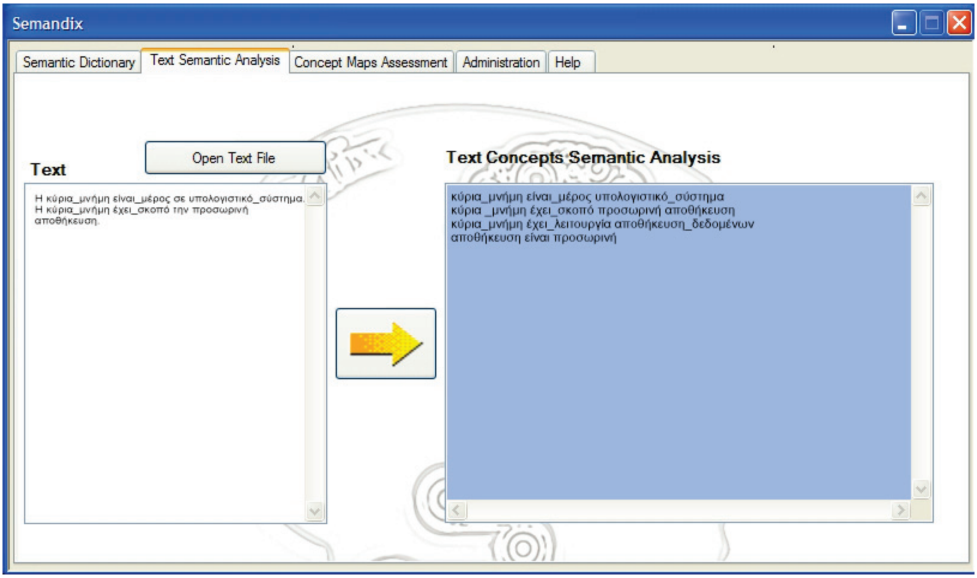

Fig. 13. Text Semantic Analysis tab of Semandix

5.4 Semandix Concept Map Assessment

Besides the text semantic analysis, Semandix concludes a module responsible for assessing propositions of a concept map created by a student (figure 14). The assessment process outputs the list of the propositions presented on the map. For each proposition there is a result "Right", whether the same proposition appears in the knowledge base, or "Wrong", whether there's not such a proposition in it. This assessment is superficial enough, but gives the opportunity of estimating quantitively the map correctness, without taking into account the alternative conceptions appeared on it.

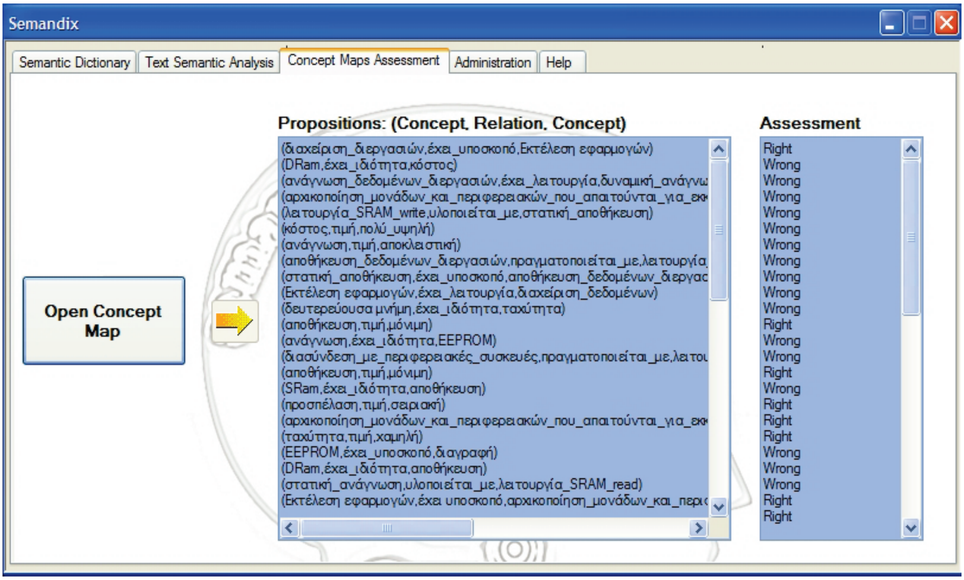

Fig. 14. Concept Maps Assessment tab of Semandix

6. Future Plans

This chapter has as a basic goal to introduce the design of a knowledge-based free-text assessment system and the efforts that have been made toward this direction by implementing basic modules of that system. It is obvious that, so far, all the implemented parts are not integrated into a whole working system; there are two implementations in different programming languages, Prolog and .Net Visual Basic, for Assessment, Functional System and Enrichment Module. So, our next step is combining the assessment rules created in Prolog with the Knowledge Base implemented in .Net Visual Basic under Microsoft SQL Server contribution. This fact leads to the need of connecting these two implementations.
Except for the combination of the above two implementations, it is necessary to

- implement the Normalization Module (NoM), in order for the system to accept as input free-text responses and normalize them, and
- elaborate Assessment Module, in order for it to diagnose alternative conceptions appeared, regarding the three substructures of the model, on the normalized responses with FSM knowledge base that includes the scientific conceptions.

For the first case, Natural Language Processing tools must be used, as

- Parsers, in order to process the free-text word by word,
- Taggers, in order to identify the syntactic role of every word in a sentence, and
- Grammars, in order to identify the grammatical role of every word in a sentence.

For the second case, there must be enrichment of Semandix Knowledge Base with content expressing the alternative conceptions that readers have during reading expository texts of the domain of Computer Science. These concepts could be in propositional form through concept mapping assessment procedure or coming from responses on open-ended questions answered by such readers, meaning that this system could “learn” during its use.

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A Software System for Inference-Based Context-Aware Vocabulary Learning

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1. Introduction

This chapter describes an educational software system for inference-based context-aware English vocabulary learning which has been put to use for three years at a university in Japan. It is a Web application so that the students can learn independently outside the classroom at their own individual paces anywhere anytime. Unlike a majority of commercial vocabulary learning software based on word-for-word translation, the current system is designed on effective learning principles from the point of view of vocabulary building as well as online learning, both of which would otherwise make learning tedious and boring. In addition, the system provides the instructor with a simple means of preparing and editing exercises according to his or her pedagogical needs.

A long history of research on the learning of vocabulary has demonstrated a high correlation between the learner's vocabulary knowledge and language proficiency (Golker & Yamini, 2007; Webb, 2005; Zareva et al., 2005; Qian, 2002, to name a few). Learning vocabulary would be probably the most important and time-consuming part of learning a foreign language (Atay & Ozbulagan, 2007). Educational software for learning second-language vocabulary, however, is not often designed on commendable learning principles. Many of the vocabulary exercises are based on word-for-word translation, which encourages the learner to learn individual words out of context and translate them into the equivalents in his or her native language. The result is that the learner has little knowledge about how the words are actually used in sentences.

The present system, on the other hand, is intended to help the students:

(i) learn the usages of the words,
(ii) infer the missing words from context,
(iii) guess the words by reading the definitions in English
(iv) think in English, and
(v) develop the habit of using an English-to-English dictionary.

To achieve the above goals, each question is provided with a sentence with a word removed. The blank portion consists of as many blank spaces as the number of the letters of the word except for the initial letter already given. The question is also furnished with an English definition of the meaning of the word. The students should be able to infer the word from (a) the example sentence, (b) the definition of the meaning, (c) the initial letter and (d) the number of the letters left out. At the end of the exercise session, they are provided with a feedback about mistakes so that they can review the mistaken words before challenging the exercise again.

In addition to pedagogical aspects, the developer of educational software should also realize the fact that online learning is indeed a monotonous and impersonal practice. The current system, therefore, made an effort to make online learning more stimulating by defining clear goals of achievement, giving graphical displays of the goals and progress of learning in real time, and making questions puzzle-like. Unlike usual commercial software, the instructor can choose words that deem appropriate for his or her students' language levels, and therefore more meaningful to them.

This chapter will elaborate on the underlying educational background, the interfaces and designs of the system, together with findings and potential improvements that were suggested from three years of use as an online system for college second-language vocabulary learning.

2. Vocabulary learning

Vocabulary acquisition is said to occur intentionally, for instance, by doing exercises or incidentally, for example, through reading texts, and extensive research on the intentional vs. incidental acquisition issue has been conducted (Herman et al., 1987; Hulstijn et al. 1996; Webb 2008, to name a few). The current system is intended primarily for intentional vocabulary acquisition, because incidental acquisition would not occur often enough in foreign language learning material (Groot 2000).

Vocabulary knowledge could be divided between passive and active knowledge, as illustrated in Table 1. Even though the distinction between passive and active knowledge may not be as clear as it may deem (Read 2000), it is helpful in discussing vocabulary knowledge. Passive listening and reading vocabulary knowledge is useful in listening and reading comprehension respectively, but not necessarily so in such productive skills as speaking and writing. Active writing and speaking vocabulary knowledge is effective in writing and speaking respectively.

	Oral	Graphic
Passive	Passive listening	Passive reading
Active	Active speaking	Active writing

Table 1. Types of vocabulary knowledge

The current system aims at helping develop active writing vocabulary knowledge primarily, and as a by-product, passive reading vocabulary knowledge, because the students read many example sentences and definitions while doing the exercises. Therefore, many of the target words included in the current vocabulary exercise are those that the students are able to recognize in reading, but are unable to use properly in writing or speaking. The words are taken from the words at Levels 2 and 3 in the Hokkaido University Vocabulary List. The questions presented in the present system are not provided with multiple-choice answers, but ask students to fill in the blank by guessing the word from the definition of the meaning written in English, and the sentence in which it occurs. The other clues are the number of the letters of the word as well as the initial letter already given.

The main purpose of the use of the definitions of the words and the example sentences is to encourage students to obtain the meanings of the words without interference from their native language. Many vocabulary exercises are types of word-for-word translation, thus likely fostering habits of mental translation between words in target and native languages. This often results in an undesirable situation in which the learners know the equivalents of the words in their native language, but have little knowledge about the usages of the words.

3. The design of the system

The current software system has two major modules: the student module which is responsible for the students' vocabulary learning, and the instructor module for the instructor's creating and editing questions. The following section will first describe the student module, and then the instructor module.

3.1 The student module

The student module contains three panels, the *login*, *question* and *end* panels, the last two of which will be discussed in detail in this section.

3.1.1 The question panel

The question panel is comprised of three components: a set of three graphs, the question section and a number of buttons, as illustrated in Figure 1. The top bar graph indicates how many levels or units of the vocabulary exercise have been completed, and the lower two graphs, how many words were answered correctly one time and two times respectively. The student can go up to the next level or unit only after giving all the correct answers twice. These three graphs are intended to help the student see graphically his or her progress in real time, and how much more left to complete the exercise.

The question section on the panel provides an English sentence with an array of blank spaces. The first letter of the word is already in the first box as a clue, and the student is expected to fill in the remaining blank spaces by inferring the missing word from the meaning of the sentence as well as the definition of the meaning of the word situated above the example sentence. In this way, the student can guess the word from several clues.

As most words are used in more than one part of speech, and have several meanings even in each part of speech, it is important to specify which part of speech and the meaning are questioned by showing the word within a sentence. For instance, the word *steady*, which is the answer of the question on the panel in Figure 1, can be used in adjective, verb, adverb or noun. *Steady* in adjective has several meanings: not moving, continuous, not changing, reliable, and so on. The meaning of not moving is in question at present.

Besides the clues to the guessting of the word, the system allows the student to access a dictionary available online at another site. When finding an unfamiliar word that occurs in the definition as well as the qeustion sentence, he or she just clicks on it to get the meaning.

At the bottom of the question panel is the button named *Send_My_Results_Now*, which allows the student to send the results intermittently to the database at the server so as not to lose the results so far during the exercise. On the other hand, the button *End-This-Session* finishes the session, and opens the end panel.

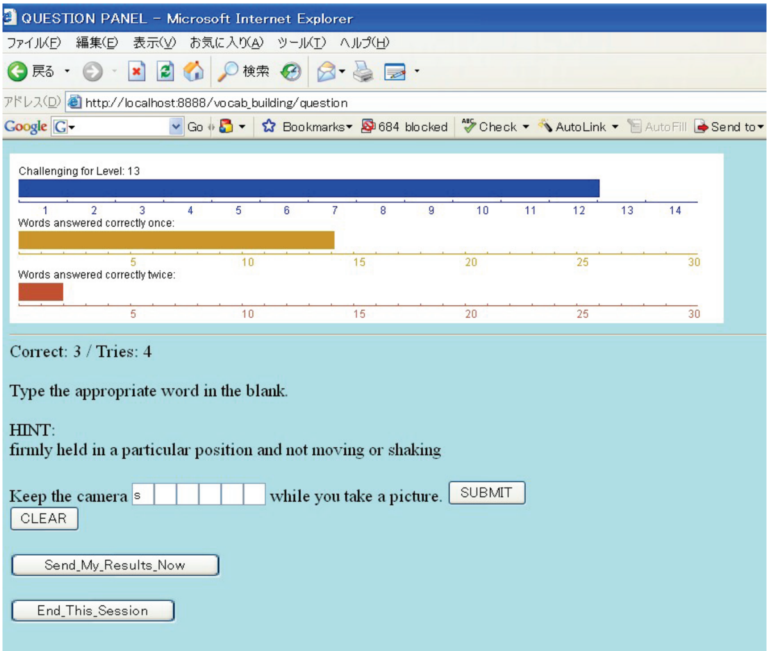

Fig. 1. The question panel

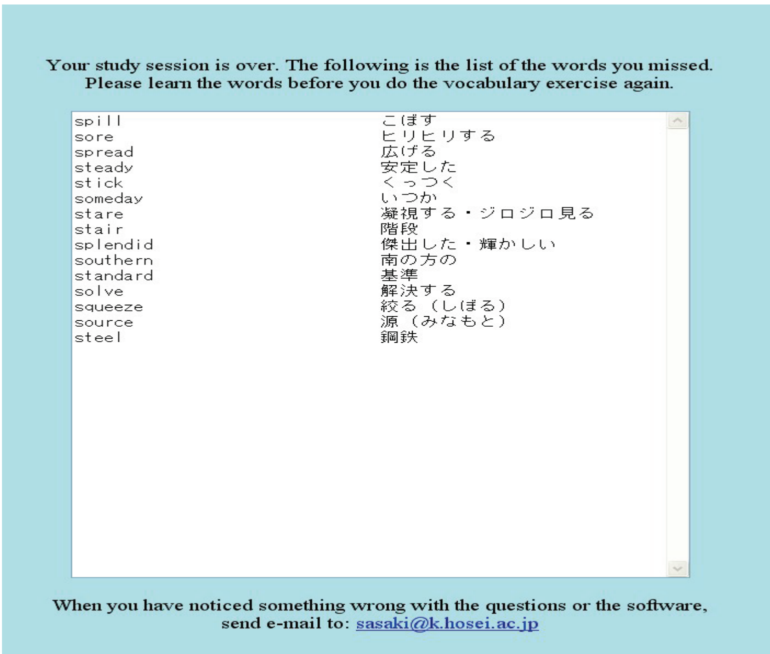

Fig. 2. The end panel

3.1.2 The end panel

The *End_This_Session* button on the question panel opens the end panel showing a list of all the words the student has failed to answer, as illustrated in Figure 2. As the Japanese glosses are provided, he or she can copy the feedback, and review the mistaken words before challenging the exercise again.

3.1.3 The student data file

The results of the student's performance is saved on the student data file in XML format, a portion of which is shown below:

```
<STUDENT>
   <ID>09k3030</ID>
   <FAMILY_NAME>sasaki</FAMILY_NAME>
   <GIVEN_NAME>yukiko</GIVEN_NAME>
   <GROUP>g</GROUP>
   <PASSWORD>secret</PASSWORD>
   <MINUTES>153</MINUTES>
   <LEVEL>13</LEVEL>
   <DONE>2</DONE>
   <STATUS>1 0 0 2 0 1 0 1 0 0 1 0 1 0 0 1 0 1 0 2 0 1 0 1 1 0 1 0 0 1 </STATUS>
</STUDENT>
```

Listing 1. A *STUDENT* element in the student data file

The content of the *MINUTES* element indicates how many minutes the student has so far spent on the exercise. The content of the *LEVEL* element denotes which level or unit he or she is currently working on, while that of *DONE*, how many words have been correctly answered two times, which is the number of times of repetion required at present for considering a word to have been learned. The values of *STATUS* shows how many times the words listed in the words file for that level have been answered correctly: the number *1* indicates one time, while the number *2*, two times. Such a data structure on *STATUS* allows for an easy modification of the number of required repetition as well as the number of words assigned for one level or unit.

3.2 The instructor module

The instructor module has three panels, the main data input panel, the text editing panel and the last-word editing panel. The data input panel allows the instructor to add questions to the questions file in XML format, which is used for displaying the components on the question panel. The text editing panel allows the instructor to edit the questions file, in case he or she needs to modify or correct it. On the last-word editing panel, the instructor is able to change the last word which has been saved in a separate file storing the last word. This function is necessary when the instructor wants to see a list of words, and make sure that he or she has not skipped any important word.

3.2.1 The data input panel

When the data input panel opens, a word to work on and a number appear in the boxes located in the middle at the top of the panel, as illustrated in Figure 3. The number does not stand for the order of the word in the dictionary corpus, but the order in the list of words selected for making questions. However, the instructor can change his or her mind and decide not to use the word for some reason. The total number of words actually adopted for making questions is shown at the bottom of the panel next to the word *total*. Another number shown next to the phrase *words saved in this session* is the number of the words that have been stored during the session in question.
The system, in reference to the last word which has been processed, retrieves the next word from the words list, and uploads to the panel the dictionary entry for the word.

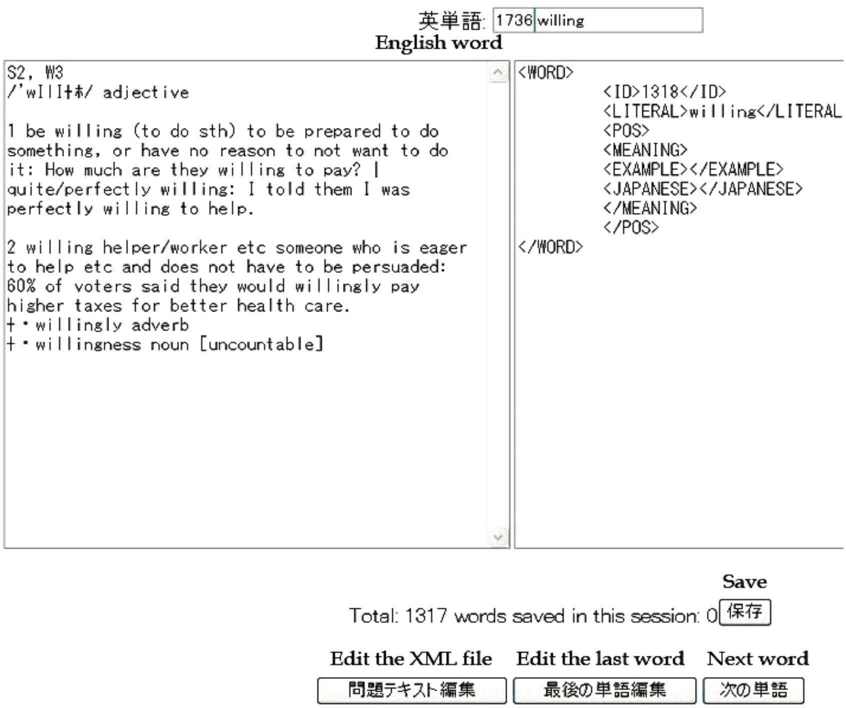

Fig. 3. The data input panel

The left column of the panel contains the meanings of the word as well as the example sentences, while the right column a blank template in XML format. The instructor is able to skip the word on the panel by pressing the *Next word* button, when he or she thinks it is not worth making a question about it.
Looking at the left column, the instructor chooses one definiton from among many in the dictionary entry and one of the example sentences in order to fill in the XML template in the right column. Listing 2 below is an XML template already filled in with such information as the part of speech (*POS*), the definition, an example sentence, and a Japanese gloss:

<WORD>
<ID>1318</ID>
<LITERAL>willing</LITERAL>
<POS>adj
<MEANING> to be prepared to do something, or have no reason to not want to do it
<EXAMPLE>How much are they (willing) to pay?
</EXAMPLE>
<JAPANESE>自発的にしようとする</JAPANESE>
</MEANING>
</POS>
</WORD>

Listing 2. A *WORD* element in the questions file.

Except for the values of the *ID* and *LITERAL* elements, which are automatically entered, others must be entered by hand. The word which will be the missing word in the question must be placed in parentheses in the example sentence, so that the system leaves out the word and put blank spaces back according to the number of the letters of the word.
The design of the *WORD* element is based on the assumption that a word may belong in more than one part of speech, and that a word in different parts of speech may each possess more than one meaning.

3.2.2 The text editing panel

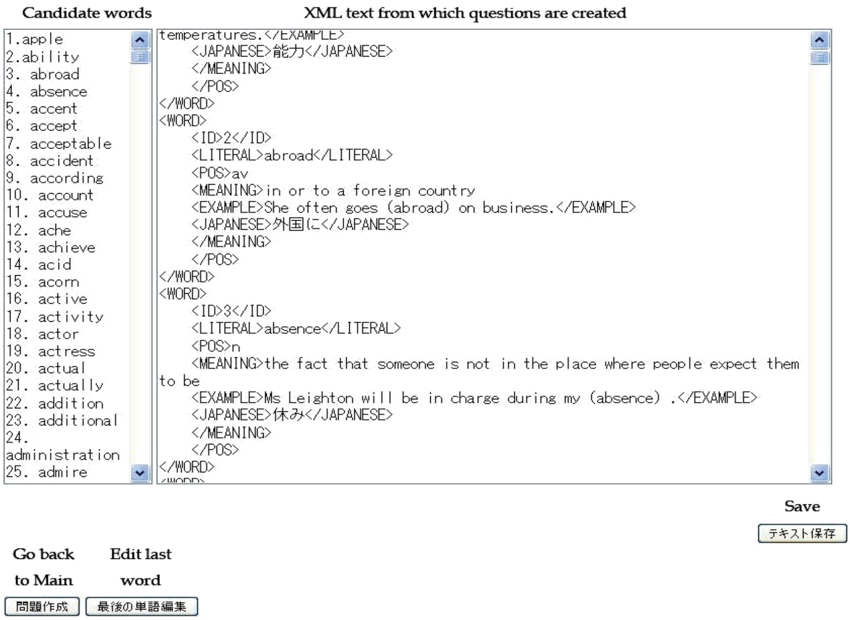

Fig. 4. The text editing panel

The instructor is able to edit directly the questions file which provides the question panel with information such as the definitions of the words and the question sentences. This editing is required when the instructor wants to make sure all the information has been placed properly or wants to check if important pieces of information or an important word have been skipped by referring to the words list displayed in the left column of the panel.

3.2.3 The last-word editing panel

The last-word editing panel shows up by pressing the *edit-last-word* button on the data input panel as well as the text editing panel. This panel allows the instructor to include a word he or she has skipped by replacing the last word, stored on a separate file, with the word preceding the skipped word, and going back to the data input panel to enter information on the word. Furthermore, it also allows the instructor to skip many words which otherwise must be skipped one by one on the data input panel. He or she just replaces the last word with a word much ahead in the words list shown in the left column.

4. Evaluation and future work

It would be certainly not so straightforward as deemed to measure effects of any educational software on learning, since one's learning depends on a variety of factors, and such factors can hardly be singled out. There was, however, an interesting result worth mentioning. The current system was incorporated as an assignment for two classes of the first-year English courses in the Faculty of Computer and Information Sciences at Hosei University, and not in the other two classes in the academic year of 2006. All the first-year students took TOEFL-ITP exams both at the beginning and end of the academic year, namely in April, 2006 and January, 2007. The students in the two classes who used the system showed significant improvement in their comprehensive as well as itemized scores, whereas the students in the other two did not. This seems to indicate a positive effect of the current system on the learning of a foreign language. However, it has not been possible to compare students' results since then, because the system has been made available to all the first-year students.

The system offers three parameters that can be changed by the instructor: (a) the number of words to be included in one level or unit, (b) how many times students should answer the questions correctly, and (c) the number of levels or units they should complete. At present thirty (30) words are assigned for each level or unit, and are contained in each different file. Each word is structured as an XML element, as illustrated in Listing 2 above. Earlier, the number of words for each level was fifty (50), but as the student has to repeat the questions twice, it has been reduced to thirty (30). The system is in use for two semesters of the first-year English classes: the students have to practice twelve (12) units in the first semester and fourteen (14) in the second semester.

According to the data collected from seventy three (73) and ninety seven (97) students respectively in the academic years of 2007 and 2008, the average time required for completing one level or unit in such settings mentioned above was about fifty (50) minutes overall in the first semesters. The time required, however, ranged from about thirty (30) to eighty (80) minutes. A wide gap has been observed in the time required for completion. For some students, the exercise was not so hard, but for others it was quite challenging initially. In the second semesters, the average time needed for completing one level or unit was about thirty six (36) minutes, much shorter than that in the first semeters.

The students were tested for remembering the usages of the words at several mid-term and final exams. The students who completed the vocabulary exercise remembered about 55% on average, ranging from 20% to 100%. It seems that some students need to repeat the qeustions more than twice, while others do not. The retention rate is a little higher than those reported in Mondria & Wiersma, 2004, probably because many of the target words here are those the students are able to recognize in reading, but unable to put to use in writing.

In spite of several clues including the definitions of the words, the example sentences, the numbers of the letters of the words and the initial letters, some students found it quite difficult to guess the missing words. There were several words even a native speaker failed to guess, and some modifications were required subsequently. It might be helpful to give more clues, for instance, by showing the constituent letters of the word in the wrong order or by introducing the words orally before testing students on them. It might also be beneficial to students at varying vocabulary levels to give clues step-by-step on demand, and not to give all the clues at once. In addition, students could be provided with an immidiate feedback in the middle of the session when their answer is incorrect. At present, they receive a feedback on mistaken words at the end of the session so as to review them for the next attempt. Another possible future arrangement would be to add more example sentences.

5. Conclusion

Unlike a majority of commercial vocabulary learning software based on word-for-word translation, the present software system is designed so that students can learn the usages of words, not the equivalents in their native language, and think in English. For these purposes, most of the words included in the exercise are those students are able to recognize in reading, but are unable to put to use in writing or speaking. All the definitions of the missing words and the example sentences in the questions of the exercise are written entirely in English, with Japanese used only for the final feedbacks on mistakes. Students can infer the missing words from several clues including the example sentences as well as the definitions of the words, and become familiar with how they are used in sentences. This encourages them to understand English words and sentences directly in English, not through their native language.

In addition, the present system is intended to make online learning less tedious and boring by making use of visual aides such as graphs. The graphs indicate several types of students' performance results, and change in real time according to the results. Students receive feedbacks on mistaken words at the end of the session so that they are able to review them for their next attempt.

The system also saves the instructor much time and labor. It provides him or her with a simple means of preparing questions from a dictionary corpus in reference to a list of words the usages of which he or she thinks the students must learn. It also allows the instructor to edit the questions file with ease.

While some improvements seem desirable as mentioned above, the system has been implemented at a university in Japan for several years as a tool for the students' independent learning of vocabulary outside the classroom, and has proved to be a useful online application in teaching second-language vocabulary.

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A Web-based Multimedia Annotation System for Language Learning

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1. Introduction

In the early Web-based learning systems, the online teaching/learning resources are restricted in static hypertext or images which can be delivered efficiently over the Internet. With the emerging of the dynamic HTML and network streaming technologies, the online courses can be designed more vivid and vigorous by integrating animations and multimedia (e.g., audio/video) features. Thus, an alternative lecture presentation can be elaborately designed by tightly integration of streaming audio/video clips and HTML-based lecture slides with animated objects. According to research work of Lauer and Schar (Lauer et al., 2001; Schar & Krueger, 2000), the voice and animation can have a structuring effect and engage the user's attention to important elements than the static text or pictures. For example, many Web lecture systems (Brusilovsky, 2000) attempt to integrate multimedia technologies for providing an easy way to capture or access lecturing content through the network. In this chapter, we keep the core ideas of automated capture and structural access of Web lectures in mind to develop a system, Web-based Multimedia Annotation system (WMA), for instructors to record the lecturing process or the correction process of students' compositions on language leaning courses.

The WMA system is aimed at capturing of teacher's lecture activities (e.g., voice and navigation events, such as tele-pointer, highlight, or pen strokes, imposed on HTML-based lecture slides) and replaying the scene faithfully by multimedia synchronization techniques (Steinmetz, 1996). The capturing and presentation processes are helpful for live experience lecture recording and efficient information access. For instance, the capturing techniques support the recording of as much relevant media streams as possible during the lecturing(e.g., voice/video or navigation events) and the presentation techniques support the flexibility in document interactions (e.g., random access and playing a specific speech segment repeatedly). Both of the techniques were implemented to support the lecturing recording or English composition correction in the WMA system.

In addition to capturing and replaying abilities on lectures, the WMA system provides the following features to assist instructors in composition correcting process and to assist students in re-editing the composition errors: (1) to ease the pressure on instructors who need to record the correcting process in real-time, an alternative mechanism is designed, which allows: (i) revising content directly like a text editor, (ii) comparing the differences of content between revisions automatically, and (iii) recording the voice comments with navigation events. (2) To compatible with the editing trace function of the popular MS Word, we designed several proofreading symbols which could further explore essential significance between pen strokes or text annotations, and underlying characters automatically after the instructor corrects a composition. The integration enables the system to translate the corrected points (i.e. proofreading symbols) to editing trace function provided in MS Word.

The remainder of this chapter is organized as follows. We address the related work in presentation recording and some of systems for helping comprehension of language learning in Section 2. An overview of WMA system, including the architecture and major characteristics, will be described in Section 3. Section 4 states the detailed descriptions about the recording procedures. The different presentation modes for recorded lecture will be described in Section 5. Finally, conclusion remarks will be given in Section 6.

2. Related Work

In this section, we discuss some of related work in presentation recording and several systems for helping comprehension of writing. This discussion includes the previous work in the field of automated capture mechanisms and applications. These issues are important for establishing an integrated learning environment which can increase the user interaction and structural content accessibility. Furthermore, we also discuss several systems that could serve as applications for improving writing skill to reveal the usability of computers.

2.1 Presentation Recording

To fully utilize the benefits of computer and multimedia networking, much research has been devoted to capture the media streams occurring in live presentations for later access. We summarized these systems into the following types by the capturing approaches: (1) *Camera-based recording*, (2) *Electronic whiteboard-based recording*, and (3) C*omputer-based recording*.

(1) Camera-based Recording: To tape a live lecture with video cameras and turn it into a streaming-media document is an intuitively approach when talking about the presentation recording (Cruz & Hill, 1994). The advantage of this approach is that lecturers can fully concentrate on the contents without adapting to new technology. However, to provide acceptable quality of recorded lectures for increasing readability and accessibility should invest much manpower in operation of recording equipments and much time in post-processing of recording content. The former problem can be solved by the automated camera management systems requiring little or no human intervention (Suganuma, 2002; Rui et al., 2004), and one solution for solving the latter problem is to survey the tools provided by computer vision and computer graphics that allow researchers to determine syntactic information about images (Gleicher et al., 2002; Wang et al., 2003). Another compromise solution is to integrate recorded video with lecturing slides. Several existing presentation systems (e.g., Microsoft Producer or Accordent's PresenterONE) and research projects (e.g., Cornell Lecture Browser (CLB) (Mukhopadhyay & Smith, 1999), BMRC Lecture Browser (BIBS) (Rowe et al., 2001), and Asynchronous Learning Network (ALN) (Latchman & Gillet, 2000)), allow recorded video to synchronize with original slides and enable users to have slide-based random access during the playback. The timestamp for

each slide change event can be determined during the recording stage or automatic post-processing. Although these systems make it possible to show the teaching materials more clearly for users, the instructional handwriting activities during the class are difficult to identify from the video and to present on the slides.

(2) Electronic Whiteboard-based Recording: The challenges of the presentation recording approaches described above are seem to the capturing of instructor's handwriting activities and the structural overview of recorded lectures. Several projects have been aimed at developing feasible tools integrating with high-tech equipments (e.g., SmartBoard) to capture as much as possible from the classroom experience (e.g., eClass (Brotherton, 2001), Smart Classroom (SC) (Shi et al., 2003), and tele-TASK (Schillings & Meinel, 2002)). The touch-sensitive whiteboard allows pen input as well as the traditional blackboard and chalk instructional activities. Therefore, all data streams, such as video, audio, and annotations imposed on the slides will be captured for later playback. Further analysis of media relations for different access degrees, such as slide-based or handwriting-based random access, are provided for increasing content accessibility. However, this recording approach has two apparent disadvantages. One is the high cost for equipments and another is that everything remains purely static during the presentation. According to literatures (Schar & Krueger, 2000) and (Lauer et al., 2001), dynamic presentation with animations is much better and helpful for descriptions of visualize dynamic phenomena or a process than static text or pictures.

(3) Computer-based Recording: Due to computers and network are in widespread use, many instructors are used to conduct a course by the assistance of computers. Through the advanced programming technologies, to capture a lecture which was taught on computers is no longer a hard work. The capturing can be classified into two mechanisms, one is *screen-based recording* and another is *event-based recording*.

■ *Screen-based recording*: The use of screen captures lead to a more effective and efficient manual for illustrating software functions or operations (Gellevij et al., 2002). Currently many commercial systems (e.g., Camtasia, Windows Media Encoder or PowerCam) not only provide screen capture to save as an image, but also provide functionalities to record any screen or window content together with instructor's audio and then produce a synchronized video output. Therefore, all events occurring on the screen will be captured as continuous images, including slide content, software operations, or handwritings. The scenario may benefit the lecturers who need to demonstrate computer programs or simulations; however, the document structure is difficult to generate because recording systems are difficult to detect the slide change event automatically.

■ *Event-based recording*: This kind of systems usually contains a monitor to detect operations, including mouse and keyboard events, triggered by the lecturer over the application. A representative work by using this approach is the "Authoring on the Fly" system (Muller & Ottmann, 2000). The idea of producing multimedia documents in this system is to combine the apparently distinct tasks of teaching in class and multimedia authoring into one single activity (Datta & Ottmann, 2001). Instead of using real pen input equipments, two whiteboard applications, AOFwb and aofShell, which are actually computer input/output devices were implemented for lecturers to prepare materials and to capture live lecturing activities. All recorded streams, including the audio stream, the graphics stream, and the application stream, are synchronizable and randomly accessible. Additionally, the dynamics of the lecturer's handwritings on a slide are preserved during the playback of a lecture. The system attempted to realize ubiquitous computing vision for a lecture theater and make it more suitable for presentation recording from a live lecture; however, the complex user interface and preprocessing phase are tedious for lecturers. For ubiquitous computers, Web browser is a commonly used application for conveying information and knowledge over Internet in our daily life. The Web plug-in techniques (e.g., ActiveX, Java Applet, etc.) enable developers to enhance browsers' capabilities (e.g., voice recording) for exchanging and sharing information via Web documents with rich multimedia content. The WEBTOUR is a system implementing the idea to record and replay dynamic multimedia annotations on Web documents in the form of guided Web tours (Sastry et al., 1999). The dynamic multimedia annotations in this system include mouse gestures, drawings, audio comments, video segments and hyperlink traversals. Therefore, lecturers can use WEBTOUR to capture instructional activities on HTML formatted course materials as well as he/she was teaching on a board.

2.2 Writing Environment for Language Learning

Writing is usually an obstacle for non-native users when they are learning a foreign language. With the advances of Internet, many Web sites are especially designed for English learning, providing various teaching materials for self-studies. The Purdue OWL (Online Writing Lab) is a good site to support students in raising their English writing. They provide writing consultative services with two common communication ways: by face-to-face tutoring and by e-mails. Students could send their articles by e-mail to the OWL center and then wait for the response about writing problems or be notified to discuss with a consultant face to face in a physical office.

Traditionally, an instructor usually corrects a composition directly in printed draft. With the research achievements in the field of Computer-Aided Language Learning (CALL), instructors can correct compositions by the assistance of computers. The literature (Farkas & Poltrock, 1995) summarized three common methods for computer-based correcting tasks:

(1) Modifying the draft directly: Editors received digital drafts, and used the text editor to revise the draft directly. In this method, authors and editors must trust each other because the revised points can not be recovered easily, and it is difficult for authors to know which content part is revised.

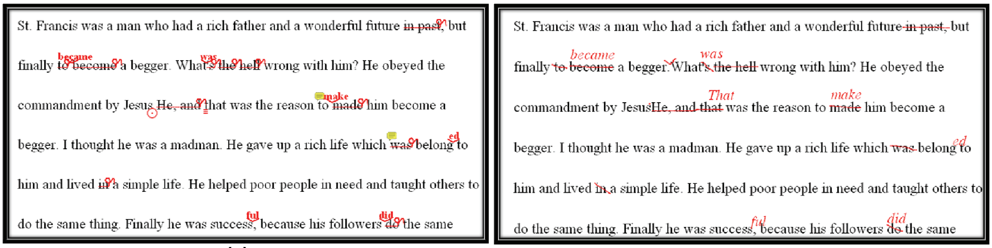
(2) Adding notes and free style symbols into text: Editors give comments in margins or draw symbols to indicate the revisions. This method keeps the overall reflection of the editors that could be viewed by the author, including the organization of the composition or the style of writing. However, using free style symbols to edit is a laborious way when editing a large number of drafts.

(3) Using clear and concise symbols for correcting: Editors use a virtual red pen to draw understandable symbols on digital draft. This method is similar to the traditional paper-based editing by using a red pen, and it helps to revise drafts efficiently.

According to the discussion above, the feasible editing model is to adopt traditional paper-based markings that are familiar and intuitive for editors and authors to the computer screen. MATE is one of the marking-based systems developed for collaborating writing with digital ink (Hardock et al., 1993). The system uses mark recognition to support automatically incorporating changes into the document. The document data structure using in the system contains information about relationships between the annotations and text of the document. The authors mentioned about the importance of speech for editing tasks, but they regarded the feature as the future work. The CoCoA system adopts the similar concepts developed to support correcting work between instructors and students (Ogata et al., 1997). The system designed several visualized markings to correct the article by using computers for Japanese composition studies. Both systems described above, however, only support the presentation in static text, markings, or comments. Few multimedia features are involved to enhance the editing task. According to the investigation of Schar (Schar & Krueger, 2000), the voice can have a structuring effect and attract the user's attention to important elements in the picture.

3. An Overview of WMA System

The purpose of the Web-based Multimedia Annotation (WMA) system is to assist learners in English composition studies. The system proposed a comprehensive solution for simulating face-to-face writing tutoring to help non-native users improve their writing skill by several pre-designed proofreading markings or free-form pen strokes. For example, Figure 1 illustrates the editing result consisting of instructor's narration and several navigation events which include proofreading markings or free-form pen strokes. The pre-designed proofreading markings and their corresponding operations are shown in Table 1.



(a) (b)

Fig. 1. The composition is corrected by (a) proofreading markings or (b) free-form pen strokes and annotations

*Note: Using "*space*" key to switch the correcting mode (pen or marking mode)			
Marking		**Description**	**Operation**
Pen Mode	~~was~~	Pen stroke	Pressing '*left button*' of the mouse and dragging it
	belong *ed* to	Annotation	Pressing key of '*a*' to invoke annotation
Marking Mode	alos	Spelling check	Using mouse to select the letters and pressing key of '*s*' to invoke the marking
	egypt	Capital letter	Using mouse to select the letters and pressing key of '*c*' to invoke the marking
	All	Lower case	Using mouse to select the letters and pressing key of '*l*' to invoke the marking
	keeping	Take out	Using mouse to select the letters and pressing key of '*d*' to invoke the marking

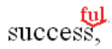
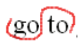
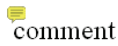
		Insert	Clicking mouse to identify the insertion point and pressing key of '*i*' to invoke the marking
		Punctuation	Clicking mouse to identify the insertion point and pressing punctuation keys
		Replace	Selecting the letters to be deleted and pressing key of '*i*' to invoke the marking
		Transpose	Selecting the letters and use the mouse to drag them to the target, a sub-menu will be popped up
		Move	Selecting the letters and use the mouse to drag them to the target, a sub-menu will be popped up
		Bracket move	Selecting the letters and use the mouse to drag them to the target, a sub-menu will be popped up
		Comment	Clicking mouse to identify the insertion point and pressing key of '*a*' to invoke the marking

Table 1. Full reference of operations for free-form pen strokes and proofreading markings

During the recording process, the instructor can use simple mouse operations combined with keyboard entry to trigger the drawing functions of different markings shown on the computer screen or switch operation functions between pen and marking modes arbitrarily. After the compositions are corrected, the learners can access editing results with audiovisual synchronized presentation via Internet or download the packaged files that could be played offline. In the presentation stage, the recorded navigation events will be displayed dynamically in accordance with synchronization information to enrich lecture presentation. Figure 2 shows an example which all of events (e.g., tele-pointer, highlight, marking-based annotations and scrolling) can be rendered synchronously along with the timestamps of playing speech.

In this example (Knoy, 2000), the original sentence is "*A statistical comparison is made of the proposed procedures with Taguchi's two-step procedure*." After the sentence is corrected by the instructor through recording tool, the visualized markings show that the sentence should be reorganized as "*The proposed procedures and Taguchi's two-step procedure are statistically compared*." We use several screen snapshots of key events to illustrate the presentation process. The scenario is detailed in the following: when a user requests a lecture, at T1, the browser with implemented synchronization mechanisms will be initialized by loading the HTML-format composition, corresponding speech and synchronization information. At T2, an event is triggered to correct the letter "t" by using a "capital letter" marking. The "replace" event, which is the combination of "take out" and "insert" markings, is invoked at T3. At T4, the punctuation is deleted by invoking a "take out" operation. At T5, a "replace" event is triggered again and an "insert" event follows it at T6. At T7 and T8, the "replace" and "take out" events are triggered, respectively. At T9, the "bracket move" marking is used to reorganize the sentence. Finally, the edited result will be shown on the display window at T10. The tele-pointer which is supplementary guidance will appear during the whole presentation process.

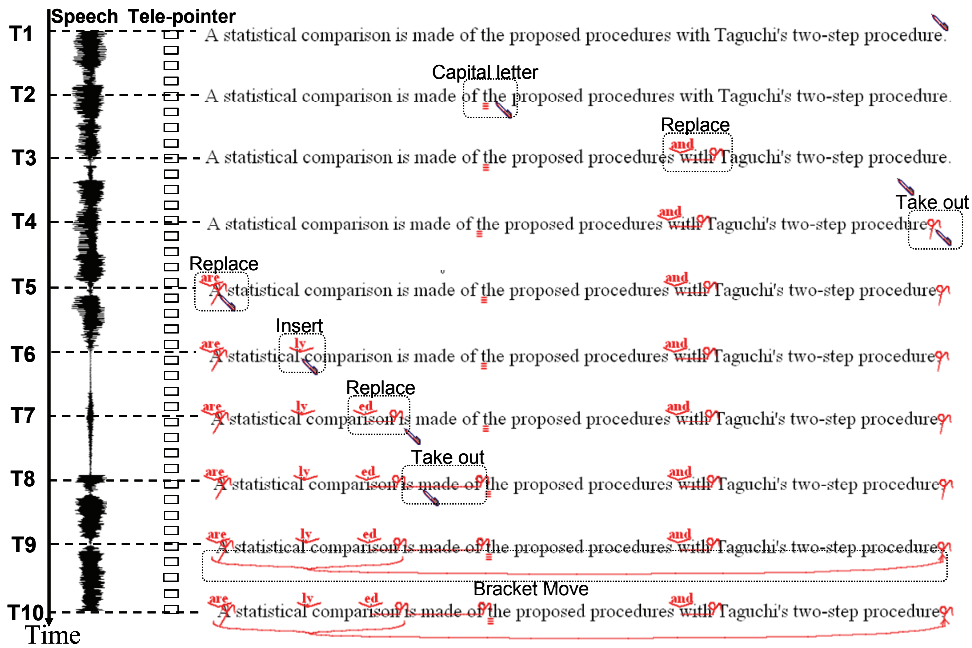


Fig. 2. An example of synchronized presentation with various marking-based annotations

4. Recording Procedures

In our developed WMA system, we provide two versions to record the lectures for instructors: online and offline. The former is constructed to apply to an environment with stable broadband network (e.g. on campus), and the latter is designed for instructors who are at somewhere with no network or unstable connections (e.g. at home). Additionally, both versions support one phase and three phases recording modes. In what follows, we will describe these features in detail.

4.1 Online version

Online learning is the most popular way for establishing a learning environment. Figure 3 shows the architecture of the online scenario in our system. We adopted the client/server architecture in common use to manage the learning resources. Learners can submit compositions through a submission interface, and the content will be stored on the Database. Once an instructor starts the Multimedia Lecture Recorder, the content of a composition will be loaded. The instructor can use the functions provided by our system to correct the compositions. After the instructor finished the recording, the voice and captured events will be uploaded to the WMA server automatically. For a learner, he/she can access the corrected compositions via the Multimedia Lecture Viewer. All of involved media objects will be downloaded, and the lecturing process could be restored faithfully according to the captured events in the recording stage.

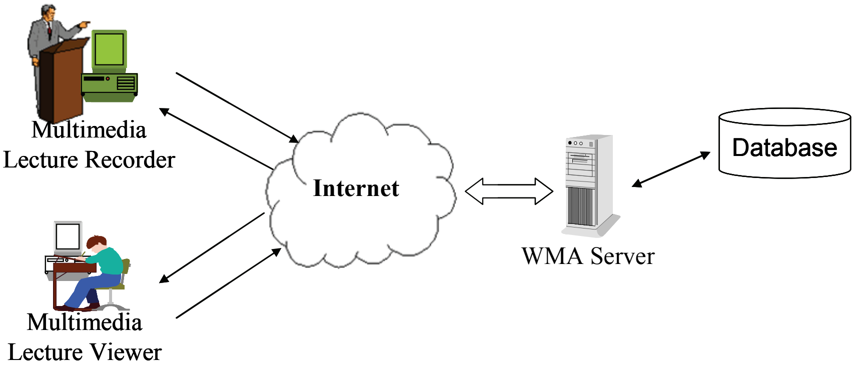


Fig. 3. Client/Server architecture for composition studies

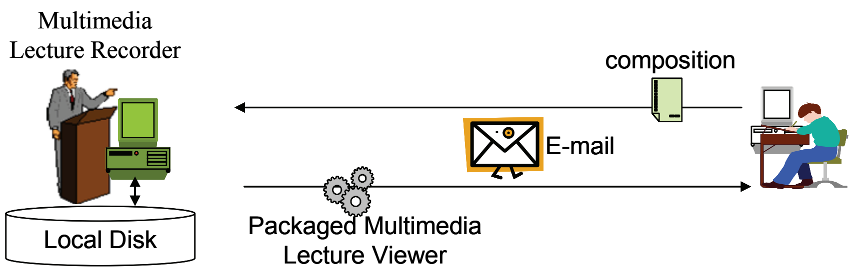


Fig. 4. Correcting procedures for offline version

4.2 Offline version

One reason for us to develop the offline version is the unstable of network connections. Although it is convenient to convey information through the Internet, sometimes instructors may encounter unexpected network problems that cause the miss or failure in uploading of captured materials. Another reason is that it is difficult for an instructor to prepare equipments for setting up the WMA server. Thus in the offline scenario, the related tools of WMA system are packaged as a stand-alone application for instructors to install on their local computers. Figure 4 shows the correcting procedures of the offline scenario. Resources exchange and transmit are achieved by the traditional e-mails. The communication steps are described as follows: (1) a learner prepares his/her composition in pure text (.txt) or MS Word (.doc) format, and then sends the file by attaching in a mail to the instructor. (2) After receiving the mail, the instructor can start the recording tool and import the content of composition into the recorder. (3) Once the instructor finishes the recording, all of involved media objects (including Multimedia Lecture Viewer) will be packaged into a zip file, and the instructor can send the packaged file to the learner. (4) The learner can extract the file and open the Multimedia Lecture Viewer to access the corrected composition as well as the online access.

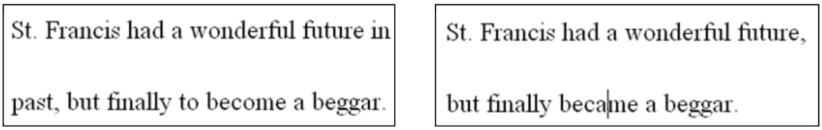
Our system provides two scenarios for English composition studies. The former (online) is suitable for an organization which contains many affiliates, and the latter (offline) may be helpful for personal use in a class.

4.3 Recording modes

Recording is usually a sequential task. Although our system provides functions of "*pause*" and "*resume*" to control the recording pace, it may still cause some instructors to record a lecture under pressure. The reason is that the instructor doesn't want to miss the errors required to correct, or to make mistakes when correcting. In our system, we devised an "*undo*" function for instructors to cancel the visualized events (e.g., markings, pen strokes or annotation) during the recording stage; however, the recording captures various data streams (text, navigation events and voice) in real-time, further analysis for "*undo*" operation is required. After a visualized event was canceled, the system needs to have the ability to remove the corresponding segment of other streams. This is the reason to explore media correlation in our system (Liu & Chen, 2005). To cancel visualized events seems to be a good solution during the recording, but any automated analysis process couldn't ensure that its analyzed result is perfect. Therefore, "*undo*" is an optional function for instructors.

In order to redeem the insufficient of our capturing tool and to reduce the pressure on instructors, we make a little bit change on the recording procedure. Instructors can achieve the recording in accordance with the following steps:

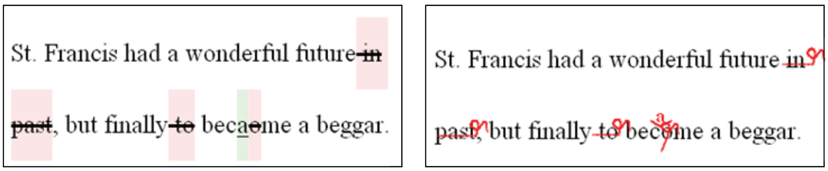
(1) Revising content directly: Before the recording, the instructor can revise the content of student's composition directly as well as the operations in a text editor. Figure 5 is an example to edit the content of a composition.



(a) Before editing (b) After editing

Fig. 5. An example of text editing, (a) before editing and (b) after editing

(2) Comparing the differences of content between revisions automatically: In our capturing tool, we applied the algorithm implemented by Neil (Neil, 2007) on the differences comparison between text contents. The differences, including additions, deletions will be highlighted in different colors, as shown in Figure 6(a). In this presentation mode, too much information is shown on the screen that may annoy the instructor during the correcting process. Thus our system will transfer the presentation from text-based to marking-based according to the compared result, as Figure 6(b) shows.



(a) Text-based (b) Marking-based

Fig. 6. After the comparison between Figure 5(a) and Figure 5(b)

(3) Recording voice comments: After the comparison is achieved, the instructor can start to record voice comments according to the revised points. The operation functions listed in Table 1 still work in this phase.

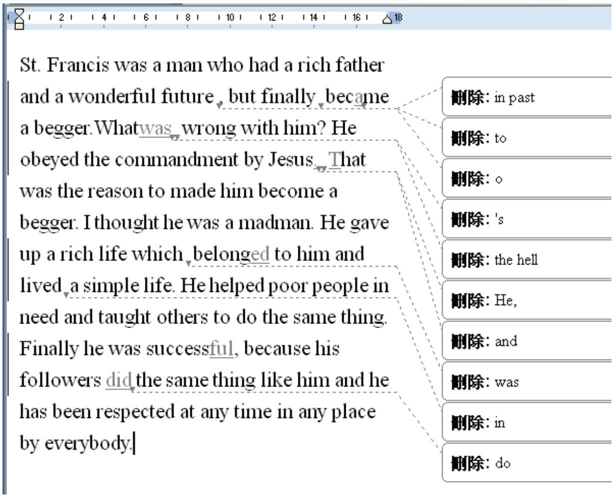


Fig. 7. An example of corrected composition opened in the MS Word

5. Presentation Modes

Once a learner requests an online corrected lecture from the WMA server or opens an offline corrected lecture from the local computer, default presentation mode of the Multimedia Lecture Viewer is marking-based. All visualized events will be rendered on the screen, and once the learner presses the '*play*' button, the correcting process can be reconstructed by synchronization mechanism. In addition to general random access function, we devised a process to analyze the relationships between speech data and the visualized events to facilitate the cross-media access (Liu & Chen, 2005). The process is used to find out the speech segment of explanation related to a visualized event. Therefore, a learner can retrieve the corresponding explanation by clicking a visualized event.

Another presentation mode in our system is text-based. In this mode, a learner will still see the entire correcting process without markings. The correcting points will be presented as well as the actual task of editing by a text editor. Moreover, our system supports the exporting of corrected composition to an HTML document that is compatible with the MS Word. Thus the exported file could be opened by MS Word application, and all the correcting points will be shown by enabling the editing trace function. Figure 7 is an example of the exported file opened by the MS Word.

6. Conclusion

We have established an environment using multimedia features for English composition studies, and the system has been used on campus of Providence University (http://english.cs.pu.edu.tw) and National Chi Nan University (http://english.csie.ncnu.edu.tw). We hope that the system functions will be helpful for both instructors and students in their teaching and learning.

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Effects of Media Richness on User Acceptance of Web 2.0 Technologies in Higher Education

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Australia

1. Introduction

Educators are increasingly developing numerous ways to use Web 2.0 technologies to facilitate teaching, learning and to keep up to date with trend. These technologies provide enhanced interactivity and allow greater amounts of information delivered via richer communication, hence gaining wide spread acceptance among educational community. However, less empirical research has been done examining their information carrying capacity or media richness and its impact on user acceptance, specifically within the educational realms. This chapter is focused on examining the impact of media richness on user acceptance of various Web 2.0 technologies. Here we present findings of an empirical study to examine the effects of media richness on user acceptance of three popular Web 2.0 technologies namely blog, podcast and Second Life (a 3-D multi-user virtual environment), within higher education. A theoretical model has been presented based on technology acceptance model (TAM) (Davis 1989) and media richness theory (Daft et al. 1984). Data were gathered using online surveys and structural model was validated using the PLS (partial least squares) approach. Findings suggest that media richness has significant impact on user acceptance of all three technologies under consideration. However, media richness of Second Life has the greatest impact on user acceptance as compared to that of blog and podcast. These results are consistent with previous studies of media richness which state that synchronous communication media are richer than asynchronous media. These results also highlight Second Life's media richness capabilities of allowing multiple cues, timely feedback, language variety and personal focus in order to support teaching and learning activities. In this chapter, we also highlight some implications of our research for educators and developers of Web 2.0 applications followed by some ideas for future research.

2. Web 2.0 Technologies

2.1 Blogs

Web-log (or blog) is a Web site that contains dated entries in reverse chronological order about a particular topic and usually has links to comments on specific postings (Answers.com 2009). A typical blog functions like an online journal and may contain text, images, or even search facilities and links to other blogs, Web pages, and media (Wikipedia

2009a). Blogging has received increased attention in both professional and academic circles as it becomes more prevalent (Pew Internet and American Life Project 2005; http://www.pewinternet.org). A number of studies have shown benefits of using blogs in academic settings. For example, Lin et al. noted that blogs successfully contributed to students' online engagement (Lin et al. 2006); Maag reported that students shared their learning experiences and expressed their thoughts to the instructor and peers through course blogs (Maag 2005). Dickey also reported that blogs sparked reflective learning and satisfaction (Dickey 2004). Similarly, Kerawalla et al. found that students enjoyed blogging and used it for community building, resource-consolidation, sharing ideas or as a personal journal (Kerawalla et al. 2008). Despite these benefits there are some conflicting results about effectiveness of blogs. For example, many blog sites were claimed to be abandoned soon after their creation (Arnold 2008); or found to be unproductive in terms of interactivity among students (Divitini et al. 2005). Since a number of communication channels can be used in blogs including text, graphics, videos and audio, it is important to know about information carrying capacity of blogs and its impact on user acceptance.

2.2 Podcasts

Podcast is a series of digital media (audio or video) files that is released periodically and made available over the Internet using the syndication feeds for playback on portable media players and personal computers (Wikipedia 2009b). Like blogs, several examples of educational podcasting are also available. For example, the Duke iPod first-year experience project, where iPods were used for course content dissemination, classroom recording, field recording, study support, and file storage and transfer (Belanger 2005). Podcasting is also known to be more flexible and effective than traditional use of Websites and printed handouts (Chan et al. 2005) or even text books or students' own notes (Evans 2007). It is also found that podcasts advanced learning and improved students' understanding of the lecture material (Bongey et al. 2006). Podcasts can be used for dissemination of knowledge, broadcasting news to staff and students, supplementing class materials, guest lecture presentations and as a marketing tool for attracting prospective students (Harris et al. 2008). Despite these benefits of educational podcasting, very little empirical research is available on the information carrying capacity of podcasts and its impact on user acceptance.

2.3 Second Life

Second Life is a 3-D multi-user virtual environment (MUVE) launched by Linden Lab in 2003. Second Life is a world solely created by its inhabitants, called 'residents'. Residents have the opportunities to create their digital proxies called 'avatars' and design their clothing, hair colour, dresses and even appearances (Coffman et al. 2007). Avatars can walk, run, or even fly in the virtual environment. They can converse with other avatars using text, images, gestures or even voice. Residents can move or 'teleport' from one location to another.

3-D MUVEs like Second Life offer a variety of potential benefits for educational use including: collaboration and communication, engagement, conducting activities in a risk-free environment, alternative space for instruction and tasks, and visualisation of difficult content (Eschenbrenner et al. 2009). Richter et al. have identified at least five different types of learner engagements that are possible in Second Life: experiential, diagnostic, demonstrative, role-play and constructivist (Richter et al. 2007). Second Life has the potential to be a useful educational tool for teaching and learning by using a constructivist approach (Coffman et al. 2007), which is the theory of knowledge acquisition obtained through interactions and building upon own knowledge and which produces the highest type of learning according to Bloom (Cheal 2007). Following this approach, students can discover and create meaningful content and interactions (Stevens 2006). Teachers in higher education have found Second Life a convenient place to conduct online classes, conferences, presentations, and meetings with students (Richter et al. 2007). However, in order to explore the teaching and learning potential of Second Life, it is important to investigate about media richness of Second Life and its impact on user acceptance.

3. Media Richness Theory

Media richness theory (MRT), originally developed by Daft and Lengel, states that the communication efficiency between people is affected by the fitness of the media and the characteristics of the communication task (Daft & Lengel, 1986). The richness of media is based upon the following four criteria: (1) capacity for immediate feedback; (2) capacity of the medium to have a personal focus; (3) capacity to transmit multiple cues, and; (4) language variety (Daft, Lengel, & Trevino, 1987). Using these categories, Daft and Lengel consider face-to-face communication as the 'richest' mode of communication while text being the 'leanest'. They also include technologies such as telephone, email, postal letter, note, memo, flier, and bulletin along their spectrum of media richness. Several other researchers follow a similar approach to classify other media such as video, voice, pictures, and text (Rice, 1992; Schmitz & Fulk, 1991; Zmud, Lind, & Young, 1990). With regard to the characteristics of communication task, MRT states that the purpose of communication is to reduce uncertainty and equivocality in order to promote communication efficiency, where uncertainty is associated with the lack of information and equivocality is associated with negotiating meanings for ambiguous situations. Therefore, a rich medium should be able to transmit sufficient amount of correct information in order to reduce uncertainty and should be able to process rich information in order to reduce equivocality (Sun & Cheng, 2007). In this chapter, we try to examine the media richness of various Web 2.0 technologies including: blogs, podcasts and Second Life and its impact on user acceptance. We would also like to examine which technology offers the maximum information carrying capacity or being the richest.

4. Theory of Technology Acceptance

Investigation of technology acceptance by target users have received considerable attention from Information Systems researchers and practitioners and several theoretical models and frameworks have attempted to explain or predict a person's decision to accept a new technology (Chakraborty et al. 2008). Of particular importance is the Technology Acceptance Model (TAM), a widely used model originally developed by Davis and his colleagues (Davis et al. 1989) to explain or predict individuals' acceptance of computer-based systems in various scenarios and organisational contexts (Chakraborty et al. 2008). TAM posits that user perceptions of usefulness and ease-of-use determine attitudes toward using the system or technology. An individual's attitude is hypothesised to influence the behavioural intention to use a technology, which in turn leads to actual use. In the follow-up studies of TAM, the attitude component was dropped and perceived technology characteristics directly influenced the individual's intention to use the technology (Venkatesh et al. 2000). TAM has been considered as being robust and parsimonious for predicting user acceptance of a variety of new technologies (Raaij et al. 2008) and has been validated for a variety of new technologies including word processors, e-mail, spread-sheets, Web-based learning systems, and multimedia learning systems (Halawi et al. 2007; Lederer et al. 2000; Saade et al. 2007). In this chapter, we aim to examine the impact of media richness on user acceptance of various Web 2.0 technologies including: blogs, podcasts and Second Life. To do this methodologically we need to build a conceptual model and test several hypotheses and gauge the outcome which will be dealt in the next section.

5. Hypotheses and Model

Perceived usefulness and perceived ease-of-use are the basic TAM constructs. In general, perceived usefulness reflects an individual's subjective estimation of the job performance enhancement that is likely to result from the use of a new technology, whereas perceived ease-of-use refers to the degree to which he or she expects the use of the technology to be free of effort (Davis et al. 1989). Both of these constructs constitute a significant influence on an individual's intention to use a technology or system (Ma et al. 2004). We follow this trend and hypothesise the following:

H1. The perceived usefulness (PU) of blog, podcast and Second Life will have a positive impact on behavioural intention (BI) to use these technologies.

H2. The perceived ease-of-use (PEU) of blog, podcast and Second Life will have a positive impact on behavioural intention (BI) to use these technologies.

H3. The perceived ease-of-use (PEU) of blog, podcast and Second Life will have a positive impact on perceived usefulness (PU) of these technologies.

As media richness is referred as the information carrying capacity of a medium or its ability to facilitate shared meaning and understanding (Daft et al. 1984), it can be assumed that media richness will have a positive impact on people's intention to use a technology and that the more the media is rich the more they will find it easy-to-use. We thus hypothesise the following:

H4. The perceived media richness (PMR) of blog, podcast and Second Life will have a positive impact on behavioural intention (BI) to use these technologies.

H5. The perceived media richness (PMR) of blog, podcast and Second Life will have a positive impact on perceived ease-of-use (PEU) of these technologies.

Based on the above hypotheses an extended TAM is presented including perceived media richness, as shown in Figure 1.

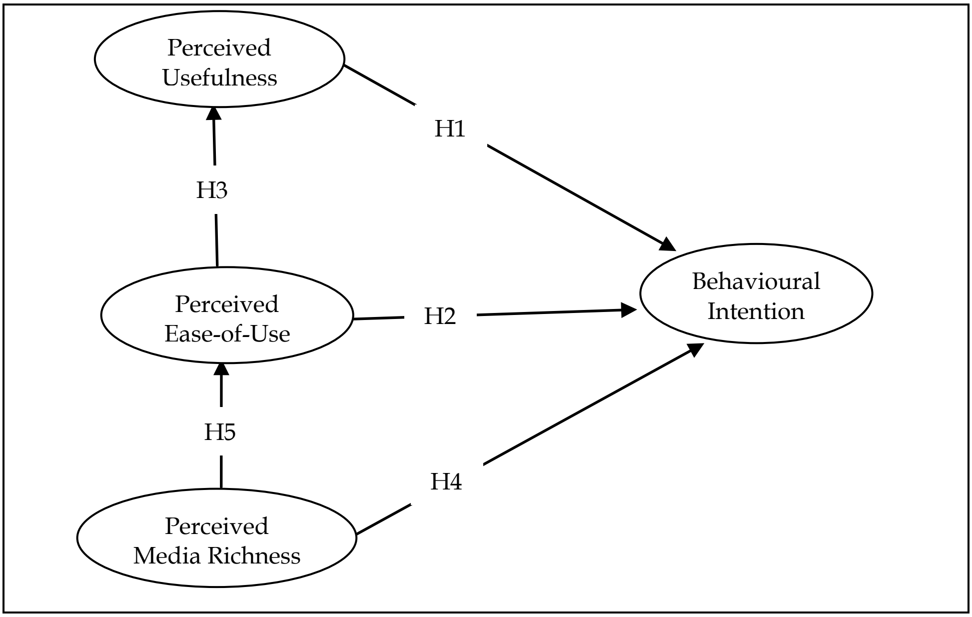

Fig. 1. An extended TAM for Web 2.0 technologies including perceived media richness

6. Participants and Data Collection

To test the model in Figure 1 and validate the hypotheses we needed to carry out a study to examine user acceptance of Web 2.0 technologies within the educational context. Ideally, our respondents should include academic-centric participants who either had attended, designed or have been involved in some form of educational activities using blogs, podcasts and Second Life. To achieve this, an online survey was developed and participants were invited to take part in the survey using a number of possible venues including educators and researchers mailing lists, personal invitations to educational groups and advertising within Second Life. Some recent studies have adopted the similar approaches in exploring Web 2.0 technologies in the education context (Alvarez 2006; Boostrom 2008; Richter et al. 2007). The total number of valid responses obtained from the above mentioned resources was 122, which sufficed to perform the PLS analyses.

Multiple items were adopted from previously published scales for the constructs used in our model (Figure 1). The scales for perceived usefulness (PU) and perceived ease-of-use (PEU) were adopted from Davis et al. (Davis et al. 1989) including six items (PU 1-6) and four items (PEU 1-4) respectively. The scales for behavioural intention (BI) were adopted from Venkatesh et al. (Venkatesh et al. 2003) including three items (BI 1-3). The scales for perceived media richness (PMR) were adopted from (Carlson & Zmud, 1999) including four items (PMR 1-4). All above items were measured on a seven point Likert scale, ranging from 1 (strongly disagree) to 7 (strongly agree). The complete questionnaire detailing above mentioned items is available in the Appendix.

7. Results

The PLS approach was used to assess both the measurement and the proposed structural model, using PLS Graph 3.0 software. PLS is a variance based latent variable structural equation modelling technique, which uses an estimation approach that places minimal demands on sample size and residual distributions (Chin 1998b). Previous research shows that PLS approach is more suitable for prediction as compared to other approaches like LISREL and EQs, because it assumes that all the measured variance in the study will be explained (Saade et al. 2005). The PLS approach has been used in several other studies of technology acceptance (see (Raaij et al. 2008), (Saade et al. 2005), (Mun et al. 2003)), thus deemed suitable for our study. After ensuring the validity and reliability of the scales, we tested the hypothesised relationships between TAM and the media richness constructs. We conducted tests of significance for all the paths using the bootstrap re-sampling method (Cotterman et al. 1992).

7.1 Demographics

Our sample included 79 females and 43 males. The mean age of participants was 42, ranging from 17-65 years. Teachers (27%) and students (25%) constituted the larger groups while researchers (13%) constituted the smallest group. The majority of participants appeared well educated as 67.2% of them held postgraduate qualifications. The survey results also showed that 82.8% of participants had Internet experience of more than 9 years. In addition, 66% of participants had more than 6 months of experience in using blogs while 50% had the similar experience in using podcasts. For Second Life, 81.9% had at least 6 months experience. These results suggest that our participants were of mature age and well educated. They had extensive experience of using Internet and adequate experience of using blogs, podcasts and Second Life in the academia. Thus they fit well into our target participants' profile.

7.2 Data validation and reliability

Table 1 presents the summary of all measurement scales including factor loadings, t-values, composite reliability and average variance extracted (AVE). The factor loadings provide the evidence for convergent validity as all constructs load greater than the threshold of 0.60 as suggested by Chin (Chin 1998a). The t-values derived from our analysis also provide the evidence for convergent validity since all values exceed the threshold of 1.96 as suggested by Gefen and Straub (Gefen et al. 2005). Internal consistency also appears significant for all of our constructs since the composite reliability values exceed the minimum of 0.70 as suggested by Nunnaly and Bernstein (Nunnally et al. 1994).

Discriminant validity was met using the Fornell and Larcker test (Fornell et al. 1981). The procedure involves computing the square root of the AVE of each construct, which should exceed the correlation shared between the construct and other constructs in the model. Table 2 shows that the square roots (in bold) of all AVEs (on the diagonal) are greater than the cross-correlations of all other constructs. Thus all our constructs demonstrate a good degree of validity and reliability.

	Construct Items	Factor Loadings	t-values	Composite Reliability	AVE
Blog	PU (1-6)	.67-.81	15.31-27.17	.87	.59
	PEU (1-4)	.64-.74	6.93-11.34	.76	.51
	PMR(1-4)	.76-.82	14.61-31.28	.88	.65
	BI (1-3)	.82-.85	19.87-29.80	.87	.69
Podcast	PU (1-6)	.71-.84	11.78-39.90	.90	.59
	PEU (1-4)	.63-.80	7.03-33.49	.81	.51
	PMR(1-4)	.76-.81	17.16-22.10	.88	.64
	BI (1-3)	.82-.85	20.63-37.48	.88	.71
Second Life	PU (1-6)	.68-.86	9.43-35.64	.90	.59
	PEU (1-4)	.60-.89	3.0-16.04	.70	.50
	PMR(1-4)	.74-.82	11.84-18.11	.87	.63
	BI (1-3)	.89-.94	28.51-49.84	.94	.83

Table 1. Construct reliability measures

		PU	PEU	PMR	BI
Blog	PU	**.77**			
	PEU	.45	**.71**		
	PMR	.52	.34	**.81**	
	BI	.56	.38	.55	**.83**
Podcast	PU	**.77**			
	PEU	.54	**.71**		
	PMR	.51	.32	**.80**	
	BI	.55	.46	.46	**.84**
Second Life	PU	**.77**			
	PEU	.42	**.71**		
	PMR	.58	.36	**.79**	
	BI	.41	.14	.52	**.91**

Table 2. Discriminant validity of constructs

7.3 Hypotheses and Model Testing

The proposed hypotheses and structural model are evaluated by examining the significance of path coefficients and the variance explained by the dependant constructs. Table 3 summarises the results of hypotheses testing and variance explained (R^2) by the dependant variables (behavioural intention to use blog, podcast and Second Life). The path coefficient values provide support for hypothesis H1 as the relationships between PU and BI appear significant for all three technologies. Hypothesis H2 is not significant (n.s.) for blogs and Second Life but appear significant in the case of podcast. However this is consistent with the previous studies of TAM. Hypotheses H3, H4 and H5 appear significant for all three technologies. Table 3 also shows the variance explained (R^2) by the original TAM as well the extended TAM, i.e., TAM including perceived media richness. The original TAM explains 32% of the users' intentions to use blogs while the extended TAM explains 41% of users' intentions to use blog, thus showing an overall improvement of 9 percent. Similarly, the extended TAM shows an overall improvement of 4% and 12% for podcast and Second Life respectively. Thus the media richness has the strongest impact on users' intention to use

Second Life. These results are further verified by comparing the path coefficient values of relationships *PMR → BI* and *PMR → PEU* for Second Life with those of blogs and podcasts.

	Blog	Podcast	Second Life
PU→ BI	4.31***	2.96**	2.0*
PEU→ BI	1.48 (n.s.)	2.06*	1.0 (n.s.)
PEU→ PU	6.43***	9.61***	5.63***
PMR→ BI	4.20***	2.56**	4.61***
PMR→ PEU	4.20***	3.88***	4.75***
Variance explained (R^2) by the original TAM	.32	.34	.18
Variance explained (R^2) by the extended TAM	.41	.38	.30
Overall Improvement (%age)	9%	4%	12%

Table 3. Hypotheses testing and variance explained by the original TAM and extended TAM.
* Path coefficient significant at the 0.5 level; ** at the 0.1 level; *** at the 0.001 level.

7.4 Analyses of Results

Several insightful results can be summarised from the above findings. First of all, the original TAM holds true for all three technologies (blog, podcast and Second Life) under consideration, except the insignificant relationship between perceived ease-of-use and behavioural intention. However this is consistent with the previous studies of TAM. For example, Davis observed that when users learn to effectively use the system, the direct effect of ease-of-use on the system use disappears (Davis 1989) while Raaij and Schepers suggested that the actual use of system can be influenced more by the perceived usefulness as compared to the perceived ease-of-use, as users are willing to overcome the usability hurdles of system's environment in favour of the prospect of better academic outcomes (Raaij et al. 2008). It can also be noted that the original TAM explains only 18% of the users' intentions to use Second Life, which suggests that the traditional approaches may not be able to explain the usage of today's highly interactive, multi-user and entertainment-oriented technologies like MUVEs or multiplayer online games. Similar concerns are echoed by (Heijden 2004), (Holsapple et al. 2007) and (Hsu et al. 2004). These results further suggest the need to explore other facets of human behaviour in order to better explain usage of emerging Web technologies.

Second, perceived media richness shows a highly significant impact on the users' intentions to use all three technologies, which suggests that the more the medium is rich the more the users perceive it easy-to-use and finally use it. However, this impact is the strongest in the case of Second Life followed by blogs and podcasts, which suggests that Second Life is a very rich medium in its capacity to provide immediate feedback, to have a personal focus, to transfer multiple cues, and to offer language variety. In line with some previous studies (Kishi 2008; Newberry 2001), our findings confirm that synchronous media like Second Life are richer than asynchronous media such as blogs or podcasts.

Third, it can also be seen from Table 3 that our proposed model (TAM with media richness) is able to better explain the usage or acceptance of blogs, podcasts and Second Life as compared to that of original TAM. However, this improvement is more significant in the case of Second Life as compared to blogs and podcasts. This suggests that Second Life offers a richer environment to interact among its users.

The findings discussed above have implications for both research and practice. First, the study contributes to the field of technology acceptance by advancing the significant effect of media richness on usage or acceptance of new technologies. Second, the study has implications for educators who wish to incorporate emerging Web technologies like blogs, podcasts and Second Life in their courses: they should employ pedagogical principles in the development of meaningful content to increase the usage of above technologies. The findings further suggest that Second Life can be used as an effective tool for content dissemination by educators and as a collaborative research activity among researchers as it offers a richer environment and a variety of communication channels.

8. Conclusion

Media richness is not new in predicting users' choice about new technology or categorising various technologies based on their richness. However the aim of this chapter is to examine the impact of media richness on user acceptance of three popular Web 2.0 technologies namely: blogs, podcasts and Second Life. A theoretical model is presented based on the theories of technology acceptance and media richness in order to examine the impact of media richness on user acceptance of above mentioned technologies. The proposed model is evaluated based on the data collected from an online survey. Findings suggest that media richness has a direct and positive significant impact on user acceptance of blogs, podcasts and Second Life. However there is a need to consider other behavioural factors in order to better explain usage of emerging Web technologies. They further suggest that Second Life is the richest medium among the three technologies under consideration thus deem suitable for educational and research activities.

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Appendix

Perceived Usefulness (PU)
PU1: Using blog / podcast / Second Life enables me to accomplish my tasks more quickly.
PU2: Using blog / podcast / Second Life improves my class or work performance.
PU3: Using blog / podcast / Second Life increases my productivity.
PU4: Using blog / podcast / Second Life makes it easier for me to understand lecture.
PU5: Using blog / podcast / Second Life makes it easier for me to communicate with lecturer/friends.
PU6: Overall, I find blog / podcast / Second Life useful in my study/work

Perceived Ease of Use (PEOU)
PEOU1: Learning to use blog / podcast / Second Life is easy for me.
PEOU2: I find it not difficult to get blog / podcast / Second Life to do what I want it to do.
PEOU3: I find blog / podcast / Second Life to be flexible to interact with.
PEOU4: It is easy for me to become skilful at using blog / podcast / Second Life.

Perceived Media Richness (PMR)
PMR1: Blog / podcast / Second Life allows me to give and receive timely feedback.
PMR2: Blog / podcast / Second Life allows me to tailor interaction according to my personal requirements.
PMR3: Blog / podcast / Second Life allows me to communicate a variety of different cues (such as emotional tone, attitude, or formality) during communication.
PMR-4: Blog / podcast / Second Life allows me to use rich and varied language during communication.

Behavioural Intention (BI)
BI1: Assuming I had access to blog / podcast / Second Life, I intend to use it.
BI2: Given that I had access to blog / podcast / Second Life, I predict that I would use it.
BI3: I will use blog / podcast / Second Life frequently in the future.

Supporting learning in online communities with social software: An overview of community driven technologies

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1. Introduction

The notion of communities has been widely studied and recognized as an increasingly important social structure for creating, sharing and applying knowledge in organizational and educational settings. Current developments in Information and Communication technologies (ICT) have provided the means for interacting across boundaries both in space and time and have greatly enhanced the development of online communities.

With the advent of Web 2.0 Internet users are not only consuming information from the World Wide Web but they are also participating in the production of Web content. Web 2.0, which is often called social web due to its social nature, is driven by an "architecture of participation" that allows users to collaboratively create and share information resources. In this context, online communities are formed in an emergent way through social interactions between peers without intentional design or structure imposed from above.

The term social software has emerged alongside with Web 2.0 and comprises a wide range of community driven technologies. One of the promises of social software is the aggregation of community knowledge through many contributions by individuals. Although, the most familiar forms of social software are likely to be Wikis or Weblogs, recently a range of technological approaches such as collaborative filtering, social tagging and social navigation have enhanced and broadened the scope of the term. The role of these technologies is dual fold in the sense that they focus on creating communities by bringing people together and they also exploit the community around an individual as a valuable resource to guide information seeking.

An important feature of social software is self-organization. Members of online communities supported by social software are able to organize their activities with little or no central control. Systems empowered by community driven technologies are characterized by a bottom-up mode of organizing information rather than top-down design.

This chapter will provide an overview of the above mentioned emerging technologies while focusing primary on social navigation, collaborative filtering and social tagging. The chapter will examine the strengths and weaknesses of these technologies and it will present examples of their application in the field of e-learning.

2. Learning in Online Communities

Information and communication technologies (ICT) provide the infrastructure to connect members of a community across the geographical or the institutional barriers. Thus, one can distinguish between traditional communities, where connections are based on conventional face-to-face interactions and online communities (Johnson, 2001), where connections are closely intertwined with the use of network technologies. Participating in a online community is first and foremost a social experience that changes according to who is present, the number of people involved, and the type of discussion that occurs (Preece et al., 2004). This social experience has been enhanced the last years with the advent of Web 2.0 applications. The openness of these applications to user-generated content supports the formation of online communities where users can share opinions, ideas, bookmarks and other information resources.

Anna Sfard (1998) has distinguished two metaphors of learning, the acquisition metaphor and the participation metaphor. The acquisition metaphor refers to learning as a process of acquiring knowledge. Once acquired knowledge becomes a property of an individual it may be applied, transferred and shared with others. The participation metaphor examines learning as a process of becoming a member of a certain community. While the acquisition metaphor emphasizes the individual mind and how it operates with knowledge, the participation metaphor shifts the focus to the evolving connections between the individual and others in particular social and physical contexts. A third metaphor, named as the knowledge-creation metaphor proposed by Paavola, Lipponen and Hakkarainen (2002) as an attempt to integrate the two metaphors in order to understand innovative knowledge communities that are emerging within the modern knowledge society. In this metaphor, learning is seen as a social process of creating and advancing knowledge.

The knowledge-creation perspective tries to explain how a community is able to transform, surpass and expand existing achievements through collaborative activities that take place within and across community boundaries (Lipponen, Hakkarainen, and Paavola, 2004). Thus, besides the examination of closed systems (individual, team and community) it addresses also the complex relations that occur when people and artefacts cross the boundaries of activity systems or communities. Such situations require learning about different knowledge domains. Members of a community have to step into unfamiliar territories in order to seek and bring information, knowledge and practices from other communities. They have to engage with members of other communities and face the challenge of negotiating and combining ingredients from different contexts to achieve hybrid solutions. In this mode of activities, namely boundary crossing (Engeström, Engeström and Karkkainen, 1995) learning should be understood both as a vertical process of development in which individuals increase and transform their conceptual understanding and as a horizontal process of development in which individuals expand their ability to act in new and different environments (Engeström, Engeström and Karkkainen, 1995; Tynjälä and Häkkinen, 2005).

The knowledge-creation metaphor is characteristic of how learners engage in social interaction with peers worldwide in order to create and share content with the use of Web 2.0 technologies – and all this is done bottom-up with an extremely high degree of self organisation (Rollett et al, 2007). Communities are formed in an emergent way through social interactions between peers without intentional design or structure imposed from above. These communities cannot be described with what constituted “community” in online learning where artificial and often contrived "discussions" are supported by learning management systems (Downes, 2005). They are better understood as Online Self Organising Social Systems (OSOSSes).

OSOSSes were first defined by Wiley and Edwards (2002) as systems that allow “large numbers of individuals to self-organise in a highly decentralised manner in order to solve problems and accomplish other goals”. With the advent of Web 2.0 and social software, Wiley (2006) revised the definition. According to the new definition an Online Self-organising Social System exists when: (1) A large number of people engages in a large number of direct or indirect interactions via the network; (2) These interactions help individuals accomplish things they have reason to value; (3) No central authority provides extrinsic incentives for participation in the system (4) No central authority regulates or controls the interactions (Wiley, 2006 p. 291)

3. Social Software

Social software has emerged alongside with Web 2.0 and comprises a wide range of community driven technologies. The term was coined by Clay Shirky who defined social software as “software that supports group interaction” (Shirky, 2003). Several traditional software applications supports group interaction, however they approach the relationship of users to groups from a top-down fashion. Social software enables groups to form and self-organize in a bottom-up manner (Boyd, 2006). According to Stowe Boyd the term social software can distinguish software built around one or more of the following premises:

- Support for conversational interaction between individuals or groups — including real time and "slow time" conversation, like instant messaging and collaborative teamwork spaces, respectively.
- Support for social feedback — which allows a group to rate the contributions of others, perhaps implicitly, leading to the creation of digital reputation.
- Support for social networks — to explicitly create and manage a digital expression of people's personal relationships, and to help them build new relationships.

Social software supports social networking and community building. *Social networking sites* like MySpace, Cyworld and Facebook allow users to present themselves and their interests, articulate their social networks, and establish or maintain connections with others (Ellison et al., 2006). Participants have the ability to list other profiles as "friends" or "contacts" or some equivalent. This generates a social network graph which may be directed ("attention network" type of social network where friendship does not have to be confirmed) or undirected (where the other person must accept friendship). This articulated social network is displayed on an individual's profile for all other users to view. Each node contains a link to the profile of the other person so that individuals can traverse the network through friends of friends of friends (Mason, 2007).

Wiki software allows users to easily create and upload content on the internet but also allows this content to be edited by other users. Users of Wiki's software can create and edit documents collaboratively, in a simple markup language using a Web browser. One of the most well known examples is Wikipedia, a free content multilingual online encyclopaedia written collaboratively by contributors around the world. The goal of Wikipedia is to create an encyclopaedia that can be shared and copied freely while encouraging people to easily change and improve the content. Wikipedia provides a model of how knowledge creation may happen in a self-organised, collaborative, "wisdom of crowds" style. Users are allowed to add edit or delete content to any page of Wikipedia. However, what would surely seem to create chaos has actually produced increasingly respected content which has been evaluated and revised by the thousands of visitors to the site over time (Lih, 2004).

Weblogs are another example of social software. They are easily updateable personal websites that allows the authors to publish to the Internet. The entries (posts) in a Weblog are usually short and listed in a chronologically order. Most Weblogs are written by individuals and thus in general a weblog is not considered as a collaborative tool. However, readers of a weblog can add their comments on the posts or link them with other weblog posts using their permalinks. When a weblog is related to other weblogs, the weblogs become social, and communities or networks are formed (Dalsgaard, 2006).

Several authors have examined the potential benefits of social software in the context of e-learning. Rollett et al (2007) investigated the potentials of integrating lightweight Web 2.0 applications for the purpose of facilitating self-directed, collaborative and responsible learning in educational settings. Downes (2005) has strengthened the potential of social software to transform the current model of e-learning where content is produced by publishers, organized and structured into courses, and consumed by students to a model of e-learning where content is created, aggregated, remixed and repurposed by students. Dalsgaard (2006) argues that social software supports self-directed, problem-based and collaborative learning processes. According to Dron (2006a), social software offers great potential pedagogic and practical benefits to e-learning, both through the amplification and creation of social ties, and through allowing learners to choose whether they want to control or to be controlled in a learning transaction.

Although, the most familiar forms of social software are likely to be Wikis or Weblogs, recently a range of technological approaches such as collaborative filtering, social bookmarking and social navigation have enhanced and broadened the scope of the term (Dron, 2006). The role of these technologies is dual fold in the sense that they focus on creating communities by bringing people together and also they exploit the community around an individual as a valuable resource to guide information seeking.

4. Community-driven technologies

Online communities provide the ground for knowledge creation, social negotiation of meaning and learning through the collective participation of their members. In order to participate effectively to these processes community members need guidance to find and synthesize information. Over the past few years several community-driven technologies have been developed to address this issue. This section will focus on three of these technologies: collaborative filtering, social navigation and social tagging.

4.1 Collaborative filtering

Collaborative filtering or social recommender systems recommend data items to a user by taking into account the opinions of other users (Schafer et al., 2007). Instead of recommending data items because they are similar to items the user preferred in the past (content-based recommendations) collaborative approaches generate recommendations about data items that users with similar interests liked in the past. In order to estimate user's preference for an item collaborative filtering systems collect ratings through explicit means (e.g the user is asked to rate the item), implicit means (e.g. the system infers user's preference by observing user's actions) or both.

Goldberg et al., 1992 first coined the term collaborative filtering while describing Tapestry, which later became known as the first recommender system (Resnick & Varian, 1997). Tapestry was an email-filtering system which allowed users to store annotations about messages. A user could filter the messages by writing queries on these annotations. This approach was later called pull-active collaborative filtering, because users who desire recommendations manually pull them by writing the relevant queries. Soon after Tapestry collaborative filtering approaches focused on generating automated recommendations led by systems such as Grouplens (Resnick et al., 1994; Konstan et al., 1997), Ringo (Shardanand & Maes, 1995) and Bellcore's Video Recommender (Hill et al., 1995). In general, automated approaches follow a process of gathering user ratings on items, identifying users with similar interests or tastes and combining the ratings of similar users to provide recommendations. With the growth of e-commerce, collaborative filtering techniques have become well known through their use in commercial web sites such as Amazon.com. When a potential customer visits a web page with information about a product A in Amazon.com the system recommends a list of similar products that have been bought by other customers who bought the product A.

One of the first applications of collaborative filtering in e-learning was done by the Altered Vista system (Recker & Walker, 2003). Altered Vista attempts to leverage the work of many people to capture and propagate the opinions of its user community. Users of the system submit reviews about the design, quality, and usefulness of Web resources for online education. These explicit ratings become part of the recommendation database. When a user requests recommendations the system first determines a neighbourhood of like-minded users for the active user and calculates a predicted rating for each of the recommended resources. The predicted rating is a weighted average of the ratings of users in the neighbourhood, based on their correlation level with the active user. Another system that produces recommendations based on explicit ratings is the Questions Sharing and Interactive Assignments (QSIA) system (Rafaeli et al., 2005). The QSIA system was designed to promote collaboration and formation of communities with interest in assignments and tests. Users of the system can rate any of the available resources on a five-level scale. The recommendation process is mostly user-controlled: the user can choose whether the recommendations would be based on a neighbourhood of anonymous users predicted by the system or on a group of friends. The second choice involves the user's selection of the characteristics of the friends to participate in the advising group.

Explicit ratings provided by users offer the most accurate description of the user's opinion about a resource. However this approach requires extra effort from the user in order to provide the rating. Implicit ratings could be inferred by observing the user behaviour but may be imprecise. The errors introduced by uncertainty of implicit ratings can be reduced through aggregating a large number of ratings (Schafer et al., 2007). This approach is followed by the CRICOS system (Ziovas & Grigoriadou, 2008). CRICOS integrates several community-driven technologies in order to support the members of a community to create and share learning resources. The system calculates the utility of a resource by aggregating both explicit and implicit ratings. Explicit ratings are provided by users who rate the quality of a resource on a 1 to 5 rating scale. Implicit ratings are inferred by observing the user behaviour with a resource and collecting the relevant data. Data from observations include the number of visits on the resource's page, the number of times the user directly recommends the resource to others and if the resource is included in the user's personal collection. Both explicit and implicit ratings are combined into a single estimated rating which represents the utility of the resource for a particular user.

Another e-learning system which combines explicit and implicit ratings is presented in Tang and McCalla (2003, 2005). The system provides individualised recommendations for learners chosen from a dynamically evolved paper repository. In order to provide recommendations the system uses a two-layered collaborative filtering approach. At the first layer, learners active assessment of the papers and their browsing sequences, are used to group them into clusters of users with similar interests. At the second layer a Pearson-correlation similarity based collaborative filtering is used to make recommendations for the target user.

Social recommender systems constitute a good approach for providing recommendations when a large number of ratings are available. However, when they are not enough ratings the performance of the systems is significantly reduced. This problem, known as the "cold start" problem, can occur under three scenarios (Schafer et al., 2007):

- When a new user is registered to the system and the system have no ratings of the user to calculate a neighbourhood of similar users.
- When a new item is added to the system and it can not be recommended as it does not have any ratings.
- When a new community should be formed and without ratings the system can not provide sufficient differentiating value in order to keep users long enough to build up ratings.

Another problem comes up with the application of collaborative filtering systems for recommending learning resources. Recommendations on these systems are mostly based on users' interests. However items liked by learners might not be pedagogically appropriate for them (Tang and McCalla, 2005). In educational settings, learning resources should be recommended to the learner not only because they are rated high by other learners but also because they fulfil a pedagogical goal (e.g. a learning resource is a prerequisite of another one). Approaches that combine collaborative filtering with pedagogical requirements still need to be developed (Vassileva, 2008)

4.2 Social navigation

Social navigation systems help users to navigate in a community information space by making the aggregated behaviour of the community visible. The concept was introduced by Dourish and Chalmers as moving "towards" a cluster of other people or selecting objects because others have been examining them (Dourish & Chalmers, 1994). Social navigation can be either direct or indirect (Svensson et al., 2000; Dieberger, 2002). In direct social navigation users are guiding each other by giving navigational advices directly (e.g. through chat or email). In indirect social navigation navigational advices are inferred by historical traces left by other users, as done in the Footprints project (Wexelblat & Maes, 1999). In this form of social navigation, communication between users is indirect, mediated through signs left in the information space.

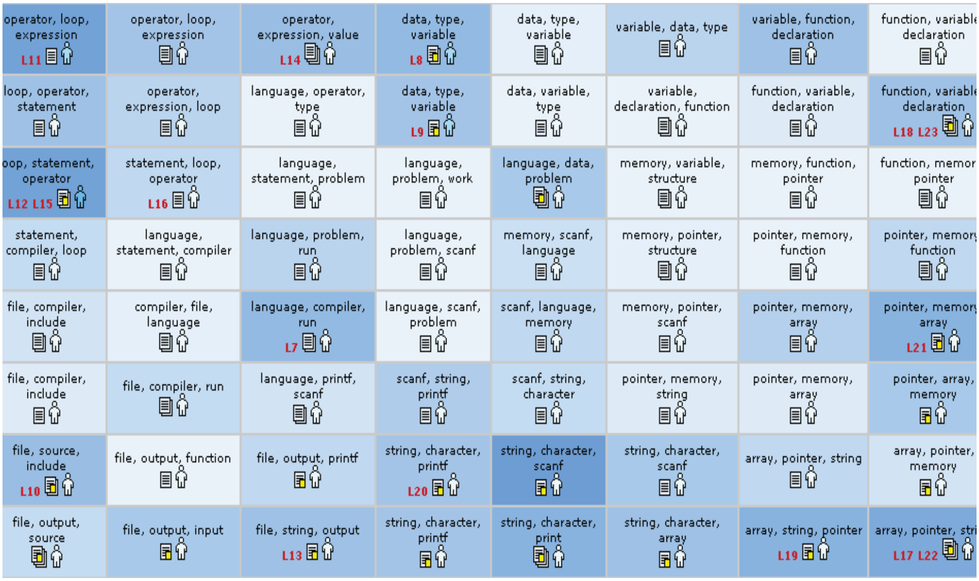

Fig. 1. The knowledge map in Knowledge Sea II.

In the field of e-learning several systems utilise social navigation to assist learners. EDUCO (Kurhila et al., 2002) is a collaborative learning environment which visualises the information space as clusters of documents. The documents change their colour according to how much they have been read in relation to other documents. Live users presented in the learning environment as coloured dots located next to the documents that they are currently viewing. The system supports both synchronous and asynchronous communication among users. Knowledge Sea II (Farzan & Brusilovsky, 2005) focuses on helping students of introductory programming courses to find relevant readings among hundreds of online tutorial pages distributed over the Web. The system represents clusters of pages in a knowledge map of varying shades of blue (Figure 1). Every cell of the map includes links to web pages that are related to keywords presented in the cell. The number of visits and the time spent on a page are used to calculate the level of attention of a user for the page. The colour saturation of a human figure in the cell represents the user's level of attention for the pages belonging to this cell while the background colour of the cell represents the group attention.
Another approach that employs the colour saturation of icons to provide social navigation support can be found in CRICOS (Ziovas & Grigoriadou, 2008). The system represents the utility of a resource for a user with the background colour of an icon: the higher the rating the darker the colour. Besides the utility of a resource for a single user, the system averages the estimated ratings for two clusters of users that their opinions about the resource could

be valuable for the user; user's friends and users with similar interests. The system represents these ratings with the colour of the relevant icons (Figure 2).

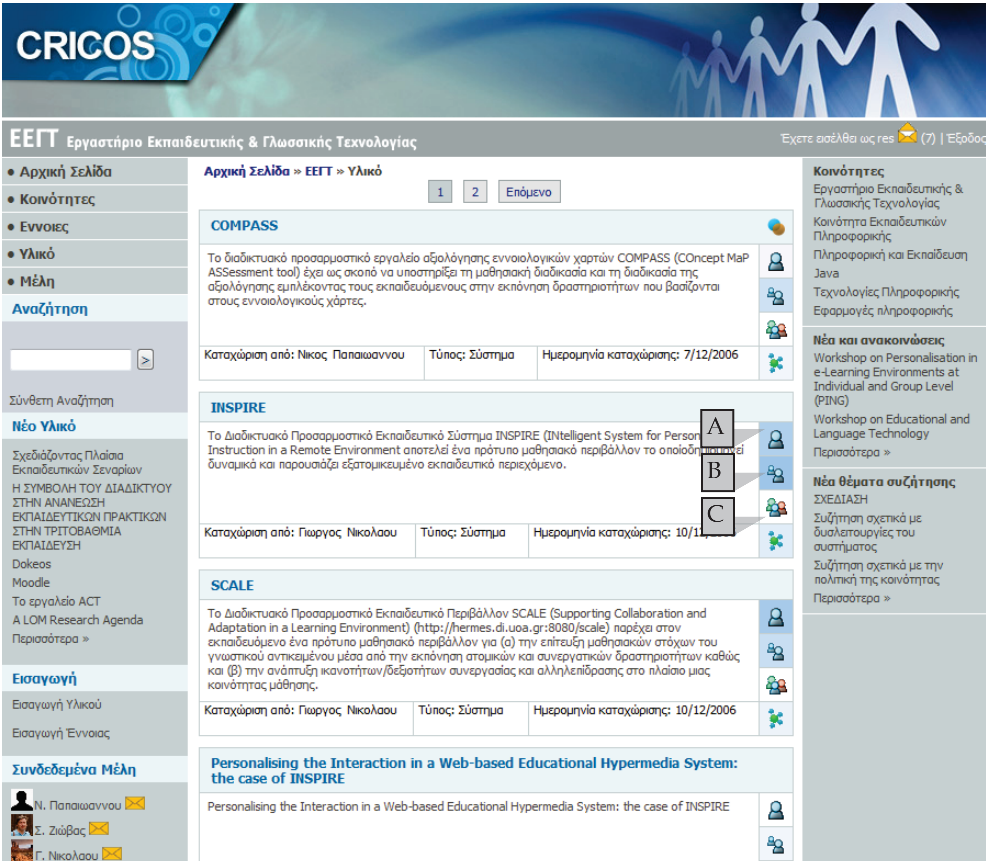

Fig. 2. A web page for browsing resources in CRICOS. Different icons represent the estimated utility of a resource for the user (A), the user's friends (B) and the users who have similar interests with the active user (C).

Social navigation systems attempt to visualise the accumulated actions of a community of users. However, social navigation systems will work poorly when there is little information about the actions of users in the information space. Thus, there is a problem to start a social navigation system before any user behaviour has been collected.

Another problem of social navigation systems is known as the snowball effect. The snowball effect arises from the "following the crowd" style that characterises these systems. If a user starts following a wrong path, this will affect the behaviour of other users. The path will be considered a good path for the system and lead more and more users down a path they do not perceive valuable in the long run (Svensson et al., 2001).

4.3 Social tagging

Social tagging or collaborative tagging is one of the latest popular social software approaches for information management and sharing. The approach became popular on the Web as part of the social bookmarking systems. Social bookmarking systems allow users to create personal collections of bookmarks and share their bookmarks with others. Moreover users of these systems may organise their collection by entering keywords which are meaningful to them. This type of manual indexing is called tagging with index terms referred to as tags. As these tags are shared a user may click on a tag and see the list of bookmarks which are linked with the tag. The tag clouds that are found in many of these systems can assist users in browsing the information space. Tag clouds are visual representations of tags in which attributes of the text such as size, weight, or colour are used to represent features of the associated terms (Rivadeneira et al., 2007). When the user clicks on a tag within a tag cloud the system provides a list of the bookmarks that are associated with the tag (Figure 3).

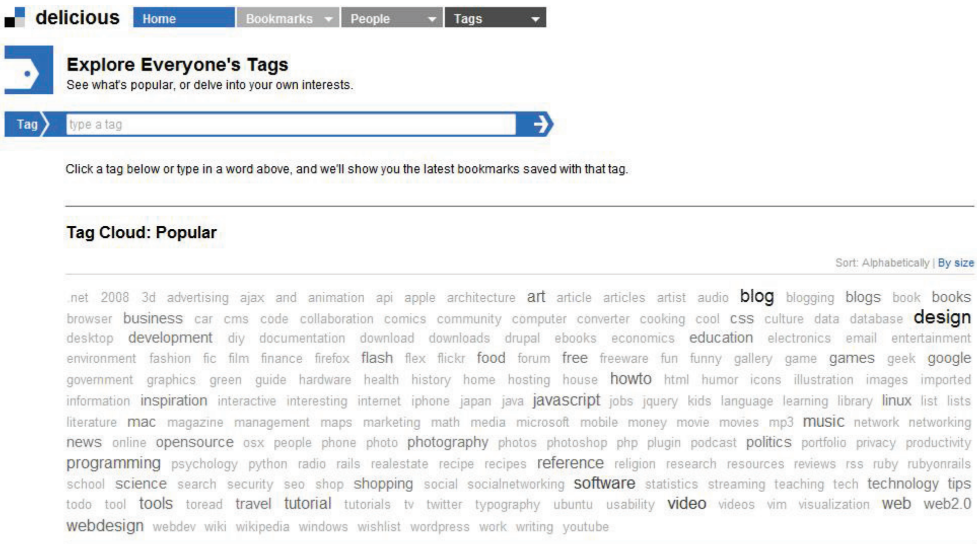

Fig. 3. An example of a tag cloud from the Del.icio.us system

The social tagging mechanism have been implemented in a number of online resource sharing environments, some popular and some academically oriented (Hammond et al., 2005), since the idea was first adopted by social bookmarking system del.icio.us in 2004. Such systems facilitate the organisation and sharing of digital resources including photos (e.g. flickr), blogs (e.g. technorati) or scientific publications (e.g. CiteULike). A critical characteristic of these systems is that the classification of resources is based on the uncontrolled vocabulary (also called folksonomy from folk and taxonomy) which emerges from the set of tags used by members of a community without any a-priory controlled vocabulary to conform to. This approach on subject indexing comes as an alternative to the traditional taxonomies. Taxonomies provide a controlled vocabulary for the classification of resources. However they often reflect one group's perspective of the knowledge domain and may become inflexible as the community evolves. On the other hand folksonomies consist a more flexible and scalable approach, since the contributors are those who provide the tags that best describe their recourses according to their perspective.

According to Bateman et al. (2007) social tagging has potential to be useful tool for e-learning systems because of the following:

- Learning managements systems currently lack sufficient support for self organization of learning content.
- Collaborative tagging has potential to further enrich peer interactions and peer awareness, centred around learning content.
- Tagging, by its very nature is a reflective practice, which can give students an opportunity to summarize new ideas, while receiving peer support (through viewing other learners' tags; tag suggestions).
- The information provided by tags provides insight on learner's comprehension and activity, which is useful for both educators and administrators.

There have been limited attempts to combine social tagging with e-learning. CoFIND (Dron et al., 2000, Dron 2006b), is a resource sharing system which allows students to provide feedback about resources and classifying them using several topics. The system encourages not only the tagging of resources according to topics, but also with pedagogical metadata known as qualities. OATS (Bateman et al., 2006a) is a tool, which was designed to enrich the functionalities provided in Learning Management Systems. The tool allows a user to highlight pieces of the learning content provided by a course and add tags or notes to them. The user assisted in browsing the information space by utilising either the tags created by her or the community's tags. In the second case the most popular tags are shown in descending order of number of times used. This gives the user an idea of what are the most important terms at the course level.

The problems inherent in an uncontrolled vocabulary lead to a number of limitations (e.g. ambiguity, synonyms) in folksonomies (Mathes, 2004). Ambiguity of the tags can emerge as users apply the same tag in different ways. Moreover, the lack of synonym control can lead to different tags being used for the same concept. Inconsistency among the terms used in tagging can make it very difficult for one to be sure that all the relevant items have been found (Golder & Huberman, 2005). In addition, folksonomies invite deliberately idiosyncratic tagging, also called meta noise, which burdens users and decreases the utility of the systems that employ them (Wu et al., 2006).

Another issue arises from the lack of relational information in foksonomies. When the learners construct their knowledge about a certain domain is essential to learn the concepts of the domain and how these concepts are related. However, even by tagging learning resources with the relevant concepts of the domain will not provide more information about how these concepts are related. Moreover the tags produced with social tagging are not machine understandable. Tags are useful for human consumption but computational entities can provide only limited reasoning in a social tagging system. Thus it would be difficult for a machine to automatically aggregate learning content based on the tags provided by a community of learners. Research towards this issue aims primarily on the integration of taxonomies and folksonomies (Bateman et al., 2006b)

5. Conclusion

This paper provided an overview of several community-driven technologies incorporated under the concept of social software. Community-driven technologies are becoming increasingly pervasive in e-learning. They hold considerable potential for facilitating and stimulating knowledge creation and sharing with a decentralised and self-organised manner. Thus, they provide the infrastructure for the development of learning environments where the student is in the centre of activities. In this sense they may better fit to the new generation of students, what is called the net generation (Oblinger and Oblinger, 2005), who has grown up with technology and values experiential learning, working in teams, and social networking.

Community-driven technologies work well in grown communities where they can harvest community intelligence to assist the learners. However, their performance is significantly reduced when they can't collect enough information to build the community intelligence or to apply it for a new user or a new resource. Therefore, researchers are working on combining approaches, in order to overcome the weaknesses associated with individual techniques as in the case of hybrid recommender systems (Burke, 2007) which integrate content-based and collaborative recommender mechanisms.

The role of the community-driven technologies is to assist the learner to find the appropriate learning resources. Learning with the use of community-driven technologies happens both by consuming and producing knowledge. Learners who produce knowledge have significant impact on the learning of the whole community as their contributions are used to recommend learning resources to other learners. Particularly in the early steps of the community development the influence of those who make the first contributions is disproportionately large, shaping the behaviours of those who follow (Dron, 2006a). When the contributors do not have sufficient knowledge of the domain then the learning environment will provide misleading information. Thus, a certain level of control should be given to more knowledgeable members (e.g. teachers) in order to keep the contributions relevant with the community's domain.

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Improving the Analysis of Students' Participation & Collaboration in Moodle Forums

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1. Introduction

This chapter is entitled to analyze interactions and collaboratively learning of students in web 2.0 resources such as forums. As it is known, forums are a collaborative resource widely used in e-Learning due to the simplicity to create threads of discussion for a given topic. It is an asynchronous resource, therefore it does not require from other students to be connected at the same time to answer to a post or to read other students' posts. Since it represents another way of learning, such as 'learn by doing', teachers may need ways to evaluate the quantity and quality of the work done in them by students.

To begin with, the chapter presents an analysis of different software packages existing to create a forum system, and particularly, how they support analysis of interactions. We found that the best educational software to create and maintain a forum seems to be Moodle. However, all of them lack comprehensive mechanisms to track students' activity in forums. We describe the main features we consider that a system should have in order to provide such comprehensive support.

A new tracking system for forums has been developed in Moodle to alleviate this lack. It is described in the chapter, as well as the results obtained with it. The system has been used in a first year programming course in Computer Science degree during the last academic year.

Finally, our conclusions on the results of our experience are explained and discussed.

2. Previous work

Nowadays, the traditional classroom has changed towards a more on-line one; therefore, teachers have had to find new ways of keeping an eye on students when they are working online, out of their site. Following to this, there is a review of previous works done in the analysis of students interactions in e-learning; first, focusing the analysis on Learning managements systems, and secondly, focusing the analysis on forums.

2.1 Analysis in Learning Management Systems

Teachers need more and more an aid from the e-learning system that provides information about how students interact with it. Thus, some applications that try to resolve the problem of keeping an eye on the student while working out of sight of the educator have already been developed in different areas of e-Learning, such us (Ramani & da Rocha, 2000) describe tools for letting instructors easily view student participation in a Web-based class using charts and graphs to display student participation. (Reffay & Chanier, 2002) identify clusters and cliques within the online class. These tools focus not on the individual student, but rather on class activity as a whole. Although both sets of tools are interesting and potentially useful in aiding the understanding of Web Based discussion forums, they aren't build on an analysis of the discussion evaluator's workflow, which is a critical requirement for improving online teaching effectiveness.

In (Mazza & Dimitrova, 2005) they had developed an Application CourseVis that visualized interactions of students with an e-learning site, and then they moved towards Moodle and offered what they have called GISMO which is an application that can be installed into Moodle and shows basically different types of graphical information (bar charts, and matrix visualizations) basically 2D graphical information about the overall classroom accesses or the detailed information from a specific student. All it is offered are graphs of the accesses, the 2D visualization may have a third dimension that is colour (from light two dark shows the quantity of accesses), or shape (bigger circles show a larger amount of contributions from the student). Even though their visualizations are more advanced than Ramani and Rocha's, they still lack of interactions and improvement.

In University of Edinburgh they have made tracking and visualization of student use of online learning materials (Hardy et al., 2007), their tracking tools are non-invasive, whilst providing information not available in standard web server logs, the tools allowed a measure of control over what information is recorded. In Universidad Rey Juan Carlos (Hijón & Velázquez, 2008) it has been developed a tool fully installable into the Moodle system, called Merlin-Mo, that collects and offers a wide variety of tracking information about students accesses from different perspectives, allowing interaction with the visualizations and statistical analysis among other features.

2.2 Analysis in Forums

Determining learning behaviour in electronic media is a complex problem. A difficulty is that students mostly use these environments away from the classroom and out of sight of their educators. Without the informal monitoring that occurs in face-to-face teaching it is difficult for educators to know how their students are using and responding to these environments. Educators have had to seek new ways of obtaining information about the learning patterns of their students. This requires the development of effective methods of determining and evaluating learner behaviour in electronic environments.

Such is the case in Integrated Participation Evaluation Tool (iPET), is a web-based application combining social network analysis and visualization to enable distance learning instructors and students to improve their participation in online discourse and so improve their overall learning experience (Saltz et al, 2007). The tool can be seamlessly integrated with commercial Web-conferencing systems such as Blackboard or WebCT and Akita Corporation´s WebBoard. They track different levels of participation in asynchronous forums namely: concrete participation of each student, such as: 'have they created an introductory post?' 'Which steps have they followed in the participation?' trying to understand general participation patterns, for example: to quickly identify people at risk because of lack of participation (class overview). Students' details module, that focuses on a specific participant's activity. The tool shows different graphs with the participation of the students.

Another work (Poggi & Di Blas, 2007), present results from the analysis of a set of asynchronous message boards within a project where students meet in real time, shared 3D virtual environments, and keep in touch through online forums. They show how forums can support more or less effectively collaboration and discussion tools, what challenges must be faced, and how the tool's evaluation must take into account the components and set of goals of the entire learning experience.

In (Palloff & Pratt, 2005) the study says that forum discussion intervention has a double importance: in one hand, like a tool to set up and enlarge the acquired knowledge, in the other hand, like a pillar in the creation of learning communities.

3. Objectives

The general objective is to develop a way of analysis of students' interactions in a web 2.0 resource such as a forum. As it is known, a forum is a powerful resource to discuss different topics using Internet and a software that supports the functionality. When teachers use a forum as a mean of communication in two ways: firstly, teachers with students, and secondly, students with students, it is important for them to have effective ways of analyzing how students communicate, cooperate and share knowledge. Essentially, if it is possible to 'learn by doing', this is to say, if students that edit or read post in forums as a mean o participation in an e-learning activity get better knowledge about the course contents. To do so, teachers need an effective way to analyze this participation in forums, in an easy way, using user friendly interfaces that show to them the forum tracking information already processed, without needing the use of an extra tool for the analysis or visualization of interactions. Thus, a way to do so is by an application that allows analysis of how students participate in a forum by:

- Identification and storage of interactions data in an effective way for further analysis.
- Providing an effective way of data confidentiality, offer security options to assure this data is only visited by teachers and administrators. Define the roles to accomplish the required security.
- Knowing how they participate, are they only reading or also writing posts. What sort of pace of learning they use, how long are their contributions. It is important to be able to make an analysis of a particular student or the overall class. Provide ways of analysis and comparison of the amount of written contributions towards the reading ones.
- Knowing when they participate, or what time variables are usually used, when do they participate and how long are these participations. Offering possible representations of participation in a chronograph or monthly participation distribution in the forums.
- Provide effective ways of visualization of participation data. Offering different ways of looking at data. Thus, easy to use interfaces. Providing of the summary of contributions to forums by student or the overall class.
- Offering detailed information of forum contributions, either answering to another person thread or starting new threads of discussion. Possibility of knowing detailed information about each student.

- Statistical analysis of answering times data, such as, estimated time to answer a topic or the overall forum. Possibility of comparison of forum contributions by students. Analysis of first and last posts by a student. Overall analysis of posts by topics written by students.
- Analysis of first and last student contribution within a course and other statistical measures that lead to participation comparison.
- Summarizing of topic/post by each student and by the overall class.
- Detailed analysis of topics related with posts.
- Identification of only lurkers' students. Relationships among lurkers and participants.

4. Evaluation of alternatives

An analysis of different software to create and maintain forums have been done. The most used and more extended applications have been analyzed and compared to be able to pick the one to develop the software for analysis, once found that the statistical analysis they provided was not enough. The applications are:

- MvnForum (Mvnforum, 2009) it is a wide scope opensource forum, easy to use and configure. It is based on Java J2EE (Jsp / Servlet). The statistics this forum produces are simply the total number of: categories, forums, themes, messages, users, last user, users online and invited users.
- PhpBB (phpBB, 2009) is a free open source package based on php to proporcionate a forum system, with wide personalization possibilities. The statistics this forum offers are total number: post, users, last user registered, online users, hidden users, invited users, day with more affluence of people into the forum.
- JavaBB (javaBB, 2009) is java based software, developed to be used in communities; it is also based on phpBB. The statistics this forum produces are total number of: articles published, users registered, last user registered, number of users connected.
- Simple Machines Forum (SimpleMachines, 2009). It is written in php and uses a MySQL database. It is designed to provide the general features a news board has in a way that has less impact on server resources use. The statistics are more complete that the ones offered by previous forums, they produce the following 'general statistics': total number of users, posts, topics, categories, online users, day with more users online, online users 'today', total number of pages visited, average of registers by day, posts by day average, topics by day average, last user, users by day average, woman and men comparison of online users average, most visited pages by day average. Also offer the top 10 of: persons with more post, topics sorted by answers, topics sorted by visits, users with more topics and users with the higher online time. Lastly, it offers historical statistics of new topics, new posts, new registered member, highest number of online users and visited pages.
- YaztForum Software (YaztForum, 2009) is open source forum software written in java. It allows the creation under many Data Bases. The statistics they produce are number of topics, posts, and last post date.
- Moodle (Moodle, 2009) is an open source LMS software to create e-Learning or Hybrid learning courses. It contains a forum application integrated to manage forum created within this courses. It is written in php and can be used on a MySQL data

base among others. It is widely used. The statistics it produces are completer than the forums seen before, but its visualizations are very poor; it only offers a table visualization showing the general information about the forums in the course like: forum, threads on that forum, threads started by, replies and last post, participants, posts by participants.

The following Table 1 shows a comparative analysis of the selected product to create forums and analyze participation in them.

		modifiable	**Widely extent**	**Design for e-Learning platforms**	**Programming Language**	**Enough interaction & participation analysis**	**Enough Visualitaion to enhace analysis**
Foros							
MvnForum	✓	✓	✓	✗	Java	✗	✗
phpBB	✓	✓	✓	✗	php	✗	✗
javaBB	✓	✓	✗	✗	Java	✗	✗
SMF	✓	✓	✗	✗	php	✗	✗
Moodle	✓	✓	✓	✓	php	✗	✗

✓ – The application has the characteristic

✗ – The application does not have the characteristic

Table 1. Comparative chart of forum software

After analyzing the applications stated above and the general features that should have the application that analyzes participation and collaboration in forums, none of the forum had a good application for analysis and visualization of participation therefore it is necessary to create one. By looking at the table, it can be seen that the forum that best suits our requirements is Moodle. Therefore, the new module for analysis of participation and collaboration would be created for the Moodle forum.

5. Technologies

Widely used technologies used in the development of the application are: HTML, PHP, JavaScript, MySQL, and XAMPP.

There have been used open source libraries also written in PHP to generate the statistics and graphs from the data received as the user presents queries to the system, such as Open Flash Chart (Open Flash Chart, 2009) is a library written in php that uses flash for dynamically generate data statistics.

6. Evaluation of existing applications

After deeply analyzing new modules developed for Moodle LMS, four have been found that were made to work directly on the forum module, what gives an idea about its importance, especially when talking about collaborative learning and participation, either in Higher Education as in life-long learning. From them, only two had some functions that could be used to analyze participation in a learning activity, and they are the following:

6.1 Forum Plus (F+)

It is a new module that has created functionality to enhanced Moodle Forum for Group Discussion and Collaboration and has a 'Reflection Board' that show some statistics about users activity in the forum. It offers reports of:

- Most frequently read messages
- All messages read and by whom (history)
- Rules activated by teachers to notify him/her:
  - Number of messages posted by the user (i.e a rule has to be defined to activate a signal to notify the teacher if a user never has taken part in a discussion)
  - Presence or absence of messages associated with a specific topic (a rule can also activate lack of participation)
  - Activity on the forum (posted messages)

Figure 1 & Figure 2 shows the data statistical data this new module offer to teachers.

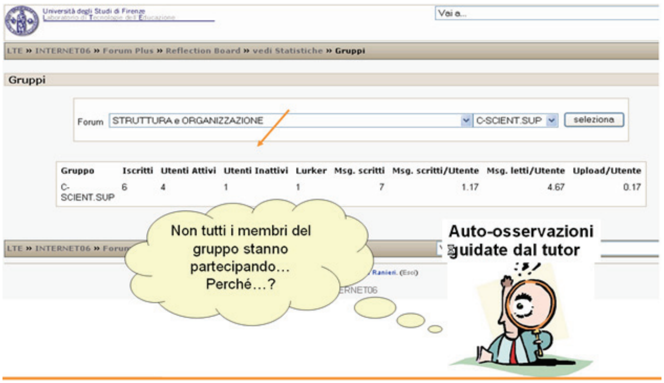

Fig. 1. Forum Plus statistics, identification of inactivity and average messages

Gruppo	Iscritti	Utenti Attivi	Utenti Inattivi	Lurker	Msg. scritti	Msg. scritti/Utente	Msg. letti/Utente	Upload/Utente
et001	6	6	0	0	86	14.33	44.83	1.33
et002	6	6	0	0	90	15	35.83	0.5
et003	7	7	0	0	85	12.14	30.86	1.14
et004	7	5	1	1	49	7	12.71	0.29
et005	7	7	0	0	75	10.71	47.29	1.14
et006	6	6	0	0	38	6.33	17.83	1.17
et007	5	5	0	0	55	11	30.4	1
etutor	0	0	0	0	0	0	0	0

Fig. 2. Forum Plus statistics, summary of users' activity

6.2 HSU Forums Enhancement

The Humboldt State University has built new Forum Enhancements into the Moodle forum module. This project includes enhancements related to visualize and analyze collaboration and participations that offer:

- Sequential View of posts
- Sort posts in order by name or topic creation date
- Expand/Collapse discussion topic display

None of these applications for the Moodle forum fulfill the initial requirements. There is lack of information about students' interactions on them and there is no possibility of data selection by the user as required, allowing to set queries into the system for further interactions assessment. Furthermore, the information the modules display lack of graphical analysis, making it hard for the user to rapidly assess students' forum interactions. Therefore, the new module for students' interactions in the Moodle forum would cover this lack of functionality.

7. Main Contribution

The new module developed for Moodle is called e-Forum, is fully joinable into any running module, and uses all its administration features, such as those that imply security and appearance. The former, since the permissions Moodle users have are also used to enter the new application, thus only teachers, administrators and course editors (following the Moodle nomination) can access to it. The latter, since all user settings like host language, are also used into the system.

Once the user is into Moodle, just by clicking on the e-Forum option (see Figure 3) the application would be shown to the user.

Fig. 3. e-Forum fully access into Moodle

The system has been divided into three main modules, the first one that show the information about all the students as a whole, considering the whole class but detailing, when needed, the information about each student. The second one shows the analysis about a selected student individually. And the last one, offer some predefined queries that complete the analysis.

7.1 Grouped Analysis

The first module for analysis is about all the students to analyze:

- Total numbers of contributions made by students, where users can obtain data about the total number of contributions students have made.

- Forum detailed contributions; the system would show a detailed chart of contributions made by students.
- Forum participation distribution, where users can obtain a table with the monthly distribution of participation making a difference among topic, post and the sum of both.

General to all options are the data restriction, the selection of a visualization type and the time restriction for that data. Thus, for any of the options explained in this part, the users' first step is to select a course, a forum within that course and a topic within that forum, or leave the default value of 'all of them' when desired. The second step is the selection of a visualization type for the data; the options are a pie chart, a bar chart or a data table. Finally, user would have to select a data range for the data selected. Figure 4 shows the interface of this first part of the analysis with the data selected for the total number of contributions made by students' option.

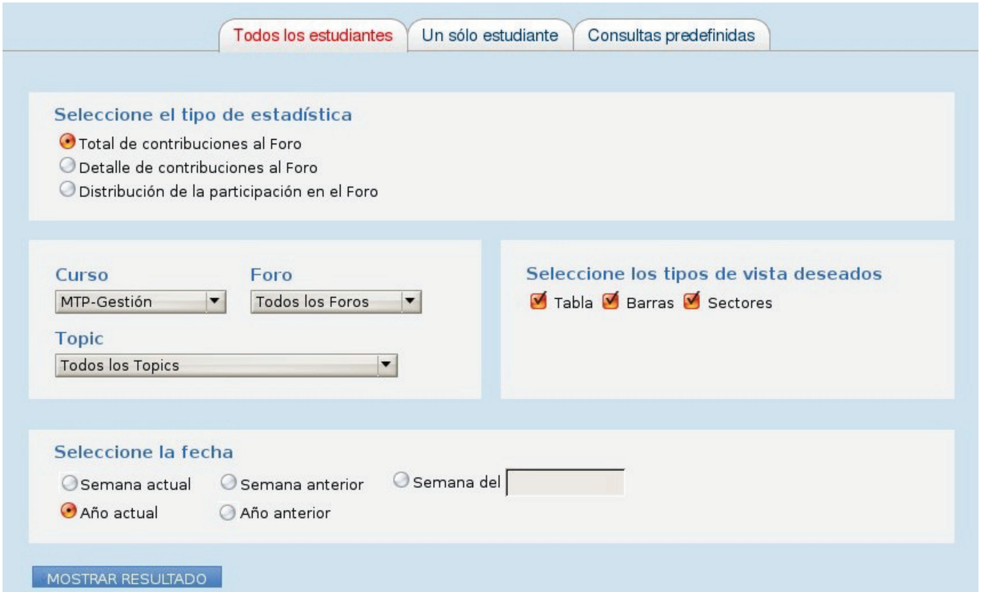

Fig. 4. e-Forum, all students interface

In the example the course selected has been the Programming first year course MTP, all forums within that course and all topics on the forums. The visualization selected has been all the possible ones: table, bar and pie chart; finally, the date restriction has been the current year, but the forum selected was only used on that course during the month of May therefore has data only on May. The table visualization (see Figure 5) offers a summary of the total number of forum contributions by months represented on the y-axis and by students represented on the x-axis, color codes helps the user to analyze data, since a darker tone means a higher amount of contributions and the absence of tone also means absence of contributions.

Estudiante	Enero	Febrero	Marzo	Abril	Mayo	Junio	Julio	Agosto	Septiembre	Octubre	Noviembre	Diciembre	Total
[illegible]	0	0	0	0	10	0	0	0	0	0	0	0	10
[illegible]	0	0	0	1	3	0	0	0	0	0	0	0	4
[illegible]	0	0	0	0	8	0	0	0	0	0	0	0	8
[illegible]	0	0	0	0	12	0	0	0	0	0	0	0	12
[illegible]	0	0	0	1	7	0	0	0	0	0	0	0	8
[illegible]	0	0	0	0	9	0	0	0	0	0	0	0	9
[illegible]	0	0	0	0	14	0	0	0	0	0	0	0	14
[illegible]	0	0	0	0	1	0	0	0	0	0	0	0	1
[illegible]	0	0	0	0	1	0	0	0	0	0	0	0	1
[illegible]	0	0	0	0	1	0	0	0	0	0	0	0	1
[illegible]	0	0	0	0	1	0	0	0	0	0	0	0	1
[illegible]	0	0	0	1	2	0	0	0	0	0	0	0	3
[illegible]	0	0	0	0	1	0	0	0	0	0	0	0	1

Año del martes, 1 de enero de 2008, 00:00 - jueves, 1 de enero de 2009, 00:00

Fig. 5. Table visualization of total number of contributions in e-Forum

The monthly bar chart represents the students on the y-axis but the x-axis represents the total number of contributions, a graph for each month appears, as well as a summary of the course at the end. In Figure 6 the students' contributions in May are represented, in the visualization, each bar is finished by a number to help comparison. Finally, the pie chart representation is shown in Figure 7, where the students' percentage of participation is represented and color coded to help understanding, for more precise analysis, users can place the cursor on the sectors to visualize the exact percentage quantity.

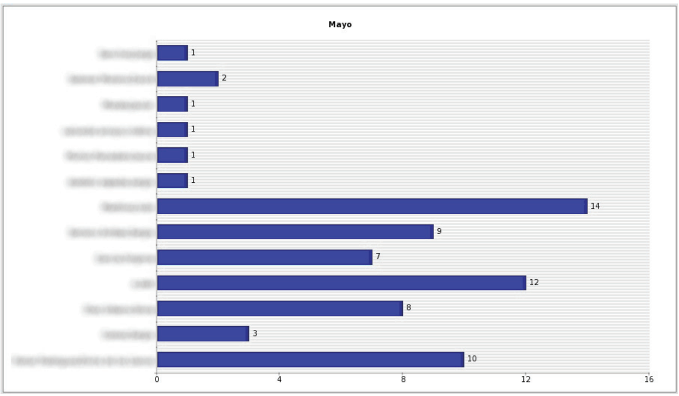

Fig. 6. Bar chart visualization of total number of contributions in e-Forum

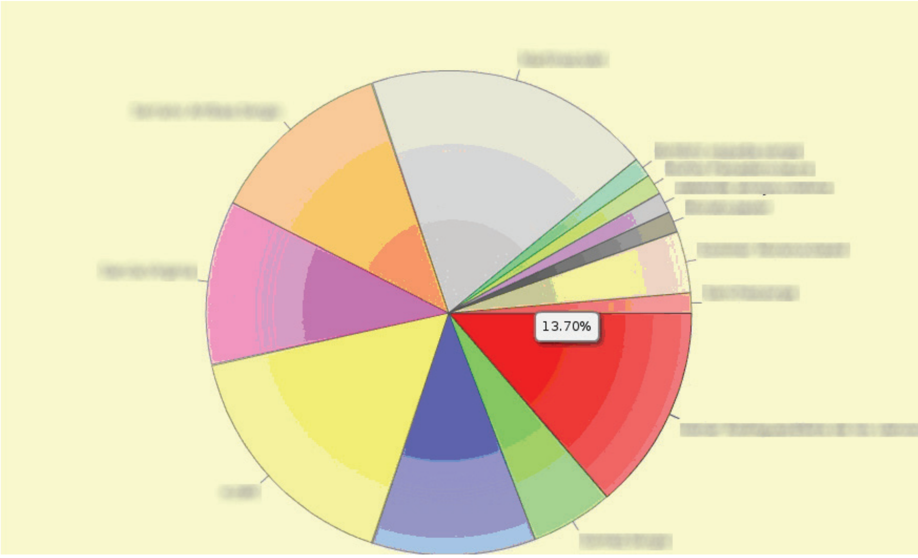

Fig. 7. Pie chart visualization of total number of contributions in e-Forum

The second option of this first part is the 'Forum detailed contributions'. When user click on this option the interface changes because the system would offer and ad-hoc representation of data made to help easy users' understanding, therefore user does not have to make any choice on the visualization type, the best suitable option has been defined in the query design at its development. This ad-hoc visualization offers a table for each student detailing for each post written: which forum and which topic it was written in, to which post it answers, to what student it answers, when it has been posted, when it has been modified, the title message and the body message by placing the mouse pointer over the body cell. Figure 8 represents the forum detailed contributions query results made by all students for all forums and all topics in MTP-Gestión course during the week of May 15th, 2008; the visualization offers a table for each student, each entry in the table represents a post and all the linked information related to that post that has been explained before. In the first table represented, the body of a post has been automatically displayed by placing the mouse pointer over the message title.

The third and last option of this first part is the 'Forum participation distribution'. The interface has also changed by clicking on this option, since the data visualization will be displayed monthly, thus the time frame selection should also be monthly. In the example, 'last month' option has been selected for all forum and all topics in the course MTP-Gestión selected. Results have been displayed in another ad-hoc table visualization that offers the monthly participation distribution in a forum, first column 'week' represents the week within the month selected, and second column 'student' identifies the student to offer in the right columns the total amount of written topics, posts and the total of both (see Figure 9)

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Detalle de Post puestos para el estudiante: [illegible] en el Curso: MTP-Gestión

Foro al que pertenece	Topic al que pertenece	Responde al Topic/Post	Responde a	Creado	Modificado	Titulo del mensaje	Cuerpo del mensaje
PRÁTICA OBLIGATORIA	fase 4			sábado, 17 de mayo de 2008, 18:40	sábado, 17 de mayo de 2008, 18:40	fase 4	Cuerpo
PRÁTICA OBLIGATORIA	YA ESTÁN COLGADOS LOS FICHEROS DE CARGA DEL APARTADO 3	Re: YA ESTÁN COLGADOS LOS FICHEROS DE CARGA DEL APARTADO 3	[illegible]	sábado, 17 de mayo de 2008, 21:35	sábado, 17 de mayo de 2008, 21:35	Re: YA ESTÁN COLGADOS LOS FICHEROS DE CARGA DEL APARTADO 3	Cuerpo
PRÁTICA OBLIGATORIA	fase 4	Re: fase 4	[illegible]	domingo, 18 de mayo de 2008, 20:04	domingo, 18 de mayo de 2008, 20:04	Re: fase 4	Cuerpo

En esta nueva fase te piden que cargues y salves en disco una lista,¿este fichero tiene que ser de texto, o binario o es indifirente? porque creo que no especifican nada. Muchas gracias.

Detalle de Post puestos para el estudiante: [illegible] en el Curso: MTP-Gestión

Foro al que pertenece	Topic al que pertenece	Responde al Topic/Post	Responde a	Creado	Modificado	Titulo del mensaje	Cuerpo del mensaje
PRÁTICA OBLIGATORIA	YA ESTÁN COLGADOS LOS FICHEROS DE CARGA DEL APARTADO 3	Re: YA ESTÁN COLGADOS LOS FICHEROS DE CARGA DEL APARTADO 3	[illegible]	lunes, 12 de mayo de 2008, 18:03	lunes, 12 de mayo de 2008, 18:03	Re: YA ESTÁN COLGADOS LOS FICHEROS DE CARGA DEL APARTADO 3	Cuerpo...

Fig. 8. Ad-Hoc table visualization of detailed forum contributions

Distribución de la participacion en el mes de Mayo

Semana	Estudiante	Topic	Post	Total
1	[illegible]	1	3	4
1	[illegible]	0	1	1
1	[illegible]	1	0	1
1	[illegible]	1	5	6
1	[illegible]	2	2	4
1	[illegible]	0	1	1
2	[illegible]	0	2	2
2	[illegible]	0	6	6
2	[illegible]	1	2	3
2	[illegible]	0	2	2
2	[illegible]	0	7	7
2	[illegible]	1	13	14
2	[illegible]	1	0	1
2	[illegible]	1	0	1
2	[illegible]	0	1	1
2	[illegible]	0	1	1
2	[illegible]	0	1	1
3	[illegible]	1	4	5
3	[illegible]	0	1	1
3	[illegible]	0	3	3
3	[illegible]	0	1	1
3	[illegible]	0	2	2
3	[illegible]	0	1	1
4	[illegible]	0	1	1
	Total	10	60	70

Fig. 9. Ad-Hoc table visualization of forum distribution participation

7.2 Personalized Analysis

The second module is for the personalized analysis of a single selected student. The first two options for the analysis are the same its precedent had, but personalized to a user selected student that, the options will be then:

- Total numbers of contributions made by selected student, where user can obtain data about the total number of contributions a student has made.
- Forum detailed contributions; the system would show a detailed chart of contributions made by a selected student.
- Last post information, where user can obtain a table with the information about when a student has written his last post/topic.

From the interface seen before, only two changes have taken part, one is that a window to select a student has been placed, and the other is that there is a fourth type of visualization to choose from, the line graph (see Figure 10).

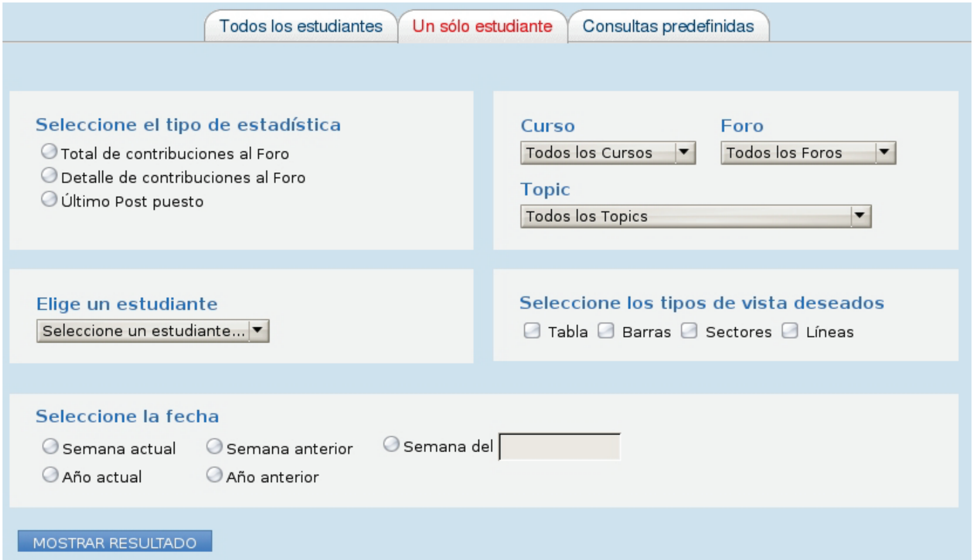

Fig. 10. e-Forum interface for a single selected student

As before, interface changes the options for the user to select by clicking on a type of analysis or another, but in this part, the analysis is always based on an only student. On Figure 11 results of a selected student total number of contributions is represented; were line graph visualization has been selected and the time frame of 'current year'. As it can be observed, the x-axis represents the months of the year, and the y-axis represents the amount of posts written by this selected student (name have been hidden). Also, by placing the cursor over the graph coordinates, the total amount of data represented (written posts) is displayed in a text label.

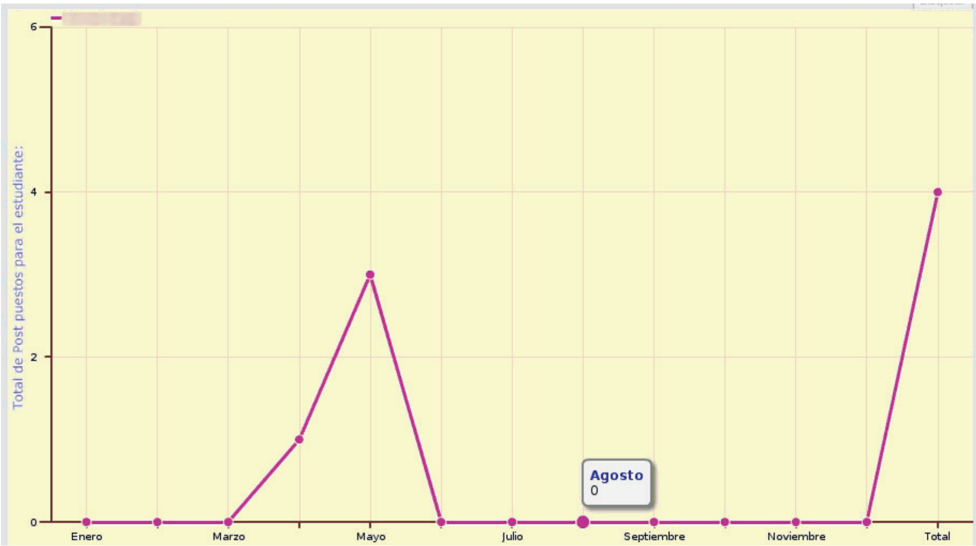

Fig. 11. Line graph visualization of a student total number of contributions in e-Forum

7.3 Preset Analysis

The third and last module is for the predefined queries analysis, for a more general analysis of participation and contribution, the study is also made over all the students on a selected course, it offers a kind of summary of participation and contribution to the forum from different views; therefore, only the query and the course are the entries to the visualizations that are predefined in the representation type chosen, in the time frame selected and in the forum/topic/post selection (see Figure 12).

Fig. 12. e-Forum interface for predefined analysis

The predefined analyses are (always based on a course selected, or all of the courses):

- Analysis of the relationship topic/post: visualizes the ranking of the total amount of post, topics written by each student.
- Open topics detail by forum: visualizes the forum names on the course selected and the total number of topics open in each of them.
- Topic detailed number of post: offers the topics opened for each forum and the total number of post in each of them.
- Only lurkers' students or students that have only read never written posts.
- Average time response to a topic: shows a table with the average time to respond a topic for each forum in the course (see Figure 13).
- Relationship between reading posts and writing posts: shows a table representing the total amount of written posts and read post by each student.

PRÁTICA OBLIGATORIA

Topic	Media de respuesta
Duda sobre Ficheros	22 minutos, 8 segundos
Dos dudas acerca de la práctica:	2 días, 3 horas, 34 minutos, 18 segundos
Dudas respesto a los listados	2 días, 3 horas, 29 minutos, 4 segundos
fase2	22 horas, 35 minutos, 12 segundos
duda al crear fichero	3 días, 1 horas, 45 minutos, 51 segundos
valor para los años	41 minutos, 58 segundos
Ejercicio 2	15 horas, 5 minutos, 54 segundos
Pasaporte	4 horas, 19 minutos, 54 segundos
DESBORDAMIENTO	6 horas, 51 minutos, 25 segundos
Listados	1 horas, 22 minutos, 59 segundos
YA ESTÁN COLGADOS LOS FICHEROS DE CARGA DEL APARTADO 3	1 día, 19 horas, 30 minutos, 13 segundos
duda ficheros binarios	4 horas, 14 minutos, 50 segundos
Problema CARGA de FICHEROS del apartado 3	10 horas, 5 minutos,
fase 4	1 día, 21 horas, 20 minutos, 38 segundos
Nota sobre la 4ª entrega	37 minutos, 11 segundos
Total	22 horas, 7 minutos, 46 segundos

Fig. 13. Table visualization of the average time response to a topic in a forum

8. Conclusion

We have developed a new module that improves dramatically the analysis capabilities of student´s interactions that the Moodle forum module provides. It offers a friendly user interface that is fully integrated into the Moodle LMS. The functionality of this application has been developed following Moodle standards, so it is easy to enlarge it. Furthermore, it was developed in two languages, English and Spanish, but other languages can be easily incorporated.

The new module produces a very complete analysis from three complementary perspectives: the course as a whole where students are individually identified, a detailed analysis of each individual student, and a global analysis of forums. The visualizations have been carefully selected to offer the user a predefined graphical representation, but she may change the representation flexibly.

First, it is possible to identify in a selected forum who are the students that most participated, just by looking at a colored table that makes it easy to distinguish among them. Alternative visual representations of the same data, such as bar or pie charts, make it possible to clearly identify students who work hard from those who do not. The analysis can be enriched by identifying only-lurkers' students, or by displaying a rank, ranging from 'harder workers' to 'lesser workers'.

Second, individual student analysis is also possible, in order to obtain more accurate information about the number and style of individual contributions. For each user, accumulated data can be obtained about her contributions to different forums identified by topic. In addition, the user may read and evaluate those contributions in detail by going over the graphical information with the mouse pointer.

Third, a general overview of what happens in the forum system may be easily obtained. The average time response into forums allows watching, at a 'bird's eye view', what forums or topics are more lively. Other general visualizations (as well as individual) can be displayed to show the relationship between students that rather read more than contribute, or the rate of this relationship in each part of the forum system.

All in all, e-forum produces a very simple and complete analysis for teachers to follow up what happens in the forum system. Therefore, teachers can obtain measures to analyze and identify students' participation in web-based learning activities, and can obtain the necessary feedback to adopt measures that foster participation of students needing assistance, to encourage only-lurkers to collaborate, and to compare forums and topics to easily identify non-lively ones.

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A Framework for Dynamic Sequential Behavioral Pattern Detecting and Automatic Feedback/Guidance Designing for Online Discussion Learning Environments

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1. The Trend and Bottlenecks of Online Teaching in the Era of Web 2.0

The new era of Web 2.0 focuses on a high degree of interactivity (Musser & O' Reilly, 2006). Changes in Internet applications also stress online knowledge-construction and knowledge-sharing. In order to develop students' critical-thinking and problem-solving skills, "project-based learning" (Marx et al., 1997; Blumenfeld, et al., 1991; Blumenfeld, et al., 1994; Thomas et al., 1999) is a popular choice for facilitating students' knowledge-construction. With the rapid expansion of online teaching technologies, efforts to provide students with interactive online project-based learning are receiving greater attention. However, past studies indicate that the extent of learning based on online project-based learning – especially analyses and discussions regarding online data — is limited (Wallace & Kupperman, 1997; Chang & McDaniel, 1995). Furthermore, since the new style of digital teaching is still in its experimental phase, teachers are finding that its actual implementation is not going as well as expected (Becker, 2001; Cuban, 2001; Cuban et al., 2001; Guha, 2001; Sung et al., 2005).

Given the limited experience that teachers have in utilizing online interactive teaching strategies, disappointing student performances may discourage teachers from utilizing online interactive teaching strategies in the first place. Therefore, in-depth investigations and diagnoses of the bottlenecks that occur in students' online interactions coupled with the formulation of relevant strategies for teachers to provide guidance and feedback are crucial.

Solely examining learning performance does not allow us to fully understand the bottlenecks in learners' online interactions and data analyses. Rather, we must conduct process-analysis focusing on learners' online interactions. Issues pertaining to learners' knowledge interactions include aspects of knowledge-construction, knowledge-sharing, and knowledge-transfer that are relevant to studies on knowledge-sharing and knowledge-transfer (Nonaksa & Takeuchi, 1995; Gilbert & Gordey, 1996; Davenport & Prusak, 1998; Hendriks 1999). Indeed, there are many factors that influence knowledge-sharing (Bock et al., 2005; Kankanhalli et al., 2005; Wasko & Faraj, 2005; Hsu, et al., 2007) and that are related to the organization character (Yang, 2007; Yang & Chen, 2007; Bock et al., 2005). Therefore, exploring knowledge-sharing and interaction in online learning communities may help us understand the limitations of online knowledge interactions.

In the digital learning environment, knowledge-interaction is mostly implemented in asynchronous forums. Such practice for the purpose of promoting knowledge-sharing and knowledge-construction has received greater attention in studies that examine their educational benefits (Vonderwell, 2003; Bodzin & Park, 2000; Henri, 1992). Teaching methods that utilize online discussions can incorporate different types of interactive learning strategies that have been widely discussed and that form the bases of diverse online discussions and learning activities, including problem-solving (Gagne, 1980; Mayer, 1985; Hatch, 1988; Sternberg, 1996; Gagne & Briggs, 1979; Henna et al., 1995; Hou et al., 2008, 2009), peer-assessment (Topping, 1998; Falchikov & Goldfinch, 2000 Cizek, 1997; Shepard, 2000; Lin et al., 2001; Sung et al., 2005; Hou et al., 2007), peer-tutoring (Annis, 1982; Cohen et al., 1982; Greenwood et al., 1988; Miller, 1995; Fantuzzo et al., 1992), and role-playing (Kirs, 1994; Bell, 2001).

Utilizing these strategies, a teacher can specify questions and themes, arrange different discussion rules, and provide appropriate guidance in order to enhance the quality of student discussions and facilitate knowledge-internalization and externalization (Hendriks, 1999). Many studies also indicate that the design of the discussion mechanism has strong influences on the quality of the online discussion (Patricia & Dabbagh, 2005; Hewitt, 2003; Vonderwell, 2003; Swan, at el., 2000; Vrasidas & McIsaac, 1999). As mentioned earlier, shallow discussions and narrow data analyses may be related to the design of the discussion mechanism (including rules of the discussion, strategies such as guidance and intervention, and content of feedback). One way to address this issue is to conduct observations of knowledge-sharing during actual discussions based on the above interactive teaching strategies and to examine the subsequent behavioral patterns. Theoretically sound strategies can then be provided to teachers. This is precisely one of the important tasks of research designed to improve the quality of online educational discussions in the Web 2.0 era.

2. Apply Sequential-Analysis to Detect Online Discussion Patterns

There have been many studies about online asynchronous discussions (Hewitt, 2005; Fahy et al., 2001; Sudweeks & Simoff, 1999; Gunawardena et al., 1997; Newman et al., 1995; Levin et al., 1990). In addition to the analysis of social interaction patterns, related coding schemes have also been formulated for the analysis of the content of interactions (e.g., Gunawardena et al., 1997). While a content analysis of the discussion would help facilitate understanding of the subject matter, the following limitations still exist:

(1) Qualitative or quantitative content analysis alone does not allow us to infer the sequential correlations between discussion behaviors. Nevertheless, these kinds of correlations are crucial to the understanding of the overall behavioral patterns in discussions as well as its implications and bottlenecks.
(2) We can only understand a certain aspect of discussion content patterns by content analysis. The validity of the analysis must also be considered (Rourke et al., 2004). The abstractive nature of certain codes in some coding schemes may also limit the coding accuracy (Marra et al., 2004).

Therefore, in order to have a deeper understanding of students' knowledge-related discussions and interactions, more appropriate analytical methods are required. Compared to other methods, "lag sequential analysis" (Bakeman & Gottman, 1997) allows better inference of the overall sequential patterns in online discussions. Furthermore, it has already been adopted in related studies (Jeong, 2003; England, 1985; King & Roblyer, 1984; Hou et al., 2007; Hou et al., 2008, 2009, in press). Ordinary quantitative content-analysis methods mainly yield data such as the frequency and proportion of different coded contents and focus more on understanding discussion content. However, for further exploring the behavioral patterns in different types of coded discussion behaviors, ordinary quantitative content-analysis methods are not able to provide sequential patterns of students' overall online discussions through statistical testing. As such, we cannot assess, for instance, what kind of discussion immediately follows another or whether the continuity of each type of discussion sequence reaches statistical significance. Sequential patterns of this type allow cross-referencing with prescriptive theory models (e.g., models of problem-solving or instructional design) that indicate differences between theories and actual practice, that allow us to infer possible causes of issues in online discussion patterns (e.g., why a learner carelessly makes a conclusion or terminates a discussion), and that suggest the timing of interventions and guidance by teachers or intelligent agents.

This kind of analytical method can not only analyze online interactive operation behavioral patterns e.g., users' browsing, responses, and posts, but it can also be combined with content analysis to reveal the sequential content patterns in users' online discussions. The specific calculation steps, as detailed by Bakeman and Gottman (1977), are as follows:

(1) Calculation of the frequency transition matrix. First, we calculate the frequency of transitions between each behavior code and create a frequency transition table that represents the frequency of inter-code transitions. The Table 1 is an example; the rows represent the starting behaviors, the columns represent the follow-up behaviors, and the numerical values represent the total frequency of having a certain behavior right after another. For example, the number "60" in row-2/column-3 means that behavior P2 is followed by behavior P3 60 times.

	P1	P2	P3	P4	P5
P1	3	118	2	0	0
P2	6	178	60	34	5
P3	3	49	6	5	1
P4	0	17	7	0	2
P5	0	4	0	0	0

Table 1. Example of Frequency Transition Table (Lag=1)

*Source: Excerpt from Hou, H. T., Chang, K. E., & Sung, Y. T. (2008). Analysis of Problem-Solving Based Online Asynchronous Discussion Pattern. Educational Technology & Society, 11(1), 17-28.

(2) Calculation of the sequential transition conditional probability. From the above sequential frequency transition table we can calculate the conditional probability of different types of inter-code transitions and determine the sequential transition conditional probability matrix, which helps us infer expected-values.

(3) Calculation of the sequential transition expected-values. From he above sequential frequency transition table and the sequential transition conditional probability matrix, we can calculate the expected-values of inter-code transitions that will help us to infer

the Adjusted Residuals Table and to formulate a diagram of transition that allows follow-up analysis.

(4) Calculation of the Adjusted Residuals Table. We can infer the adjusted residuals by the above data and examine each sequence to see if the p<0.05 level of significance is reached. A Z-score greater than +1.96 indicates that the sequence reaches the level of significance (p<0.05). Table 2 is an example, boldface represent sequences (P1->P2, P2->P3, P2->P4, and P4->P5) that reach the level of significance.

	P1	P2	P3	P4	P5
P1	0.04	3.91	-5.08	-4.11	-1.86
P2	-0.70	-4.67	6.21	5.85	0.51
P3	1.35	0.36	-1.33	0.00	-0.03
P4	-0.83	-0.49	1.66	-1.50	2.59
P5	-0.31	0.63	-0.78	-0.56	-0.26

Table 2. Example of Adjusted Residuals Table (Z-scores) Lag=1

*Source: Excerpt from Hou, H. T., Chang, K. E., & Sung, Y. T. (2008). Analysis of Problem-Solving Based Online Asynchronous Discussion Pattern. Educational Technology & Society, 11(1), 17-28.

(5) The creation of a behavioral transition diagram: The significant sequences from the above z-score table are depicted in the diagram of sequential transitions (e.g., Figure 1) in which the coded behaviors are represented as nodes that are linked together with arrow heads, the thickness of which represents the level of significance. The z-scores are also shown in the diagram. Figure 1 depicts the transitions of significant sequences in Table 2 and provides analyzers and teachers a visual presentation of discussion-patterns, thereby facilitating the analysis of patterns and bottlenecks in students' discussions.

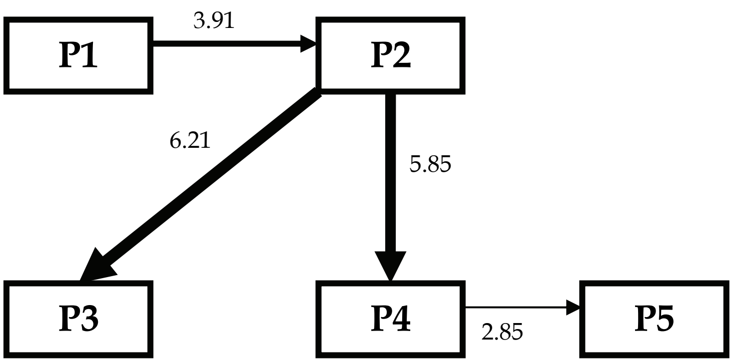

Fig. 1. Example of the Behavioral Sequence Transition Diagram

*Source: Excerpt from Hou, H. T., Chang, K. E., & Sung, Y. T. (2008). Analysis of Problem-Solving Based Online Asynchronous Discussion Pattern. Educational Technology & Society, 11(1), 17-28.

As for the actual analysis researches, Hou et al. have used the mixed-method approach, which includes quantitative (e.g., quantitative content analysis, sequential-analysis, and correlations analysis) as well as qualitative (e.g., learners' attitudes and protocol analysis) approaches to analyze the behaviors of learners who engage in different types of online learning discussions (Hou et al., 2007; Hou et al., 2008, 2009, in press).Although the above methods enhance research validity and provide teachers, researchers, and system developers with relevant suggestions, they still have limitations: they allow for neither the dynamic detection of real-time limitation patterns of discussion nor provide instant feedbacks. Without real-time diagnosis and intervention, the depth of discussions can be hindered, leaving teachers with insufficient analytical tools to instantly evaluate the content of student discussions/performances and to intervene accordingly. If real-time discussion analysis tools can be introduced to the discussion system, teachers will be better equipped to provide effective feedback that instantly improves the quality of discussions.

Since sequential-analysis allows for the inference of behavioral patterns and their visualized graphs from online operations and discussions and is statistically sound for examining behavioral continuity, teachers and researchers can be provided with real-time analytical data as long as the method is built into an online forum. As such, teachers will be able to evaluate students' discussions, and researchers will be able to use the data to analyze and develop feedback strategies. Researchers will even be able to design an automatic diagnostic feedback system that better assists teachers. Introducing this kind of tool would satisfy both educational and research purposes and facilitate knowledge-sharing in the digital learning environment.

To summarize, our research purpose is to apply the calculations of sequential-analysis to design a framework for a knowledge-sharing forum that allows for the analysis of sequential discussion behavioral patterns. This would not only provide teachers with a real-time, visualized diagnosis of sequential-patterns in learners' online discussions operations (including posting, answering, and reading articles), but it would also allow detailed or random analyses of students' discussions through customized or existing content-analysis coding schemes and generate graphs of sequential-behavioral patterns based on the content of discussions. These two types of patterns (i.e., operation sequential-behavioral pattern and content sequential-behavioral pattern) provide teachers and researchers with real-time, dynamic references for designing a feedback/guidance mechanism. The system also enables the configuration of an automatic feedback mechanism through which teachers can provide students with pre-designed feedback when certain behaviors occur.

3. The Knowledge-sharing Environment Combined with Automatic

The framework and function of the knowledge-sharing environment based on automatic sequential-analysis are explained below.

3.1 System Framework

Most of today's online educational discussion forums have basic features such as article-posting/replying. Some are further equipped with more advanced features such as topic-search, highlights, and mail-notification. However, only a few are equipped with the tool of discussion behavior/process analysis. In our study, we wish to have the sequential-analysis calculations discussed in Section 1 (Bakeman & Gottman, 1997) built into the forum and to develop modules such as dynamic feedback rule-base as well as the interfaces for automatic and manual behavior-coding and feedback-design in order to create a knowledge-sharing forum with automatic analysis and feedback. The framework is depicted in the following diagram:

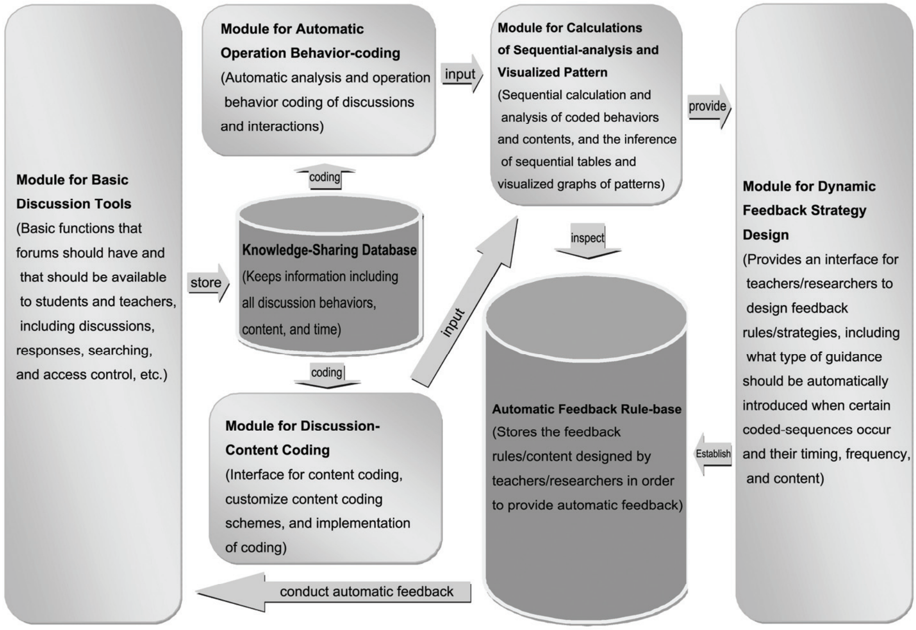

Fig. 2. Framework of Knowledge-sharing with Automatic Sequential-analysis

As shown in Fig. 2, our framework consists of five modules and two databases. In the system, teachers can use different interactive-learning strategies and specify online educational discussion activities that students need in order to participate in a specific forum. The module of basic discussion tools includes the public forum, group-discussion forums, topic-search, configurations of the highlight section, and configuration of automatic replies and mail-forwarding. The entire discussion process, including the time, frequency, content, and users' operations, is recorded in the knowledge-sharing database.

To facilitate our understanding of discussion behaviors, sequential-analysis is implemented based on two main categories of data: interactive behaviors (such as posting/answering/browsing articles) and content of discussions (detailed coding of discussions based on a given coding scheme). In regards to interactive behaviors, the system utilizes the built-in, automatic operation behavior coding module to code all users' operations. As for the content of discussions, the system provides the user (researcher or teacher) with a module of discussion content coding that allows the user to utilize a coding interface in order to code based on his/her own coding schemes or existing ones proposed in previous studies (Hou et al., 2008; Gunawardena et al., 1997).

Both types of codes are then outputted to the sequential-analysis calculation and pattern visualization module for instant processing. The yielded sequential transition table is subsequently converted into a sequential-diagram of patterns in operation and content. The analyzer or teacher can then browse the data and give instant feedback. Furthermore, the teacher can simultaneously view the behavioral patterns and either intervene or adjust the rules of discussions, thereby reaching the goal of dynamic real-time assessment. On the other hand, the teachers or researchers can also use the module for dynamic feedback strategy design to design the rules and content of automatic feedback. For example, when sequential-pattern “A->B” of knowledge-construction occurs and is followed by sequential-pattern “D->E” of the operation behavior, the system automatically announces guidance-message “C”. Teachers or researchers can design this kind feedback rules by having the rules and guidance-messages stored in the automatic feedback rule-base. When learners' operations or discussions match a certain pattern, the system automatically searches the automatic feedback rule-base and announces appropriate guidance-messages, thus greatly improving the quality of knowledge-sharing.

The above system not only allows teachers to conduct dynamic assessments but also assists researchers in long-term strategic analysis. However, various theories of interactive-learning strategies and knowledge-sharing still need to be considered when designing the optimal guidance strategy. Moreover, dynamic, empirical observations of the system are needed before better automatic-feedback strategies that assist teachers and enhance knowledge internalization/externalization can be formulated.

3.2 System Functions

The functions of the above system modules are explained in the following table.

Module	Function	Description
A. Module for Basic Discussion Tools	A1 Configuration of Group Forum	Configuration of users, settings in different group forum sections.
	A2 Configuration of Users	Add new users or configure each user's access modules or basic information.
	A3 Configuration of the Highlight Section	Selection and related configurations of articles in the Highlight Section.
	A4 Teacher Control Panel	Configuration allowing the teachers to delete articles and manage discussion-rules.
	A5 Configuration of Links with e-Learning Platforms	Configuration of links with other online learning platforms that allow learners or teachers to access/upload materials.
B. Module for Automatic Operation Behavior Coding	B1 Configuration of Operation Behavior Types	The analyzer chooses the types of operation behaviors for automatic analysis and assigns code names.
	B2 Operation Behavior Coding Report	View, output, or print the current report of operation behavior codes.
C. Module for	C1 Coding Schemes	Add, input, or choose existing coding

Discussion Content Coding	Management	schemes to code discussions.
	C2 Interface of Coding	The coding interface allows the user to choose a forum and code a certain article or response using multiple coding schemes.
	C3 Content Coding Report	Allows the user to view, output, or print a report of content coding data for analysis.
D. Module for Calculations of Sequential-Analysis and Visualized Pattern	D1 View Sequential Tables	Choose and view the transition table of content patterns at a certain point in time for further analysis.
	D2 View Diagrams of Sequential-behavioral Patterns	Choose and view the diagrams of the sequential-transition of content/operation patterns in a certain time slot for further analysis.
E. Module for Dynamic Feedback Strategy Design	E1 Configuration of Sequential-pattern Feedback Strategies	Provides an interface allowing the teacher/analyzer to configure feedback rules/content according to a certain sequential status. The user can formulate his/her own rules and strategies and store them in the rule-base.
	E2 View Rule-base	Browse the current content of the rule-base, and view/manage relevant rules.
	E3 View Rule Tracking History	View the "hit" rate of each rule and link it to the discussion article/message for further analysis.

Table 3. Functions of the Knowledge-sharing Environment with Automatic Sequential-analysis

Table 3 indicates that this system has both educational and research values and can combine digital learning platforms with the actual practice, design, analysis, and evaluation of different types of online knowledge-sharing discussions. This process greatly facilitates in-depth analysis of behavioral-patterns in discussions. It also assists managers of online learning communities to promote interactive learning activities, knowledge-sharing, and knowledge-construction.

4. Conclusion and Future Studies

In order to improve the depth of online knowledge-construction in the highly interactive Web 2.0, the theory of knowledge-sharing/transfer as well as different instructional strategies for online discussions is taken into consideration. As such, this develops discussion strategies that promote the depth of knowledge-construction as well as the frequency of knowledge-transfers. Efficient discussion strategies for knowledge-transfers are the key to deepening online project-based learning.

This critical topic in research on interactions among online learning communities, however, still lacks a dynamic, real-time evaluation tool that would facilitate relevant studies and educational practices.

In this study, sequential-analysis yields instant references for the analysis of knowledge-related interactions. It has thus been incorporated into our online forum in order develop a knowledge-sharing discussion framework for the real-time analysis of sequential-behavioral patterns. This framework provides flexible coding tools and feedback-configurations, facilitates teaching, and allows teachers and researchers to develop, observe, refine, and test different interaction strategies. In addition, it also serves as an important reference for the developers of intelligent discussion systems.

Future empirical analyses can enhance the validity of process-evaluation by completing the system based on the framework provided in this study. Furthermore, future studies can not only utilize the original method of sequential-analysis but also employ multi-dimensional (quantitative and qualitative) approaches that combine quantitative content-analysis, original protocol analysis, correlation analysis, performance evaluation, and attitudinal surveys. Doing so will greatly facilitate our understanding of the actual discussions and feedback occurring among teachers and students.

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Towards the integration of adaptive educational systems with SCORM standard and authoring toolkits

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1. Introduction

Web courses and hypermedia systems deliver knowledge to a wide number of users with different characteristics, preferences and knowledge of the domain, irrespective of where they live, their age or their study credentials. However, these systems do appear to have some quite major problems which have been identified and documented through research studies and have differentiated into three distinct categories. The first deals with problems related to disorientation, cognitive overload, discontinuous flow (Murray et al., 2000), content readiness and distraction. The main solution that research proposes is the use of adaptive and/or interactive systems. The second category of problems is those that arise from the absence of a common development framework for course construction. Course content, thus, lacks reusability, durability and interoperability. A suggested solution is the adoption of common educational standards for course construction and delivery. The third category involves instructors who come up against difficulties during course construction as most of the time course development requires not only specific programming capabilities but also deep knowledge of adaptive strategies and educational standard specifications. Easy authoring tools for non-programmer instructors may reduce these difficulties and allow more people to create easy and fast web and/or adaptive courses.

The present work deals with three aspects of web learning systems: adaptivity, adoption of educational standards, and authoring tools. Initially it discusses the problems of web-based courses at both the construction and delivery stages, and the possible solutions. It then introduces the reader to the theoretical background in the area of adaptive learning systems with emphasis on user modelling, adaptation technologies, and learning style models. A discussion on educational standards and their usefulness follows with focus on SCORM and its specifications. Next, it reviews adaptive systems and their functionality. It also presents systems that provide adaptive features according to user learning style and SCORM compliant systems. Finally, this chapter deals with the available authoring tools that support either the construction of adaptive or SCORM compliant courses.

Special emphasis is given to the functionality of a new system we have developed, named ProPer, which implements all the above aspects. ProPer combines adaptive technologies with the adoption of SCORM standard and is also accompanied by an authoring tool of SCORM compliant and/or adaptive courses that allows easy course construction without any programming knowledge prerequisites.

2. Problems and solutions of hypermedia courses

Web courses can be used either as an independent integrated solution for distance learning or as supplementary material for conventional classroom education. Furthermore, web courses are available to a broad range of users with different characteristics, preferences, educational goals and knowledge of the domain. Users can follow different navigational paths and study courses with alternative structure and content according to their goals and individual needs (Murray et al., 2000).

Some of the above abilities, however, can actually become drawbacks for these courses since it is not reasonably practicable to cover the range of needs and preferences of every individual user. Brusilovsky et al. (1998) agree with this conviction and state that a course or system that has been designed for a particular class of learners may not suit learners of another class. In addition, research has documented the following major problems of web-based courses: disorientation, cognitive overload, discontinuous flow, content readiness (Murray et al., 2000) and distraction (Scheiter & Gerjets, 2007). More specifically, users are disoriented when they are uncertain of what they have or have not read; are not sure where to find the information they need (Chen et al., 2006); or simply when they become lost in hyperspace (Conklin, 1987). Disorientation is more likely to occur when the knowledge domain is too big or the learner is a novice. The availability of huge quantities of information or the large variety of options and functions a system provides can leave some users bewildered and overwhelmed (Murray et al, 2000; Ng et al., 2000). This constitutes the cognitive overload situation. The discontinuous flow problem distinguishes two issues: narrative flow and conceptual flow. Narrative flow refers to the way the text proceeds, while conceptual flow refers to the stream of ideas presented in the text (Murray at al., 2000). The content readiness problem or “prerequisite problem” arises when the learner finds the content either too easy and is bored, or too difficult and is overwhelmed (Murray at al., 2000). According to Foss (1989) distraction problems arise when the users find too many interesting things or too many relevant topics to explore that distract their attention away from the course’s main goal.

Hence, the use of adaptive and/or interactive hypermedia systems were proposed as a promising solution (Brusilovsky, 1996; Prentzas & Hatziligeroudis, 2001). Adaptivity in e-learning is a new research trend which personalizes the educational process through the use of Adaptive Educational Hypermedia Systems (AEHS). These systems attempt to create an individualized course according to the user’s personal characteristics, such as language, learning style, preferences, educational goals and progress. In this way, instructors expect to solve some of the main problems of web courses and hope to succeed in achieving a better learning outcome.

Apart from requiring authors to expend a significant amount of time, course development and more so the construction of an adaptive course often involves spending vast amounts of resources. It is difficult to apply the educational content from one course to another; or to distribute a course from one AEHS to another, since most times they are not compatible. Moreover, the reuse of educational content and its recall require additional effort from course authors, not to mention that many times, the actual structure of the educational material changes due to the educational platform being upgraded. As a consequence, emphasis is placed on the development of the application where most time and effort is spent, at the expense of instructional strategies development (Sidiropoulos & Bousiou-Makridou, 2005). Adopting educational standards, like SCORM, comes as a solution to the above problems for content reusability, accessibility interoperability and durability. It is expected that the adoption of such a standard will help authors to construct more effective courses faster with less effort and at a lower cost.

Another problem of hypermedia systems lies in the lack of simple authoring tools for SCORM and/or adaptive courses that are appropriate for the non-programmer. This situation naturally, hinders instructors from constructing web-based courses. Thus, the construction process could also be improved with the use of authoring tools that allow fast and easy course construction even by non-programmer authors.

In accordance with the above, we believe that an integrated solution for web-based learning would concern the development of an AEHS which adopts the SCORM standard and provides a tool for easy course authoring.

3. Adaptive Educational Hypermedia Systems Background

By combining the tutor-driven learning process of Intelligent Tutoring Systems (ITS) and the flexibility of student centred Hypermedia Systems (HSs), AEHS have integrated several technologies from both these systems. More specifically, typical AEHSs include a Domain Model (DM) which represents the systems domain; maintain a User Model (UM) which records the user's personal characteristics and knowledge; and are able to adapt the course structure and presentation according to the UM (Eklund & Brusilovsky, 1998) through the Adaptation Module (AM). These systems provide personalized training according to UM records through a set of adaptive rules prescribed by course instructors. They adapt the learning process in a way that enables users not only to learn better but also much easier and faster. Thus, through the use of various techniques, adaptive courses initially and/or during the learning process acquire the requisite user information and store it on the UM. Through a set of adaptive rules, AEHSs use Adaptive Presentation (AP) and Adaptive Navigation (AN) technologies so as to provide various instructional strategies that are personalized to each individual learner.

3.1 Adaptation factors

The exploration of user characteristics in order to ensure the provision of adaptation is an important issue for the success of AEHS. An ideal system would be one that adopted every factor that can affect both the learning process and the user's progress in a course (Wegner, 1987). However, due to difficulties in representation, the large effort that is required by course designers, as well as the complexity of implementation, results in only a few specific factors in practice being modelled by the systems (Kavcic, 2000). The most popular of these, according to Brusilovsky & Millan (2007) are: user knowledge, educational goals, preferences, background and experiences, personal traits (learning style, aptitude), and technology infrastructure.

- **Knowledge.** User knowledge of the domain is one of the most important features that is modelled by AEHSs (Kavcic et al., 2002; Brusilovsky & Millan, 2007; Brusilovsky 2003).

Estimated user knowledge can initially be retrieved through a set of questions (pre-test) or even directly by user declaration. The user's acquired knowledge during the learning process can be retrieved either through assessment questions or by the system's observation of the user's behaviour throughout the course. A variety of techniques and models can be implemented for knowledge representation, such as the overlay model, the differential model, the perturbation model etc., which are presented in a later section of this chapter.

- **Educational goals.** The modelling of this factor allows learners to have individual educational goals in a course or a system (Brusilovsky, 2003). For instance, they may choose a subset of domain concepts as their current educational goal. During the learning process, the student may have a primary goal that consists of several predefined elementary goals. Goal orientation can be carried out either by the course author, the teacher or the learner (Brusilovsky, 2003) itself.
- **Preferences.** Each user may prefer some nodes, links or page fragments over others (Brusilovsky, 1996). User preferences are mainly applied for the course's adaptive presentation. They can be retrieved either directly through the user state or indirectly through observation of user behaviour.
- **Background and experiences.** These concern the user's previous experience that may be relative but outside the core domain of a system (Brusilovsky & Millan, 2007). User experience may concern user familiarity with hypermedia systems and web or likely knowledge of technical definitions used in a course. Systems mainly use background and experiences to adapt course content.
- **Personal traits.** The user's cognitive and learning styles, as well as their aptitudes comprise some personal traits, which many systems take into consideration when adapting their courses (INSPIRE, AES-CS, CS383, TANGOW etc.). Personal traits can be retrieved through specially designed psychological tests (Brusilovsky & Millan, 2007). Learning style theories and models are further expanded on in the next section.
- **Technology infrastructure.** This is an important factor for distance and online learning. For instance, low connection speed may produce problems in the study content based on video. Moreover, content presentation needs to be adapted according to the user device (PDA, mobile, PC etc.).

3.2 Technology Background

According to Eklund and Brusilovsky (1998) all the adaptive hypermedia systems comprise a DM, which consists of elementary pieces of knowledge and their relationships, a User or Student Model as it is referred to in many works, that is responsible for the recording of the factors which adaptation depends on, and an AM, responsible for system adaptation according to the UM.

3.2.1 Domain Model

The role of the DM is to represent the knowledge that is to be taught (Wegner, 1987). Various techniques have been used for knowledge representation,, however, a formal DM is commonly comprised of three layers.

The first layer is made up of the concepts of the cognitive domain. The breadth of knowledge that covers each concept is differentiated depending on the size of the domain, the thematic region and the choices of the course designer (Brusilovsky, 2003). The concepts can be independent, in the simpler form of the DM, or related to each other, thus forming a conceptual network which represents the structure of the domain (Brusilovsky, 2003). A simple relation between two concepts is the link connection that leads to the page of the corresponding concept. One of the most popular relations is the prerequisite one. This is used when it is considered that it would be good for users to know certain concepts before applying others that it is an essential precondition to studying the relative educational material (Prentzas and Hatziligeroudis, 2001). Other relations are: "part of" where certain concepts are part of a more complex concept; and "is a" where concepts constitute characteristic cases of another concept (Prentzas and Hatziligeroudis, 2001).

Each concept may correspond to one or more web pages, which constitutes the second layer of the DM. Each author can choose whether a concept's educational material will be presented in one or more web pages. The passage from a web page to another can be either sequential, by selection and/or adaptive.

The final layer of the DM is comprised of smaller cognitive fragments, such as text, picture, animation, video etc. Each web page constitutes at least one of these fragments. The choice of the fragments that will be presented in each web page can be either static, where it remains the same, or dynamic where the fragments are automatically selected according to user properties. A dynamic web page is able to adapt the presentation of a fragment itself or even be composed of a combination of different fragments.

3.2.2 User Model

The UM constitutes a representation of user knowledge, preferences, characteristics and educational goals (Brusilovsky, 1996). An ideal UM should include all the properties that influence the user's learning and progress within a course (Wenger, 1987). According to Kavcic (2000) three aspects have to be considered with regard to the UM: (i) the information that will be stored in the UM and how it can be retrieved; (ii) the representation of this information in the system; and (iii) the process of forming and updating the model. The representation of information in the UM can be achieved through a variety of methods. Some knowledge representation models include the scalar model, the overlay model, the differential model, the perturbation model etc. presented further below. The methods for forming and updating the UM are similar to those for constructing it (Kavcic, 2000).

The information stored in the UM can be separated into static and dynamic depending on the system's retrieval mechanism (Kavcic, 2000). Static information remains immutable during the learning process (unless the user decides to redefine it); it is collected once and refers mainly to the user's particular characteristics, such as language, occupation and learning style. On the other hand, dynamic information can be altered during learning and requires continuous updating. Information of this category may include user knowledge, progress, goals etc. Modelled information can be either domain-independent or domain dependent. The former contains information regarding user properties which usually remains stable during learning, while the latter contains information related to the DM, such as user knowledge, educational goals etc.

Knowledge representation models

As previously mentioned, user knowledge is one of the main factors of adaptation. Some of the proposed models for knowledge representation are the following:

- **Scalar Model**. The simplest form of knowledge representation is via scalar models. These models can be quantitative, evaluating the user's knowledge on a scale (e.g. from 1 to 5) or qualitative, classifying the user into stereotypes, such as novice, intermediate, advanced according their knowledge level (Brusilovsky & Milan, 2007). However, scalar models represent user knowledge for the entire course. In cases where user knowledge is different for particular concepts of the course, then the use of structural models is needed.
- **Overlay Model.** This is the most popular of the structural models. It is based on the assumption that user knowledge constitutes a subset of expert knowledge in the domain (Beck et al, 1996). A user may acquire knowledge with the ambition to reach the level of an expert but s/he cannot learn something more or different from this. The overlay model keeps a value for every DM concept, which represents the coverage of expert knowledge in that particular concept.
- **Differential Student Model**. The differential model improves on the overlay model (Holt et al., 1994). It does not view all gaps in student knowledge as necessarily undesirable. Similar to the overlay model, user knowledge is a component of expert knowledge. The difference, however, lies in the fact that knowledge in this model is divided into two categories: (a) expected knowledge, and (b) knowledge that the learner could not be expected to attain. Accordingly, it is not necessary for the former to be the expert's knowledge but can comprise its subset.
- **Perturbation Model**. The two structural models stated above cannot represent likely knowledge queries or misconceptions that the user may have outside the boundary of expert knowledge. In this model learner knowledge and aptitudes are considered to be a perturbation of expert knowledge rather than a subset (Martins et al., 2008). The perturbation model extends the overlay model by representing possible user misconceptions also called faulty or buggy knowledge. More specifically, it combines the overlay model with a representation of faulty knowledge.
- **Genetic Graph.** The previous models give an instant representation of user knowledge. In contrast to the overlay model, which besides representing user knowledge as a part of expert knowledge also deals with the time involved in knowledge gain, the Genetic Graph (Goldstein, 1982) records the time factor involved in the process of knowledge development
- **Bounded Model.** (Elsom-Cook, 1988) This can be considered as a variant of the overlay model which rather than representing the exact user knowledge acquired, employs fuzzy bounds by setting a low and high limit.

Instead of using one specific model, many systems tend to combine functions and properties from two or more models. One of the most usual combinations is to initially classify learners using stereotypes and later during the learning process construct an overlay model for a more individualized adaptation.

3.2.3 Adaptation Module

The Adaptation Module (AM) includes a set of rules and conditions, which through the application of various adaptive technologies individualizes the course to each individual user. More specifically, AM is triggered by specific user actions and initially reads information from the DM and UM. Following, through its set of rules, it checks for any possible adaptation needed. If this is the case, it uses the appropriate adaptation technologies to adapt navigation and/or presentation of the system while at the same time updates the UM with the new data.

The rules that the AM contains can be applied before the delivery of a new page (pre-conditions), for instance, when the system checks if the user knows the prerequisite concepts. They can also be applied (a) at the page exit (post-conditions), e.g., the UM is updated with the user's latest knowledge acquisition of a concept; or (b) during the study of a page, e.g., if the test score is above a specific limit then the user is allowed to study the following concept.

Various adaptation technologies are implemented to personalize the system. These can adapt either the content of a web page or the links provided. Thus, in accordance with the Brusilovsky taxonomy (Brusilovsky, 1996, 2001), adaptation technologies can be separated into two major categories: Adaptive Navigation and Adaptive Presentation.

There are three main **Adaptive Presentation technologies**:

(i) Adaptive multimedia presentation. Sometimes the use of multimedia may create problems for users due to their not having adequate technological infrastructure. This technology adapts the quality and size of the multimedia that is used in a course according to the user infrastructure.

Adaptive text presentation. This allows the adaptation of text to user preference. It is further divided into Natural language adaptation and Canned text adaptation which is the most usual. Canned text adaptation according to Brusilovsky (2001) uses the following technologies:

- Inserting/removing fragments: System inserts or removes specific text fragments.
- Altering fragments: System provides many alternative text fragments and only the most appropriate is presented.
- Stretchtext: Additional text or explanations can be collapsed or un-collapsed on a page depending on user preferences.
- Sorting Fragments: the sequence of text fragments can be changed.
- Dimming Fragments: system dims or fades text that according to the UM is inappropriate for study, without completely removing it.

Adaptation of modality. Some times the same concept is presented in different media, like text, video, sound etc. This technology chooses the best media for concept presentation and delivers it to the user.

On the other hand, **Adaptive Navigation** aims to help the user find the optimal path within a course (Brusilovsky, 1996). The main AN technologies (Brusilovsky, 2001) are:

- direct guidance - the system proposes the next best concept for study;
- link sorting – adapts the order of the links;
- link hiding – the system presents links as simple text (hiding), disables links (disabling) or totally removes them (link removal);
- link annotation - links are annotated corresponding to the user model;
- link generation – the system generates new links;
- hypertext map adaptation - the system provides and appropriately changes a graphical representation of the link structure.

3.3 Learning Styles

Each individual has his/her unique way of learning. Thus, learning style greatly affects both the learning process and the outcome (Carver and Howard, 1999). In order to achieve better learning outcomes, several research streams are attempting to provide adaptivity of the learning process. One of these streams exploits educational theories about student learning styles in order to gain a better learning outcome. Some of the most well known learning styles are:

- **Kolb's learning style theory** (Kolb, 1984). Learning is a process of knowledge construction through a cycle of four distinct stages: Concrete Experience (CE), Reflective Observation (RO), Abstract Conceptualization (AC) and Active Experimentation (AE). The student can start from any point in the cycle and continue going through the remaining stages in sequence. This model classifies learners into four categories represented by the combination of two preferred styles: Divergers (CE, RO), Assimilators (AC, RO), Convergers (AC, AE) and Accommodators (CE, AE). Users are placed in one of the above categories by answering a 12-sentence questionnaire describing how they best learn (Kolb, 1981).
- **Honey and Mumford** (1992) **Model**, which is based on Kolb's learning style theory. The four stages of the learning cycle are: (i) having an experience; (ii) reviewing the experience; (iii) forming conclusions from the experience; and (iv) planning the next step. Similar to Kolb's circle the student can start from any stage and continue to the others. Each stage corresponds to a related learning style: Activist, Reflector, Theorist and Pragmatist. Learners are classified with an 80-item- true/false questionnaire (Honey and Mumford, 2000).
- **Felder & Silverman** (1988) **Learning Style Model (FSLSM)**. This model classifies learners by using a five dimensions sliding scale: sensing-intuitive, visual–verbal, inductive-deductive (similar to Kolb's CE-AC), active-reflective (similar to Kolb's AE-RO), sequential-global. However, the inductive-deductive dimension is abandoned with the development of the assessment instrument (Felder & Soloman, 1996). The student learner style can be acquired through the Index of Learning Style (ILS) questionnaire (Felder & Soloman, 1996) which consists of 44 two choice answers.
- **Witkin's Field Dependent- Field Independent Model** (Witkin et al., 1977). Field dependent individuals are global on their perceptions, intrinsically motivated, enjoy cooperative learning and require externally defined goals. On the other hand, field independent people are more analytical in their approach, enjoy individualized learning and tend to develop self oriented goals (Triantafilou et al, 2002). Learner's style can be defined through the Group Embedded Figures Test (Witkin et all, 1971).
- **Dunn & Dunn** (1978) **Model**. This model is based on the theory that individuals have unique sets of biological and developmental characteristics that impact on the way of learning. It involves 21 elements that are grouped into the following five "stimuli" categories: environmental, emotional, sociological, physiological and psychological preferences. The first versions of learning style inventory for this model were developed for children and consisted of 104 Likert scale questions, while the current adult version (Rundle & Dunn, 2000) is comprised of 118 five-point Likert questions.
- **Grasha-Riechmann Student Learning Styles Scale (GRSLSS)** (Riechmann & Grasha, 1974). This model classifies three bipolar dimensions in respect to students' social interaction: competitive-collaborative, avoidant-participant, dependent-independent.

To find the student's learning style, GRSLSS uses the Student Learning Styles Scale (Grasha & Riechmann, 1975) of 90 questions, 15 for each subcategory.

- **Gardner's theory of multiple intelligences** (Gardner, 1993). Gardner identifies eight aptitude-like traits, which he refers to as "intelligences": mathematical-logical, musical, linguistic-verbal, visual-spatial, bodily kinesthetic, interpersonal and intrapersonal. A further intelligence has been added called naturalistic. A multiple intelligence inventory by Shearer (1996) is available.

4. Educational standards and SCORM

Authors would save much time and effort if they could easily find and reuse qualitative educational content from other courses and/or platforms. Moreover, they would save time if there where no need to update their courses when the host platform was updated to a new version. Thus, the need to have reusable, accessible, interoperable and durable (RAID) content has led to the creation of learning technology specifications. For the time being the most popular educational standard is SCORM (Sharable Content Object Reference Model) (ADL, 2009) which was implemented by the ADL (Advanced Distributed Learning) Initiative.

SCORM is a collection of specifications and standards for the development, packaging and delivery of educational content. More specifically, it describes the components used in learning and how to package them for exchange between compliant systems; how they should be described using metadata in order to enable search and discovery; and how to define sequencing rules for the content objects (ADL, 2009). SCORM consolidates the work of other standards and organizations, such as ARIADNE, AICC, IMS, and IEEE's LTSC into one unified reference model. The application of SCORM ensures the reusability, accessibility and durability of the educational material, as well as interoperability between learning management systems (LMS).

SCORM Components

SCORM is comprised of three main components (ADL, 2009): Content Aggregation Model (CAM), Run-Time Environment (RTE), and Sequencing and Navigation (SN).

CAM describes the format of content structure, how to package, describe and identify them, and how to define sequencing information (ADL, 2009). It is made up of five components (ADL, 2009): (i) Assets: electronic representations of media, such as text, images etc.; (ii) Sharable Content Objects (SCOs) which are collections of one or more assets. It must be noted, however, that SCOs are differentiated from assets by their ability to communicate with the LMS using the IEEE ECMAScript Application Programming Interface (API); (iii) Activities: structured units of instructions. These may provide either a SCO or an Asset to the learner or even be composed of subactivities; (iv) Content Organization: representation that defines the intended use of the content through the activities; (v) Content Aggregation: describes the composition process of related content objects so that the set can be applied in a learning experience.

RTE provides a means of interoperability between SCOs and LMSs. Its goal is the interoperability of educational content between different LMSs, independent of how these were developed. In order for this to be achieved there must be a common content launch process, communication with the LMS and predefined tracking data elements that are exchanged between the LMS and content objects. The launch process defines a common way for content object initialization. The communication of content objects with the LMS is performed via an API used both for retrieving and storing data between LMSs and SCOs. A Data Model is used for the definition of the information being tracked for a SCO (ADL, 2009).

The SN describes how content objects may be delivered to the learners through a set of navigation events and how to control the delivery sequence using run-time based programming rules. SN includes subjects such as sequencing concepts and terminology, sequencing definition and behavior models, navigation controls and requirements, and a navigation data model (ADL, 2009).

A SCORM compliant course is made up of a collection of assets, such as, images, text etc., one or more SCOs and an XML manifest file that is found at the top of the course folder and stores data not only about the course structure but sequencing and navigation rules as well.

The application of SCORM standard allows instructors to reuse educational material and thus save time on course development.

5. Related Work

The first pioneer adaptive systems were implemented in the early 1990s. Brusilovsky classifies the systems that have been developed since then into three generations (Brusilovsky, 2004). The first generation systems (1990-1996) were experimental and were developed to explore innovative ideas. The second (1996-2002) were developed to be used in real life problems (Brusilovsky, 2004). Some of the best-known, such as ELM-ART, TANGOW, AHA! and Interbook were developed between 1996-2002. The second generation research can be split into three main streams (Brusilovsky, 2004): (i) systems that re-used existing technologies and explored a number of approaches and various subject areas; (ii) work on producing new adaptive hypermedia techniques, like adaptation to student learning style; and (iii) research on frameworks and authoring tools for adaptive hypermedia development. Despite the fact that these second generation systems tried to solve real life problems, they failed to influence practical Web-based education (Brusilovsky, 2004) which relies on LMSs. The third generation of AEHS attempts to compete with these systems following three alternative streams: (i) systems which incorporate as many functionalities of LMSs as possible; (ii) systems working on open corpus web content; and (iii) systems that focus on interoperability and reusability of educational content using appropriate educational standards, such as SCORM.

Our work is based on three of the previous presented research streams. Principally, our aim has been to combine adaptive hypermedia with the SCORM educational standard. Moreover, our prototype, called ProPer, supports adaptation to various user learning styles with an evaluated application of the Honey and Mumford learning style theory. A framework for the creation of SCORM compliant courses that are adaptive to learning styles has been proposed in (Kazanidis & Satratzemi, 2009b). Furthermore, we are working on an authoring tool, called ProPer SAT, for the development of SCORM compliant and/or adaptive courses.

This section deals with the areas that we are working on presently. Firstly, the area of AEHS is presented. Particular emphasis is given to the second-generation systems that exploit learning style theories in order to achieve a better learning outcome, as well as on the authoring tools of adaptive courses. Next, we present third generation systems, which combine adaptation with the adoption of educational standards. Lastly, authoring tools for SCORM compliant and/or adaptive courses are presented.

Adaptive systems

Many adaptive systems are similar to ProPer. Following are some such:

ISIS-Tutor (Brusilovsky & Pesin, 1994) is an intelligent tutor for the CDS/ISIS library system that was developed by UNESCO. It belongs to the first generation AEHS and applies adaptive link annotation, hiding and removal, as well as direct guidance using an overlay student model. ELM-ART (Brusilovsky et al, 1996) is a second generation adaptive system and many subsequent models have their roots in it. It is a hyperbook which also provides adaptive link annotation and sorting, index-based guidance and problem solving support in order to assist programming in LISP. It was the first to use the adaptive link annotation technique. For user modelling it employs a multilayer overlay model. One system based on ELM-ART is KBS-Hyperbook (Henze & Nejdl, 1997). It is an open hypermedia system, which delivers content from information resources located anywhere in the WWW. KBS-Hyperbook follows the constructivist educational process building on project based learning, group work and discussions (Henze & Nejdl, 1997). It uses Bayesian networks for user modelling and provides direct guidance and adaptive link annotation. Another well-known AEHS is ALICE (Kavcic et al., 2002). It is an electronic textbook on the Java programming language, which uses link insertion, link annotation and direct guidance as its main adaptation techniques. For user modelling it includes the elements of knowledge uncertainty.

Adaptive systems focused on learning style

While the systems presented above endeavour to individualize the educational process to user knowledge and navigational history, some others adapt instruction to user learning style. INSPIRE (Papanikolaou et al., 2003) generates adaptive courses that provide adaptive link annotation and adaptive presentation of the educational content according to user knowledge level and learning style. It presents the same educational material in a different sequence of knowledge modules (e.g. activities, examples, hints from theory, exercises) for particular learning styles. It adopts the Honey and Mumford (1992) learning style model and categorizes students accordingly through an appropriate questionnaire (Honey and Mumford, 2000). AES-CS (Triantafillou et al., 2002) incorporates the FD/FI learning style model. It adapts content presentation and provides navigation support according to the user's prior knowledge and cognitive style. Cognitive style is used in order to provide adaptive learner control, contextual organisers and lesson structure support. TANGOW (Carro et al, 1999) implements the sensing-intuitive dimension of the FSLSM. It presents the contents by example and theory similar to INSPIRE. The ILS questionnaire (Felder and Soloman, 1996) is applied to classify user into their corresponding learning style. If the questionnaire results are balanced, the default order defined by the designer is presented; appropriate adaptivity is also provided. Several dimensions of FSLSM (global-sequential, visual-verbal, sensing-intuitive and inductive-deductive) are also implemented by CS383 (Carver et al, 1996), which provides different types of media, such as text, movies, graphs, slideshows etc. User learning style is identified through the ILS questionnaire. LSAS (Bajraktarevic, 2003) is another system that incorporates the global sequential dimension of FSLSM. Sequential learners are provided with advanced organizers, more structured lessons and maximum instruction with feedback, while global learners are guided with an overview and summaries of the lessons (Stash et al., 2004). iWeaver (Wolf, 2002) is based on the Dunn and Dunn learning style model and for the adaptation of content presentation it incorporates two dimensions: the perceptive domain and the psychological domain. In addition, it provides specific learning tools in accordance to user preferences. User learning style is established through a questionnaire (Rundle, & Dunn, 2000). EDUCE (Kelly & Tangney, 2006) is a system based on Gardner's MI theory (Gardner, 1993). It classifies users through a questionnaire (Shearer, 1996), as well as dynamically during the educational process. EDUCE allows learners to study with/without adaptivity. While in the adaptive mode, the student is guided to a specific MI resource type but does have the option to go back and view alternative resources.

Course authoring tools

The existence of appropriate course authoring for the above systems is a crucial parameter. Most of them are available for specific domain knowledge but only programmers are able to develop additional adaptive learning material. However, there are adaptive systems that incorporate appropriate authoring tools to enable authors to develop various courses. Some of the most well known are the following: Interbook (Brusilovsky, et al., 1998) is a tool for authoring and delivering adaptive textbooks on the web. It provides adaptive guidance, navigation and help, following ELM-ART's adaptive methodology. InterBook addresses authoring by allowing tagged text to be imported from word processing files. NetCoach (Weber et al., 2001) is another authoring tool derived from ELM-ART. Authors can provide content in HTML with its presentation parameters and specify through appropriate forms prerequisite and inference links. AHA! (De Bra, et al., 1998) is an open-source software and addresses authoring through XML-based mark-up language, as well as through certain form-based authoring tools (Brusilovsky, 2003). It supports adaptive hiding of fragments, adaptive link annotation and hiding. Early modifications (Stash et al., 2004) enable AHA! to provide adaptivity to user learning style. It does not provide any one particular learning style support, but rather attempts to create enough flexibility to make it possible for authors to design many variations for learning styles (Stash et al., 2004). Learning style in AHA! is discovered by manual user declaration, instead of through a particular questionnaire. MetaLinks according to Murray (Murray et al., 2000) seems to be the only hypermedia system to have a fully featured GUI authoring system. Among other things, it can adapt content depending on where the learner came to this page from and it provides focused as well as exploratory learning. It should, however, be noted here that the use of this particular system presupposes that authors not only provide a good but also careful organisation of the instructive material, which should create and connect all the web pages of the electronic book that s/he wants to create with concrete criteria. Another authoring tool of adaptive courses is WINDS (Specht, 2001). The author can design adaptive courses through the use of relations, such as prerequisites, part_of, related_to. In a course WINDS implements direct guidance, link annotation, sorting and hiding, as well as additional explanations, various sequences of contents and even different graphs. For all these adaptive methods the author should write the appropriate rules; needless to say, a difficult task for non-programmers. Some other authoring tools, like REDEEM and VIDET aim to provide easy course authoring for teachers who are not programmers. REDEEM (Ainsworth et al., 2003) allows instructors to import pre-existent courses and provide tools to define the instructional strategies. VIDET (Armani, 2005) is a visual authoring tool which lets authors manipulate the hypertext structure, the content, the user model, and the adaptive interaction model.

Systems based on SCORM

Despite the attempts for reusable educational content (Stash et al., 2004), none of the above adaptive systems and authoring tools conforms to a widely accepted standard, resulting in their having limited reusability. Nevertheless, it must be stated that some systems are trying to incorporate the SCORM specification in order to obtain the RAID educational content. Some of these third generation systems are the following:

OPAL (Conlan et al., 2002) is an LMS which supports learning resources tagged by SCORM metadata. It performs adaptivity at the level of content packages by employing stretch-text type methods to selectively hide or remove individual content. However, it does not support SCORM compliant courses and its adaptive features are restricted. VIBORA (Morales, 2003) supports SCORM and lets students choose between three types of sequences in the course: pre-established sequence, manual selection of activities through the table of contents (TOC), and by following the "Socratic" method, where the student is evaluated and if necessary additional activities (exercises, examples and explanations) are provided. Even though VIBORA is SCORM compliant, its adaptivity is very restricted. AdeLE (Gütl & Mödritscher, 2005) is a project intended to support existing systems and enhance them with adaptivity. Its current implementation utilises ADL's SCORM RTE as the front-end of the system and is quite similar to our prototype. AdeLE builds its user model by tracking user interaction with the LMS and by tracking eye movements. Its adaptation process is highly dependent on SCORM specifications and is applied through an improved tree-view navigation. More specifically, in addition to SCORM RTE, AdeLE provides (i) automatically generated concepts, (ii) alternatives to the adapted decision about the current instruction, and (iii) information about the learner model. Not only the new but also the older systems are endeavouring to incorporate SCORM by extending their functionality. For example, a new version of AHA! enables authors to import (and soon to export) SCORM compliant courses (Romero et al., 2005). However, imported courses do not include all the facilities that AHA! offers, so further changes to navigation, content etc. using AHA! authoring tools is required.

As is apparent, much effort is expended on the development of adaptive systems and authoring tools that are compliant or that partially use an educational standard, such as SCORM, in order to provide quality personalized instruction and at the same time accommodate reusability of the educational material.

6. ProPer

ProPer (an acronym for the Greek translation of Adaptive Environment) (Kazanidis & Satratzemi, 2009a) is an LMS which is not only compliant to SCORM, but is also enhanced with adaptive and adaptable features. ProPer allows authors to upload SCORM compliant courses and provides adaptation to user knowledge, goals and progress. We have shown in (Kazanidis & Satratzemi, 2009b) that it is also possible to apply adaptation to user learning style as well as to other personal characteristics via SCORM specifications. ProPer tries to address the problem of reusability and durability that AEHSs encounter by adopting the SCORM standard. Thus, the educational content used by ProPer is reusable, easily accessible and interoperable. Furthermore by providing adaptive and adaptable technologies, ProPer provides dynamic and adaptive educational content in contrast to the majority of SCORM compliant LMSs. In addition, ProPer provides an Online Java Editor in order to help support students on Java programming.

6.1 Design and implementation

Therefore, its architecture adopts modules from categories of both systems. ProPer is comprised of four main modules: DM, UM, AM and RTE Sequencer. The DM provides the essential educational material in the form of concepts with specific properties and relationships between them. It contains the entire mandatory from the SCORM Content Aggregation Model and SCORM RTE Data Model data, for every single concept of the course. The concepts in the DM are implemented by SCOs. The DM is also surrounded by additional data, like the permission of manual knowledge declaration, FAQ and their answers. The UM keeps records of user characteristics, knowledge, goals and behavior so as to enable the system to provide the appropriate adaptation. Details about user modeling and UM architecture are presented later in the chapter. The AM is responsible for the system's adaptation. It interacts both with the UM and DM and provides all the system's adaptive features which are likewise presented in a later section. Finally, the RTE Sequencer is the system's sequencing engine. It is triggered by course navigation controls, interacts with the DM and AM and delivers the appropriate educational content to the learner. It sets up the user navigation process applying SCORM specification and rules.

For the implementation of ProPer, rather than use a brand new LMS, we decided to rely on ADL's SCORM Runtime Environment 1.3.3. Therefore, our main exertions focused on the development of adaptive and intelligent technologies and not on simple LMS functionalities. Nevertheless, the database was changed to MySQL and several extensions where added in order to enhance the AM and to enable the system's adaptive functionality.

Our concern was to design a simple and friendly interface (Figure1) based on SCORM RTE layout. On the top of the screen a functionality toolbar was added while the TOC was extended with appropriate adaptive annotations. A new frame was added at the bottom-left of the screen, which provides visualization of user progress, manual knowledge declaration and direct guidance controls. The main frame of the interface is assigned to the presentation of the educational content.

6.2 User Characteristics for adaptation

The user characteristics considered in ProPer for adaptation include: user knowledge, educational goals, user actions, learning style, language, which can be further extended using SCORM specifications.

6.2.1 Knowledge

The user's knowledge level is a crucial parameter for adaptive systems. ProPer stores the user's previous knowledge and estimates in real time his/her current knowledge. More specifically, the system initially assumes that the user has no previous knowledge of the domain. However, it lets the user declare whether s/he knows (or does not) the course concepts through the "User Model" screen. Once the user defines their previous knowledge, the system updates the UM and adapts its interface accordingly. In contrast to other systems, ProPer enables users to change their previous knowledge declarations even during the learning process. In addition, the system records user progress and counts user knowledge at three levels: a) in each activity; b) in the entire course; and c) in accordance with the user's educational goals.

Knowledge at the activity level is obtained by the SCO's mechanism and stored in the UM at the time the learner leaves the SCO. Course designers need to take special care to allow the UM to update, even when the user changes the web page into a multipage SCO. In actual fact the system, through a progress visualization mechanism (PVM), calculates and updates the user's total course score every time a new activity score is sent to the UM. Additionally, the PVM calculates a score based on user goals. It reconstructs the DM structure dropping out activities that do not constitute a part of the user's goals and changes the organization and activity weights accordingly. The outcome of this process is to annotate TOC in real time and display user's progress on two bar graphs that represent the percentages of course knowledge and the goals of the activities that the user has actually achieved.

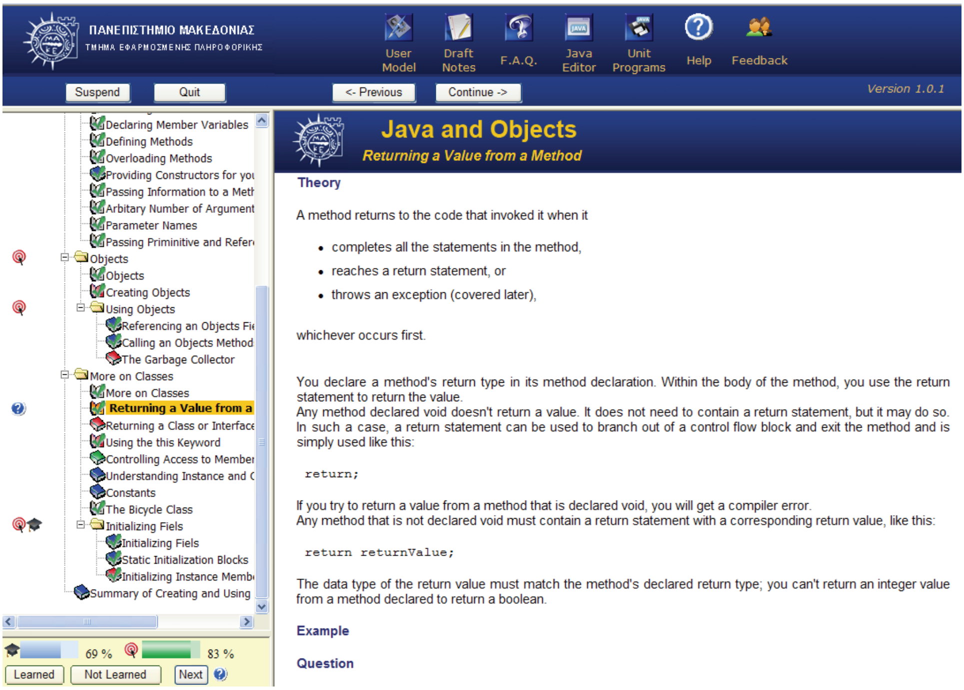

Fig. 1. ProPer's interface

The user knowledge in a SCO can be calculated by various methods, such as, by the visit(s) to a page, the study time spent on a page, how many subpages of a SCO the user has studied, the results of the assessment questionnaire etc. However, it must be mentioned that there is dispute as to the accuracy of user knowledge estimation by adaptive systems. It is true, we cannot assume that a visit to a page means that the user has learned the corresponding concept. For that reason, ProPer under specific conditions (i.e. with the instructor's permission) allows users to directly define whether they have or have not learned the concept of that activity. In this way we attempt to anticipate any possible faulty UM estimations

6.2.2 Educational Goals

As mentioned earlier, educational goals is a very important factor for adaptation. Users may have stable educational goals, e.g. learn the whole course content or the first two chapters, or might even change their goals during the learning process. Therefore, ProPer has been designed in a way that permits students to declare their educational goals at any time throughout the duration of the learning process. The user goals declaration, like the knowledge declaration, is carried out by the "User Model" screen. However, this time the system at the beginning assumes that every activity constitutes a user goal. There are situations where novice students may not know what exactly they want to learn and thus have problems with declaring their goals. Obviously n this case, it would be helpful to the student if they had a clearly described set of goals to select from. ProPer allows just this to happen by enabling instructors to predefine particular sets of goals that have been elucidated with a title and a short description as to which level they refer to, e.g. beginner, intermediate, advanced etc. In this way, different classes of users are initially categorized into stereotypes and then afterwards they are given the opportunity to appropriately modulate their goal selection (overlay model) in order to personalize them to their individual needs.

When the system knows what exactly the user wishes to learn, it can inform them in real time about the status of each activity (whether it is a goal or not), by annotating the TOC accordingly, as well as propose an optimal learning path which omits non-goal activities. Moreover, through the PVM system a score and a bar graph representing how much area has been covered of the user's educational goals are displayed.

6.2.3 User Actions

The user actions that are recorded in the system's UM are his/her navigational history and the study time for each course activity. In courses with many activities, it is essential for the user to have a clear idea which of them have already been visited. Thus, the system records whether or not the user has visited an activity, annotating the TOC accordingly. ProPer, however, goes one step further by recording the number of visits for each activity. Hence, it can provide statistical data to the user about the number of times a page has been visited, as well as, to apply structure adaptation. The statistics are available to the course instructor in order to be able to infer if an activity is difficult or confusing for students and where necessary, improve course design.

In addition, the system records the time a user spends on each activity. We have taken special precautions for the case where the user might have left the course window open without actually studying the content. If an activity page is visited for longer than the predefined time, then the counter is automatically set to zero. In this way, we hope to achieve better user modelling and subsequently more effective adaptation. In addition, the time a user spends on an activity can be used for content adaptation. Moreover, by way of the course statistics, the student can see the total time spent on an activity, while the instructor can view the average time students spent on any particular activities. From this instructors are able to make an inference about an activity, for instance, if less time is spent on a particular exercise then it is most probably easy or known to most users. In contrast, if students spend more time, this most likely means that the activity is difficult and/or confusing. These assumptions can bring about course improvement through structure and content modifications.

6.2.4 Learning Styles

As we have already seen there are many learning style theories and models that various AEHSs have adopted. ProPer is able to record the user's preferred learning style applying SCORM specifications. However, this method has both pros and cons. On the one hand, it enables instructors to design courses that adopt any learning style model they like with the appropriate content adaptation, but on the other hand, instructors may not actually have the necessary knowledge of learning style theories and SCORM specifications in order to develop such courses. Although we sought to address this problem by proposing a framework for easy learning style adaptation in SCORM compliant courses (Kazanidis & Satratzemi, 2009b), we believe that it would most certainly be better if an automated tool helped authors in the development of these types of courses.

For our summative evaluation we developed such a course that provides adaptation according to the Honey and Mumford learning style model. The first course activity retrieves the student's learning style either by declaration or through a specific questionnaire. The system then stores a corresponding value in a SCORM objective called "lstyle" (Kazanidis & Satratzemi, 2009b). Every time students visit an activity the SCO communicates with the LMS, reads the "lstyle" value and adapts its content presentation accordingly.

6.2.5 Other characteristics

As previously stated, instructors can use SCORM specifications to provide further adaptation to their courses. In this way, the system can also model the user learning style or any other user characteristic can be acquired through a questionnaire or user declaration. For instance, adaptation can be provided according to user language, knowledge of specific concepts (pre-requisites), occupation, age etc. Writers following the framework presented in (Kazanidis and Satratzemi, 2009b) have already designed courses that support learning style, language and pre-requisite adaptation.

6.3 Learner Modeling

This section presents the implemented UM architecture so as to be able to keep records of user characteristics, which are necessary to generate adaptation. ProPer's UM (Kazanidis & Satratzemi, 2009a) stores three categories of data: (i) knowledge of the domain, (ii) user actions and goals, and (iii) domain independent data, such as username, password, mail, language and privileges.

For knowledge representation a multilayered overlay model is used which consequently follows the DM structure. For every DM concept the UM maintains a number of four different layers. The first layer stores navigation history, in other words, data that shows whether the user actually visited the corresponding web page. The second layer contains a value which represents the percentage of expert knowledge that the user has already learned through study. The third layer stores the user's previous knowledge of the domain. Consequently, by this data being stored in different layers, means that every layer can be independently updated. Therefore, user knowledge data from one layer does not overwrite identical information from another.

The second category of data (number of visits, study time and whether an activity is a goal or not) is stored in an additional layer since they too are domain dependent. The user goal

model is a combination of overlay and stereotype models since the user can select one of the tutor's predefined sets of goals according to a category (stereotype model) or manually define his/her goals (overlay model). In this category can also be included, some domain dependent data that is not used for adaptation, but rather to inform both the user and the instructor. The user's draft notes and Java program details in regard with an activity constitute this particular data. Draft notes are kept by users to enable them to keep useful information about each activity. The information stored according to the Java programs is (i) the program code in every compilation, (ii) the total time the user spent writing this program, (iii) the number of compilations, (iv) the time the user spent between two subsequent compilations, and (v) the output and execution of each compilation. This data is available only to instructors in order to study users' behaviors and programming skills.
Finally, the user's personal data is stored separately as it is static and domain independent.

6.4 Adaptive System functionality

Every educational system and consequently the AEHS aims to make not only the learning process but also the learning outcome more effective. ProPer improves the latter through adaptive and adaptable features. A thorough presentation of the system's functionality has been made in (Kazanidis & Satratzemi, 2009a). Here, we will briefly present the adaptive and intelligent features in regards to the type of user they are designated for. As a typical LMS, ProPer supports three types of users: students, instructors and administrators. As far as administrators are concerned, the system provides some basic LMS functions. In the next section are presented the students' and instructors' functionality.

6.4.1 Adaptive and intelligent functionality for students

ProPer provides a variety of adaptive and intelligent features in order to personalize learning and help the user learn faster and easier. These features are presented below.

- **Adaptive link annotation**. ProPer annotates the TOC's links appropriately so as to inform the user whether the corresponding activities: have already been visited, constitute user goals, seem to be known or are suggested for study. The current activity is also annotated accordingly. Furthermore, the user can instantly see his/her estimated score in an activity or folder by placing the mouse over the icon s/he is interested in. Additionally, annotation is applied to the course structure folders, showing whether the activities therein are considered as known and whether the folder's goals have been accomplished. This functionality prevents users from coming up against disorientation, narrative flow and distraction problems during their study.
- **Link hiding**. Instructors can use conditions in order to apply link hiding, disabling and removal. This function supports students' navigation by reducing both cognitive overload and the number of navigation steps needed for a certain goal and in addition can address the distraction problem. Nevertheless, in agreement with de Bra and Calvi (1998) we too discourage the use of link removal.
- **Direct guidance**. There is a button that guides users to the next appropriate activity for study according to their previous and current knowledge, goals and navigation history. This function facilitates novice learners in particular to pursue the best learning path for their study.

- **Adaptive text presentation**. ProPer provides adaptive text presentation using SCORM specifications and JavaScript. The course author may use the framework presented in (Kazanidis & Satratzemi, 2009b) in order to provide adaptivity according to learning style, knowledge level or other factors. This technology reduces content readiness and narrative flow.
- **Adaptation of modality** and **Multimedia adaptation** can both be applied by ProPer following the same framework as the adaptive text presentation. This technique assists authors to provide students with the appropriate media according to learning style, preferences, disabilities or technological infrastructure.
- P**rogress visualization**. ProPer displays in numerals as well as in bar graphs a visual image of the user score for the entire course which are associated with user goals. We strongly believe that this feature will motivate students to want to proceed with their learning.
- **Goal and previous knowledge orientation**. The system lets students, via the specific interface, to declare their previous knowledge and their educational goals in order to provide the appropriate adaptation.
- **Manual knowledge declaration**. In order to avoid faulty knowledge estimation by the UM, ProPer provides a mechanism to manually declare if an activity is considered known by students.
- Some other remarkable functions ProPer provides are the **Java Online Editor**, which can compile and execute Java programs recording user behavior during the development process, a **dynamic FAQ mechanism**, writing **draft notes** for every course activity and **analytical feedback** for users' progress.

6.4.2 Adaptive functionality for instructors

ProPer provides considerable functionality for instructors. It supports most of the usual LMS functionalities (course upload, course and user management etc.) as well as some features that promote adaptivity.

- **Permission for manual knowledge declaration**. As already mentioned, the system lets users declare if they consider an activity as known or not. However, sometimes (e.g. in assessment activities) instructors may want to prohibit users manually declaring their knowledge. For this reason ProPer asks authors to define the activities where the manual knowledge declaration is permitted.
- **Easy creation of group goals**. ProPer supports adaptation to user educational goals. However, sometimes users, especially novices, have problems defining their goals since they do not know exactly what they want to learn. For this reason, ProPer allows authors to define various sets of goals with a short description for whom the goal is designed in order to facilitate novice learners to choose one of the available groups.
- **Analytical statistics and feedback for both the users and the course.** Learning is a process that is liable to continual readjustment and improvement. Authors may export useful conclusions for the above statistics and feedback that will help them improve their courses.

6.5 Evaluation

The evaluation of ProPer is based on the procedures presented in (Samarakou, et al., 2006), which includes formative and summative evaluations. The overall aims of our evaluation were to examine the system's usefulness and how easy it is to use in accordance to the Technology Acceptance Model (TAM) (Davis, 1989), to identify any possible improvements in the learning outcome, as well as to detect the existence and the absence of the major problems often encountered in hypermedia courses.

For the formative evaluation the Tessmer Model (Tessmer, 1993) was adopted, which involves the following four phases: (i) Expert review, (ii) one-to-one evaluation, (iii) small group evaluation, and (iv) field trial. A revision of the system was carried out following the completion of each phase. Experts identify the system's navigation and the adaptive annotation as its strong points. However, it was suggested that better annotation symbol explanations and a mechanism for user feedback be provided. One-to-one and small group evaluations perceived some bugs in the system, which helped us to better organize the field trial that followed. The system was revised according to the proposals offered by the experts and the bugs were eliminated.

For the field trial 22 subjects were divided into two equal groups. Group A worked with ProPer and Group B with ADL SCORM Runtime Environment 1.3.3, which ProPer originated from. Both groups studied a course on Java and Object Oriented Programming. In brief, the results clearly showed that Group A participants not only proceeded faster but were also more goal oriented than those of Group B ($P=.001$). In addition, qualitative results indicate that all participants agree that the system greatly facilitated their learning and they the vast majority reported being pleased with using the system (90%). Following the formative evaluation the system and the interface were debugged and revised according to the evaluation results.

For the summative evaluation, we designed a new course that went beyond the formative evaluation course, which provides adaptation to the user learning style according to the Honey and Mumford (1992) learning style model. We also intentionally increased the number of subjects to 64, which were divided into four equal subgroups (ProPer vs SCORM RTE, adaptivity to learning styles vs no adaptivity). The evaluation process was similar to that of the formative field trial procedure. The results found that subjects who used ProPer gained significantly more knowledge ($p=.046$) than the others. However, there appears to be no significant difference among the four subgroups possibly due to the small number of subjects in each. Overall, the summative evaluation results confirmed the system's usefulness and usability that the formative evaluation had initially revealed.

In addition, an important finding in both the formative and summative evaluation results was that there was no evidence whatsoever of the major problems often found in hypermedia courses mentioned earlier.

7. ProPer SCORM Authoring Tool (ProPer SAT)

The problems that instructors without a technological background may have in course construction have already been mentioned. The matter becomes even more serious when adaptation is applied. Even when with the use of an educational standard, such as SCORM, issues of reusability, durability and interoperability can be addressed, instructors still have to spend a lot of valuable time in programming or constructing their courses, applying more or less complicated adaptation rules and strategies etc. ProPer was developed with simplicity in mind; we wanted it as simple as possible both for instructors and students. However, it does require the pre-existence of SCORM compliant courses that can be uploaded into the system. Instructors, thus, need to know not only SCORM specifications but also how to apply adaptation, which is not an easy job. For this reason, our aim is to implement a SCORM Authoring Tool, called ProPer SAT, which will enable authors with little or no prior knowledge of programming or SCORM specifications, to construct quick and easy adaptive and adaptable SCORM compliant courses.

So far, the design for ProPer SAT has been completed and we are now working on its development. The ProPer SAT design was based on three main axes: (i) to help instructors with little or no programming knowledge compose SCORM compliant courses; (ii) to provide course patterns for easy authoring of adaptive courses to user learning styles; and (iii) to enable easy reusability for both SCOs and content fragments. The prototype will support content writing, course structure construction and course packaging functionalities. Additionally, the system will enable instructors to easily create adaptive courses according to the Honey and Mumford model following the process proposed in (Kazanidis & Satratzemi, 2009b). However, in order to keep it as simple as absolutely possible, we had to leave functionalities, such as prerequisites and conditions out of the prototype provisions, since authors can use specialized free SCORM package editors, like Reload.

The ProPer SAT interface (Figure 2) keeps the main layout of ProPer. Thus, there is a functionality toolbar on the top of the screen, on the left is the course's TOC, and at the bottom of the screen is a place where further explanations and help about system functionalities are displayed. On the main frame of the screen, the user may define all the essential properties of the activity and write the appropriate educational content.

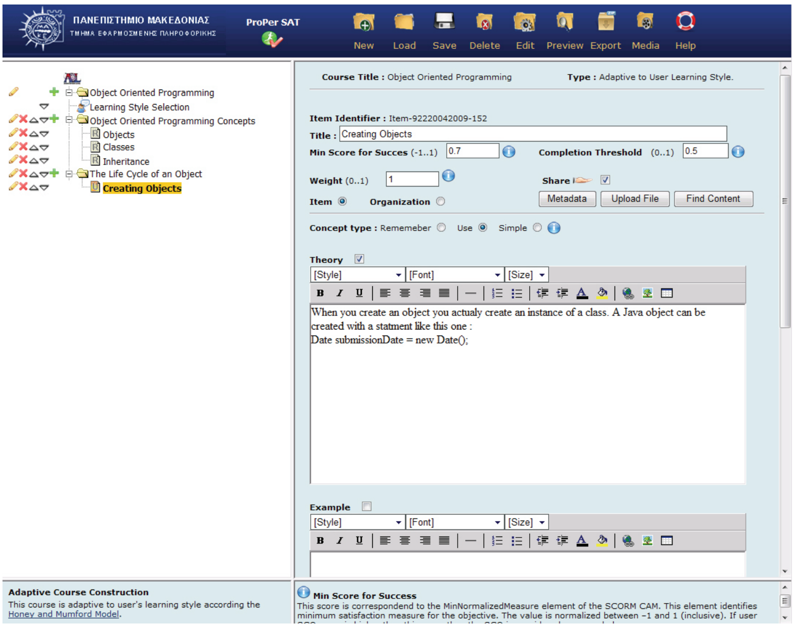

Fig. 2. ProPer SAT interface

For the implementation of both ProPer and ProPer SAT we use Apache Tomcat as a web and application server and MySQL 5 as a database server, while system's intelligece is written in Java Server Pages (JSP) and Java servlets. By adopting the same web technologies for both systems, they can function either complementarily or independently. Therefore, since ProPer SAT developed courses can be uploaded into every SCORM compliant LMS, this makes it a most useful tool for every instructor who wants to develop SCORM compliant and adaptive courses.

8. Conclusion

This work puts forward a proposal for distance education technology through the presentation of an integrated framework, based on three axes: adaptivity, educational standards and appropriate authoring tools. Our strong conviction is that knowledge over the Internet should be delivered through adaptive and interactive systems. Adaptivity will help students follow personalized instruction while interaction will make them active participants in the education process. This can address the major problems of web-based systems presented above. In addition, adaptivity to user learning style will certainly further improve the learning outcome. However, in order to develop a web-based course – even more so an adaptive course - a lot of effort is required. The adoption of a common educational standard, like SCORM, accepted by most of the web-based educational platforms allows the discovery, reusability, interoperability and durability of the educational content. It is of major significance if authors are able to reuse the material from quality courses and adapt it to their needs. This fact would enable distance educators to focus on the educational perspective of e-learning, instead of trying to solve design and system compatibility issues of the educational content. However, since authors without a firm background in technology may run into difficulties in constructing SCORM compliant and/or adaptive courses, the development of appropriate simple authoring tools is a crucial parameter of the e-learning process.

We have already implemented an adaptive to user preferences, knowledge and learning style SCORM compliant LMS (ProPer) and are in the process developing of a simple authoring tool (ProPer SAT) for such courses, which will also be appropriate for authors with little or no programming knowledge.

ProPer supports most of the adaptive technologies of Brusilovsky (2001) taxonomy. It personalizes instruction according to user knowledge, goals and navigational history, such as Interbook, KBS Hyperbook, Netcoach, INSPIRE, as well as the user learning style, like INSPIRE, AES-CS, CS383, iWeaver, EDUCE etc. It provides adaptive navigation as do the majority of AEHS as well as adaptive presentation of educational content, as do AHA!, INSPIRE, AES-CS and TANGOW. Similar to ELM-ART, AES-CS, INSPIRE ProPer uses a multilayered overlay model for user modelling. It can also include pre-tests and post-tests like ELM-ART and AES-CS and it allows students to explicitly define their knowledge on a course activity by using the appropriate buttons on the screen. This feature, which is not found in any other AEHS, we believe can improve the system's accuracy of user knowledge estimation. Furthermore, unlike other systems (e.g., Interbook, AES-CS) the system lets students change the UM during their study of the course. Besides being very competitive to similar AEHSs, ProPer's main strength over them lies in the combination of adaptivity with the adoption of the widely accepted learning standard SCORM. Thus, in contrast to the

majority of AEHSs, it is able to offer RAID courses. It must also be noted that while some other systems, like OPAL, VIBORA, AdeLE support either SCORM metadata or even SCORM compliant courses, they do not present the range of adaptivity that our system does. Moreover, with both systems (ProPer and ProPer SAT) we provide an integrated solution for the adaptive educational process supporting instructors at the course authoring phase much like AHA!, Interbook and MetaLinks. ProPer SAT, stands out for its simplicity through identical authoring tools, as well as supporting the construction of both adaptive and SCORM compliant courses. To the best of our knowledge up until now with the creation of ProPer SAT, AHA! was the only authoring tool for adaptive and SCORM compliant systems. Like AHA!, ProPer SAT enables the development of such courses yet goes one step further and supports adaptivity to user learning style. Furthermore, in contrast to the other authoring tools, ProPer SAT provides patterns for easy and guided course authoring.
Our immediate aim is to finalise the development of ProPer SAT and evaluate both its usability and usefulness. Next, the courses that will be constructed with the use of this authoring tool will form supplementary educational material for traditional face-to-face classroom lessons, whose results will be checked for confirmation with the evaluation outcomes. Finally, following the completion of ProPer SAT's first development phase, we aim to enhance it with new features and patterns for better and more effective adaptive course construction.

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21

Impact of Standardisation and Open Source Software in e-Learning

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1. Introduction

The trends towards open technology are forming a large stream in the field of e-learning (Iiyoshi & Kumar, 2008). These trends include open technology standardisation and open source software for e-learning as well as recent open courseware activities. The importance of e-learning technology standardisation has been well recognised since the early days of e-learning. Several organisations concerned with e-learning standards (Fallon & Brown, 2003), including the Aviation Industry CBT Committee (AICC), IMS Global Learning Consortium Inc., Advanced Distributed Learning Initiative (ADL), IEEE Learning Technology Standards Committee (LTSC), and ISO/IEC JTC1 SC36, were established from 1998 to 2000. Along with these standardisation activities, open source software e-learning platforms, such as Moodle and Sakai, have emerged.

These open trends have had a significant impact on not only e-learning and education but on the much broader information and communication technology (ICT) industry in general (Moody, 2001). These trends are not superficial phenomena but are essential driving forces for rapid progress and growth of the ICT field (Baldwin & Clark, 2000) including expamsion of the Internet and recent trends of so-called “Web2.0” (O'Reilly, 2005). The impact of technology standardisation, often described as “the power of modularity” (Baldwin & Clark, 2000), has resulted in the particularly rapid growth of the ICT industry over the past 50 years. A system consisting of modules connected by standardised interfaces can be quickly improved in terms of performance and functionality because the modules can be enhanced independently without loss of system consistency. Moreover, open standards facilitate market entry by module providers because the providers can develop product modules without the need for detailed knowledge of the whole system—they simply need knowledge of the standardised interface. This promotes competition among vendors, pushing them to pursue innovations leading to higher performance, and more cost-effective products. Another important driving force in the ICT industry is open source software. The open source software community has an embedded mechanism to produce high quality products quickly. This mechanism is completely different from that of the commercial software development approach (Raymond, 1997).

This chapter first discusses the general mechanism by which technology standardisation and open source software drive the growth of the ICT industry. It then describes open trends in the e-learning field emphasising Japanese activities promoting e-learning standards. It especially concentrates on activities for disseminating the Sharable Content Reference Object Model (SCORM) specifications in terms of support for system development and conformance programs. Last it discusses the future role of open technology in the field of e-learning.

2. Impact of Technology Standardisation and Open Source Software on ICT Industry

2.1 Technology Standardisation as Driving Force of Industry

A technology standard usually defines the interface between two entities (or "modules") (Nakabayashi, 2004). It specifies the functions one entity provides to the other. For example, in the case of a videotape and video deck, a standard defines the shape and size of the videotape cassette, the format of the video signal recorded on the tape, and the tape driving speed. The videotape records the video signal written by the video deck. Any combination of videotape and video deck compliant with the standard should work together. Thus, users can choose the videotape they most prefer on the basis of price, recording length, image quality, etc. without having to worry about whether the tape they select will work with the video deck they own.

This user freedom to choose products from various suppliers means that suppliers face tough competition so they must continuously improve their products' cost effectiveness and quality. Even though competition is a typical part of industry, it should be noted that standardisation accelerates competition. This is because each entity or module connected by a well-defined standard or interface can evolve independently while system functionality as a whole is retained. Vendors can develop these modules merely by considering the open interface defined by the standard and not be concerned about the whole system. If there are hidden dependencies between modules and the rest of the system, development is not easy. An open standard encourages vendors to enter the market, which increases competition. This results in products that are more cost effective and that perform better. For example, the DOS/V personal computer has a well-defined open interface through which anyone can replace or add memory, hard-disk, and display modules. Numerous hardware vendors have entered the personal computer market by taking advantage of this open interface. This competition produces today's high-performance, low-cost, and ever-evolving personal computers.

It is important to note that the architecture into which the modules are plugged and the interface the architecture provides must be very carefully designed to achieve this competitive environment (Baldwin & Clark, 2000). The functionality of the modules may otherwise be restricted or the extensibility of the system may be limited. While it is relatively expensive and time consuming to design the architecture, designing modules on top of a good architecture is quite cost effective. In other words, designing a first-class architecture is the key to success and should be a top priority.

2.2 Open Source Software for High-Quality Products

Another important driving force in the rapid growth of ICT is "open source software". Since the early days of the Internet, its technical progress has been supported by the widely shared concept of "rough consensus and running code", meaning that defined specifications or standards have real values by making them open to the public with the computer programs that actually implement these specifications or standards demonstrating that they are workable in practice. One of the recent typical examples is the World-Wide Web (WWW), consisting of specifications such as HTTP, URL, and HTML. The WWW rapidly spread and continues to grow, through the early stage initiative of the National Center for Supercomputing Applications (NCSA)-developed Mosaic browser, which implemented practically WWW's concept with HTTP, URL, and HTML, and was made open to the public with its source program code free of charge. Recently, open source software has become an indispensable infrastructure for the ICT industry. The quality and performance of some open source software, such as Linux operating system or Apache WWW server, far exceed that of commercial proprietary software having same functionality (Moody, 2001).

Why is it possible for software developed by volunteers to achieve higher quality and performance than commercial software? The tremendously high software productivity can be achieved by the software development process in the open source software community (Raymond, 1997; Raymond, 1998; Raymond, 1999). First, the members of the open source software community work as volunteers with the primary motivation of "winning the admiration of the other participants by solving technically interesting problems with solutions as smart as possible". As pointed out (Raymond, 1998), this kind of motivation, corresponding to the esteem needs in Abraham Maslow's well-known "hierarchy of values" model of human motivation (Maslow, 1970), may result in software development of extremely high quality.

Second, because the members of the community work simultaneously but independently to solve a problem, it is highly probable that a high-quality solution will be found quickly. This mechanism of open source software development is completely opposite to the common traditional view of the conventional software development approach, which claims that increase of software engineers involved in a software development project increases the probability of the failure of the project due to the increase of communication overhead between the engineers (Brooks 1975). A similar idea to this optimisation of product quality by simultaneous problem solving can be found in the mechanism of product value improvement through the competitive and parallel development of product modules enabled by the standards (Baldwin & Clark, 2000). It is also worth pointing out that this concept is closely related to the collective knowledge production or collective intelligence of Web 2.0 (O'Reilly, 2005). However, it should also be noted that the target system must have highly modular architecture, which enables this parallel optimisation or problem solving.

3. e-Learning Activities in Japan related to Open Technology

As described in the previous section, open technology standards and open source software play essential roles in the growth of the ICT industry. Neither is independent; they are like the two sides of a coin. They are also not superficial but are essential driving mechanisms for rapid progress and growth of the ICT industry. The importance of open technology standards and open source software is well recognised in the field of e-learning which is one of the application areas of ICT. Several organisations concerned with e-learning standards, including the AICC, IMS, ADL, IEEE LTSC, and ISO/IEC JTC1 SC36, have cooperated to develop those standards. The importance of open technology has also been recognised in Japan from the early stages of the introduction of e-learning. Considerable efforts have been made by the government and corporate sector since 2000 to promote e-learning standards especially SCORM (Advanced Distributed Learning Initiative, 2001; Advanced Distributed Learning Initiative, 2009), by means of open source software and an open community of engineers. These promotion activities include

- system module development such as the SCORM RTE module, SCORM 2004 sequencing engine, and SCORM extension for mobile learning,
- seminars and publications for SCORM content and system development,
- the SCORM assessor program, which certifies skilled SCORM engineers as assessors capable of conducting content certification, and
- cooperation with other Asian countries to share experience and knowledge.

These activities have been supported mainly by two organisations that have conducted e-learning promotion in Japan. One is the Advanced Learning Infrastructure Consortium (ALIC), which is supported by the Ministry of Economy, Trade, and Industry of Japan. The other is the e-Learning Consortium Japan (eLC) which is a non-profit organisation consisting of about 100 e-learning companies. These two organisations cooperated to promote e-learning in Japan in terms of technology, human resources, and user benefits. They took the initiative in the SCORM promotion activities described in the following sections.

3.1 System Module Development

Several system modules have been developed based on SCORM 1.2 (Advanced Distributed Learning Initiative, 2001) and SCORM 2004 (Advanced Distributed Learning Initiative, 2009) specifications. Most of them are available as open source software. They were developed to minimise system development costs and interoperability problems by providing well-tested reference modules that can be integrated into commercial systems. Some of these developments are described in the following subsections.

3.1.1 Interface Modules for SCORM 1.2

Several interface modules were developed in 2001 to support implementation of a learning management system (LMS), authoring tool, and content compliant with both SCORM 1.2 and the Aviation Industry CBT Committee (AICC) Computer Managed Instruction (CMI) specifications. One is a course-structure-handling module intended for integration into a courseware-authoring tool. This module can work with both manifest files for SCORM and CSF files for AICC CMI. A pair of modules, one for servers and another for browsers, has been developed to implement the API adapter of a SCORM-compliant LMS. The HACP protocol has been used for communication between the server-side and browser-side modules so that they can handle AICC CMI specifications as well. Another module has been provided to help content developers implement sharable content objects (SCOs) containing typical test questions.

3.1.2 SCORM 2004 Sequencing Engine

Development of a sequencing engine was started in 2002 on the basis of an early version of the IMS simple sequencing specifications and the SCORM 1.3 specifications. The latest version of the sequencing engine was designed on the basis of SCORM 2004 2nd Edition. The updating process for the latest edition is underway.

A block diagram of the sequencing engine is shown in Figure 1, illustrating a full-set implementation of the SCORM 2004 specifications. The three functional modules are shown in bold boxes. The sequencing module, the primary part of the sequencing engine, executes the SCORM 2004 sequencing specifications, which are implemented as a Java class. The run-time environment (RTE) module, which is on the server, and the application programming interface (API) module, which is on the browser, together implement the SCORM 2004 RTE and navigation specifications. They communicate using HTTP. The API module provides the API adapter functionality defined in the SCORM RTE specifications. This module is invoked every time an SCO is launched, and it communicates with the RTE module during SCO execution. The RTE module is implemented as a Java object that is instantiated for each leaf activity. The RTE module object updates and stores runtime data elements exchanged with the associated SCO.

The sequencing engine has several utility functions. One is a recording function for sequencing trace logs that helps content developers debug course content with complicated sequencing rules. Another is a GUI customisation function that enables LMS and content vendors to customise the GUI of the sequencing engine by simply modifying an external definition file.

The sequencing engine has been available to the public as open source software since 2004, and more than 1500 copies have been distributed. The engine is used in several commercial LMS and e-learning services.

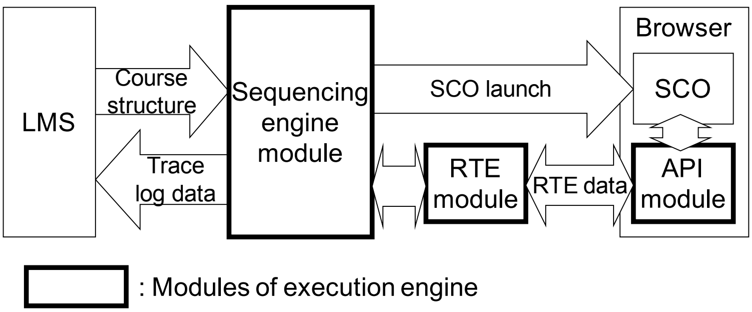

Fig. 1. SCORM 2004 Sequencing Engine

3.1.3 Mobile Extension of SCORM 2004 Engine

The growing use of personal mobile devices and the spread of wireless networks are making mobile learning more popular. Among the various personal mobile devices, mobile phones are broadly accepted as easy-to-use mobile terminals capable of both voice and Internet communication.

Development of a mobile learning environment in Japan started in 2005 (Nakabayashi et al., 2007). In this environment, both mobile phones and personal computers can be used as terminal devices. There were three design goals.

(1) To provide a standards-based mobile learning infrastructure independent of device characteristics (which often differ from mobile phone to mobile phone and from carrier to carrier) using existing e-learning standards.

(2) To enable offline learning using mobile phones.

(3) To implement a learner adaptation function by which learning materials and a learner’s status are shared between mobile phones and personal computers and the learner’s status is reflected in the next learning activity in either environment.

These goals were achieved by developing a system consisting of the SCORM 2004 sequencing engine described in 3.1.2, adding content browsers to the mobile phones, and placing a protocol transformation server between the engine and mobile phones, as shown in Figure 2. The content browsers can display downloaded content offline. The results of learning on a browser are sent to the protocol transformation server, which modifies the data format so that it is compliant with SCORM 2004 learner tracking information. The learning material format of SCORM 2004 was partly extended to support mobile learning. The communication protocol specifications among the mobile phones, protocol transformation server, and SCORM 2004 engine were newly designed. The developed system is currently available to the public as open source software.

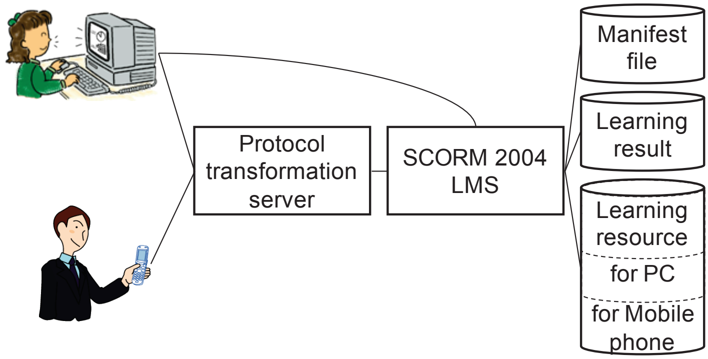

Fig. 2. SCORM 2004 Mobile Extension System

3.2 Seminars and Publications

The SCORM specifications are disseminated to the e-learning community through periodic seminars for technical and lay people. The eLC has organised two- or three-day conferences twice a year since 2001. At each conference, a full-day track is always allocated for e-learning standardisation. The seminars for lay people are designed to emphasise the benefits of introducing e-learning standards and their impact on the e-learning business model. For technical people, the seminars deal with various types of information, e.g., briefings on emerging standards, technical details, new tools, sample implementations, and use cases.

The SCORM specifications are also disseminated through publications, including translations of technical and tutorial documents. Several technical and tutorial documents have been translated into Japanese, including SCORM 1.2, SCORM 1.3 working draft 1.0, and IMS Simple Sequencing in 2002, 2003, and 2004. The “SCORM Best Practices Guide for Content Developers” from the Learning System Architecture Lab. was translated in 2004. SCORM 2004 3rd Edition is currently being translated.

Tutorial documents dealing with technical details, use cases, and interoperability issues have also been disseminated. A set of tutorial documents dealing with SCORM 1.2 was published in 2004 and has been used for the SCORM assessor program, which is described below. This set includes a document dealing with interoperability issues and solutions gleaned from periodic surveys of both system and content vendors about interoperability problems. The SCORM 2004 tutorial, including technical digest, content design, and sample content, was issued in 2006.

3.3 Conformance Programs

Conformance programs dealing with learning management systems and content have been conducted since 2003. After each conformance test, there are periodic follow-up activities in which LMS vendors and content vendors come together to check whether their products are compatible. This promotes the sharing of experiences and knowledge of interoperability issues in the e-learning community.

A unique conformance activity in Japan is the SCORM assessor program. The original motivation for this program was to improve the technical skills of content developers. Developers come from various fields, such as multimedia design and instructional design, so they are not necessarily sufficiently skilled to deal with interoperability issues related to the SCORM specifications. Thus, in this program, skilled SCORM engineers, rather than products, are certified. As certified assessors, they can conduct the SCORM 1.2 content conformance test. The candidates attend a two-day lecture and undergo the certification test. The required skill set is defined in Table 1.

Knowledge about assessor program	
	Program purpose
	Assessor responsibilities and authority
	Content conformance procedure
	Content registration procedure
	Interoperability problem management
	Assessor community purpose
Knowledge about SCORM specifications	
	General
	Content aggregation
	Run-time environment
	Conformance requirements
Knowledge about SCORM applications	
	Content development
	Content test
	Typical interoperability issues and solutions
Knowledge about related fields	
	Industrial product standardisation
	e-Learning product standardisation
	Communication protocols
	Client-side programming
	Server-side programming
	Basic computer knowledge

Table 1. SCORM Assessor Skill Set

The program started in 2004 with 16 assessors. There were 106, as of February 2008 (Figure 3), belonging to the SCORM Assessor Community, in which they can exchange information about commercial learning management systems and interoperability issues and obtain the latest information on specifications. The recent ongoing activities include localisation of SCORM-related tools for a Japanese language environment, tutorial and technical document creation, and publication of interoperability issues of SCORM 2004 gathered by the Assessor Community members.

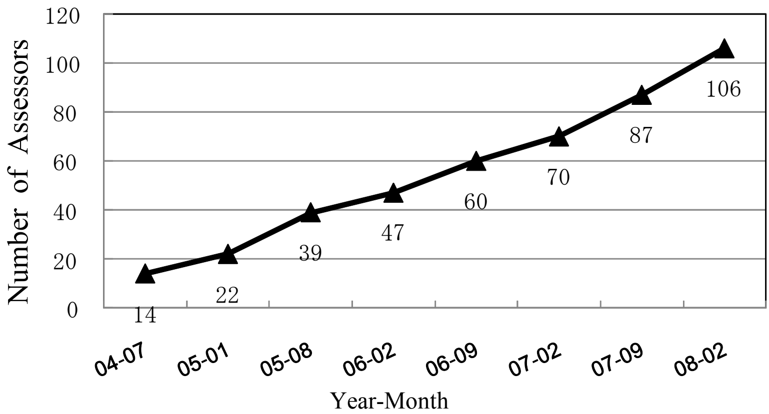

Fig. 3. Increase of SCORM Assessors

3.4 Asian Country Cooperation

Several cooperative activities took place involving member countries of the Asia E-learning Network from 2002 to 2005. They included the interoperability test program called AEN LMS & Contents Interoperability Validation Experiment (ALIVE), which was conducted three times. In this experiment, participants brought their SCORM-based LMS and content for checking of interoperability with those of the other participants.

4. Future Direction

This section discusses the future impact of open technology on e-learning in terms of triggering a discontinuous change of industry structure and promotion of diverse learning environments.

4.1 Triggering Discontinuous Change of Industry Structure

Standardisation and open source software can significantly impact the structure of the existing industry. A phenomenon often observed in business called "disruptive innovation", which disrupts a "sustaining innovation" (Christensen, 1997), is shown in Figure 4. This indicates the situation in which the sustaining innovation, which sufficiently (or superfluously) fulfils customer needs by consentingly providing high quality products, is made obsolete by the disruptive innovation, which provides low-quality but drastically cost-effective products. The disruptive innovation often appears not from the same business segment as the sustaining innovation but from a completely different business segment.

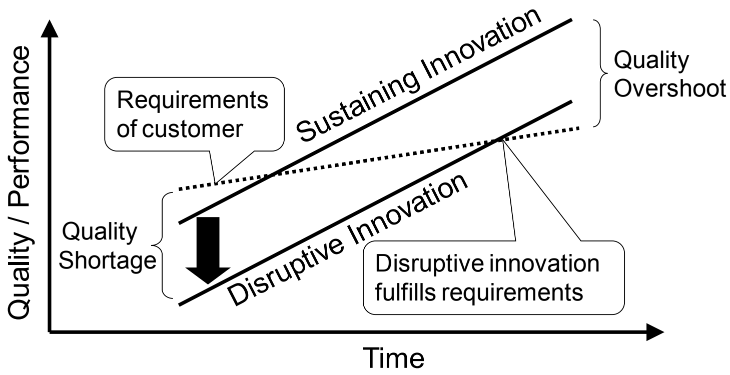

Fig. 4. The Innovator's Dilemma (Christensen, 1997)

An example of this kind of situation is the relation between conventional telephones (sustaining innovation) and IP phones (disruptive innovation). Conventional telephone technology has achieved sufficient (or superfluous) service quality meeting the customer requirements. Very high quality voice transmission is available not only for domestic but also for international calls. One can connect to any party in the world by simply dialling the appropriate number. These high quality services are achieved due to the continuous improvement and optimisation of technologies for telephone exchanges, transmission lines, voice encoding, and so on. However, a disruptive innovation in its early stages appears as a robust, cheap, but low-quality, product compared to the sustaining innovation. For example, in the early days of the Internet, no one imagined that it might one day replace conventional telephones because it was slow and unreliable. It was good for only e-mail and file transfer. The Internet technology was designed based on a "best-effort" concept i.e., it was intended to support minimal data exchange function between computers connected through very bad quality transmission lines causing frequent packet loss.

However, in contrast to the conventional telephone system, which is based on the all-in-one technology designed by telecom companies, the Internet system is based on the open standards and open source software. In this sense, there is an embedded mechanism in the Internet architecture that very easily achieves simultaneous drastic cost reduction and quality improvement. Thus, improvements in technology will make Internet telephone quality satisfactory enough for customers despite the technology originally not being designed for voice communication. Once this happens, the disruptive innovation's cost-effectiveness will give it a significant advantage over the sustaining innovation, and conventional telephones will made obsolete by IP phones.

There are two important issues regarding this phenomenon.

(1) It is often very difficult for a company providing a sustaining innovation to introduce a disruptive innovation, as a disruptive innovation is characterised by low cost and low performance, which does not match the company's business structure. Their current customers require a high-performance product and are willing to pay a higher price for

it. This forces the company to continue improving the current technology and prevents them from introducing a disruptive innovation even if they know that one exists.

(2) Technology based on standard and/or open source software often becomes a disruptive innovation. A product based on standard and/or open source software can potentially become cost effective and then quickly evolve as described above. In the early stages, however, such products tend to have poor performance and low quality compared to the all-in-one products provided by the sustaining innovation because the standard- and/or open-source-based technology is not mature. Once their quality reaches the requirements of the customer, they will make the all-in-one products obsolete.

These considerations lead to interesting questions, such as, "Can e-learning disrupt traditional learning?" and "Can standards-based e-learning disrupt non-standards-based e-learning?" In the company training field, e-learning or technology-based learning makes it possible to provide training for a large number of employees in a very short time which was impossible in traditional face-to-face training. e-Learning also makes it possible to provide individually customised or personalised learning for each learner, which was also difficult in traditional face-to-face training.

In the higher education field, numerous good e-learning practices also appear. Of the various success cases, the Open University in United Kingdom will be discussed here. The UK Open University was established in 1971 as a university dedicated to distance education aiming to provide higher education to greater number of people by exploiting technologies.

The Open University was founded on the belief that communications technology could bring high quality degree-level learning to people who had not had the opportunity to attend campus universities. (http://www.open.ac.uk/about/ou/p3.shtml)

It is noteworthy that, despite its dedication to distance education, the Open University achieves top-level ranking among UK's conventional universities such as Oxford and Cambridge. For example, the teaching quality of the Open University is ranked in the top five of UK universities (The Open University News Release, PR4890). According to a UK national student survey in 2005, the Open University achieves the top ranking in terms of student satisfaction (The Open University News Release, PR5064).

Here, let us consider that the Open University case can be regarded as a disruptive innovation against conventional higher education. The comparison of "Traditional universities (sustaining innovation) vs. the Open University (disruptive innovation)" as well as "Telephone (sustaining innovation) vs. IP phone (disruptive innovation)" is shown in Table 2. As discussed above, the IP phone is based on the best-effort IP technology, which was originally designed for data communication not voice communication. In addition, IP technology is general purpose standardised technology while traditional telephone technology is virtually integrated closed technology specialised for voice communication.

Now let us think about "Traditional universities vs. the Open University". The Open University was established to provide education to greater number of people, which is a different target from that of the conventional universities accepting only high-level students. The Open University aims to provide education by exploiting technologies, which is a different means from that of the conventional universities, which usually use face to face communication. Thus, the Open University started its business for a different target by different means from that of conventional universities, though they are in the same higher education field. In terms of its educational methodology, the Open University organises

course development teams to develop technology-based learning courses with standardised methodology. A typical development team consists of members such as a media producer, graphics designer, and software engineer in addition to the subject matter expert.
Thus, there are remarkable similarities between the IP phone and the Open University as disruptive innovations. Both originally have different targets and different means from those of the sustaining innovations. Both then improve their quality by standardised technology and become disruptive innovations triggering discontinuous change in a certain field.

Field	Innovation	Original Target	Means (Technology)	Standardisation of Technology
Tele-communication	Sustaining: Telephone	Voice communication	Proprietary technology	Virtual integration, Special purpose
	Disruptive: IP phone	Data communication	IP technology, Best effort	General purpose, Open standards, Open source
Higher Education	Sustaining: conventional University	High level students	Face to face	Non-standardised teaching methodology different from teacher to teacher
	Disruptive: Open University	Students not able to enter conventional universities for some reason	Communication technology	Standardised course development methodology by development team

Table 2. Comparison of Innovations in Telecommunication and Higher Education fields

4.2 Promotion of Diverse Learning Environments

As discussed, open technology is indispensable for the innovation and dissemination of technology by facilitating competition and collaboration in the ICT field. One of the recent technology trends is Web 2.0 (O'Reilly, 2005), which has been strongly affected by open technology. Web 2.0 does not correspond to specific technologies or activities but to a very comprehensive concept. The common idea underlying Web 2.0 activities is not simply use the ICT network for traditional business models, but to create novel value-added activity models themselves by introducing communication frameworks that were physically or economically impossible in the past without the existence of the ICT network. Google's advertisement or Amazon's market place business models do not simply use the ICT network for a traditional mass-communication advertisement model or mass-production sales model. They fully exploit the low-cost ICT network to create additional value by facilitating the linkage between diverse seeds and the needs of individual people in the community.

From the view point of education, noteworthy aspects of Web 2.0 are the change from one-way communication to bidirectional communication, adaptation to individuals' diverse needs, and utilisation of collective intelligence. The traditional communication model of Web 1.0 was a mass-communication one in which limited information providers send information from their Web site to massive numbers of information consumers. In contrast to this model, Web 2.0 provides a bidirectional communication model in which users actively participate to community through blogs or SNSs. Another unique characteristic of Web 2.0 is the adaptation to individuals' diverse needs, often recognised as "long tail". Typical examples of this characteristic include provision of diverse communities through blogs or SNSs and Amazon's market place model. In both cases, provision of such individualised communication fields was physically or economically impossible before the introduction of the low-cost ICT network. Such provision facilitates the mechanism of collective intelligence in which participants actively provide their information or knowledge to others in accordance with their own interests. Good examples of collective intelligence are Wikipedia or customer reviews on Amazon. This mechanism of collective intelligence has similarities to that found in open source community described in 2.2.

These characteristics of Web 2.0 might be regarded as similar features found in the recent "learner-centric" approach (National Research Council Committee on Learning Research and Educational Practice, 2000) of education or e-learning. e-Learning in its early days was mainly focused on one-way information transmission that is common to teaching in large classrooms or broadcast-type distance education. However, recent e-learning focuses on personalised learning by taking advantage of the bidirectional communication capability of the Internet. One of the background factors of this trend is the recognition that supporting learners' individual needs is essential for keeping them motivated (Simpson, 2002). Another background factor is that, to provide a much richer and higher quality learning experience, it is important to introduce activities based on the constructivism learning theory (National Research Council Committee on Learning Research and Educational Practice, 2000), such as collaborative learning in a small learner group. In contrast to the traditional view of learning —that "the knowledge is transferred from teacher to learner in one direction", — the recent view stresses that the knowledge is constructed by the learner who participates to interact with the learning field. From these perspectives, a new direction of the learning environment, sharing its basic concept with Web 2.0, would become clear, in which learners continue to learn while contributing to the construction of collective intelligence by providing their own knowledge to communities that meets their individual diverse interests and needs.

5. Conclusion

As discussed above, open technology in the ICT field has become increasingly important in this decade. It will have similar impacts for the e-learning field in the next decade. Although overlooking whole aspects of these ongoing trends is difficult, let us look at some issues that will become relevant to consider the future direction of open technology in e-learning.

5.1 Aim of Open Technology

When one thinks about standardisation or open technology, consideration of the purpose of the technology should not be forgotten. Technology standardisation is often an "enabler" for other application technologies, and standardisation itself has no specific purpose. This general purpose characteristic of standardised technology enables it to be applied to various fields, as seen in the "The Innovator's Dilemma" (Christensen, 1997), or allows unlimited diversity, as seen in Web 2.0. However, because it has no specific purpose, evaluating the real potential value of the technology at the research and development stage is very difficult. In the educational field, maintaining multiple viewpoints is also important. This means that, on the one hand, pursuing general-purpose aspects of the technology is necessary, while on the other hand, one should not forget that the final goal is to provide high quality education meeting learner needs in an efficient manner.

5.2 Importance of Infrastructure Architecture

A well-designed system architecture is vital to enable autonomous and distributed evolution of system modules observed in technology standardisation. The importance of the platform architecture is the same in enabling simultaneous solution search in the open source software community. It is impossible to make this happen if the architecture is poorly designed so that the change of one system module may trigger a change of other modules or complete knowledge of the whole system is needed to modify only a small part. Thus, establishing a well-designed platform is a very important issue, but it is sometimes misunderstood or not recognised. The importance of infrastructure architecture should be repeatedly stressed.

5.3 Target Area, Motivation and Quality of Open Source Software

The field in which the volunteer-based open source software development model is applicable should be carefully considered. Currently, the most successful fields of open source software are those of operating system, database, web server, and so on. They are platform software or middle ware for which developers and users overlap. There are many demands for software for these fields because they are commonly used in almost all ICT systems. Thus, these fields of open source software easily attract many volunteers highly motivated for development. In contrast, in the ICT application fields such as education, developers and users are usually different, and the number of users is relatively small compared to that of platform software. If the number of participating developers is too small to establish a community, there are few chances to create high quality product because the essential mechanisms of an open source software community, such as simultaneous solution search, does not work. Recently many educational open source software projects have emerged that are promoted by not individual volunteers but governmental organisations or corporate sectors. A future issue is to construct a success model of such open source software development communities, taking into account the source of the participants' motivation and product quality.

As discussed in this chapter, technology standardisation and open source software have essential impacts on the growth of the e-learning field. It should be noted that open technology has strong influences on not only technical but pedagogical aspects of e-learning. One should realise that open technology is not only a support tool for conventional style of education but an enabler for a novel value-added way of learning.

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22

Application of E-Learning Standardization Technology

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1. E-Learning Standards in China

1.1 Standard Organizations

With its rapid development, e-learning had a lot of problems, such as the resource formats not unified, lacks of unified interaction interface between learning platforms, interoperability between platforms not realized and so on. In order to solve these problems, a number of international organizations, as well as companies, are dedicated to the research of standardization. The most important organization include IEEE LTSC（Learning Technology Standards Committee）, IMS（IMS Global Learning Consortium）of ISO and organization of National Educational Technology Standards for Students from different countries.

China E-Learning Technology Standardization Committee (CELTSC), a subcommittee under Standardization Administration of the People's Republic of China (SAC), is the research institute and management organization for standards development, as well as associated API and application system models.

Moreover, CELTSC, as the counterpart of ISO/IEC JTC1 SC36 in China, plays an important role in the international standards development and promotes the application and localization of those standards.

1. 2 CELTS Standards

China had been basically formed a relatively complete standards system with the development over the past few years. The research work of standards can be divided into five categories: fundamental guidance, learning resources, learners, learning environment and education management. Some of these five categories are adapted or brought from IMS or IEEE, such as Architecture and Reference standard mainly refers to LTSA from IEEE. We can solve part of the problem of unification of platforms and resources through these five categories of standards.

Among these standards, “Architecture and Reference” is the most basic one. It provides the platform framework of e-learning, which describes the design and components of high-level system.

The most widely used standards are Learning Object Metadata (LOM), Content Packaging（CP）and Learner Model. LOM is used to describe the information of learning object, aiming to help learners, educators or automated software to search, estimate, acquire and use the learning object. And learning object can exchange and use cross platforms through meta-data model defined by LOM.
In CP standard, a data structure is defined to exchange leaning contents, in order to exchange and use learning contents in different creation tools, leaning management systems and process environments.
Learner model standard mainly formulate the semantics and syntax of learners information. Through learners data model, content management and learning managment system, leaner model can provide a more personalized and effective learning experience. Learners database created by this standard could be used in their whole education, learning experience and career path, and can be transplanted among different platforms.
Culture, belief and concept of a nation varies from nation to nation, which should be considered when develop e-learning service. And in China, some other typical factors should be noticed: political factors, individual file information, education background and management, and etc.
We make some rules based on local factors when we develop learners' model standards: we use residents' ID card to mark their identities. When we use vocabulary to describe learners' information during the LOM standard making process, we make vocabulary types based on domestic situation in China, such as "learning resource type" components vary widely from IEEE's LOM standard.

2. The Design of Learning System Architecture

Standard-setting is only a part of the standardization work. The promotion of these standards is more important. The application of standards is based on an open, standardized learning platform. We design a learning system structure based on "System Architecture "standard and " Learning system architecture and service interface " standard.

2.1 Concept Model

"System Architecture" standard provides high-level system structure of e-learning platform. This standard is based on LTSA of IEEE, as shown in Figure 1.

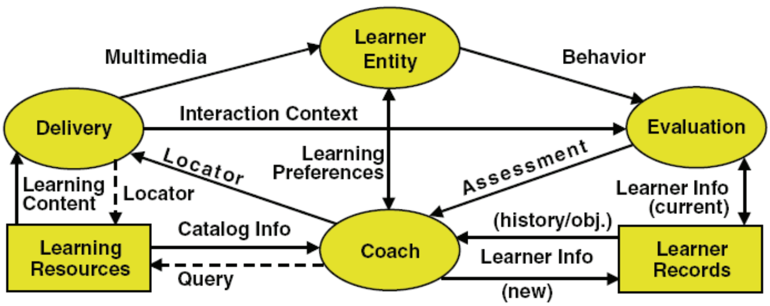

Fig. 1. Learning Technology Systems Architecture from IEEE

In Figure 1, the system components are divided into three categories, namely:

1. (Processes): Learner Entity, Evaluation, Coach, Delivery
2. (Stores): Learner Records, Learning Resources
3. (Flows): Learning Parameters, Behaviour, Interaction Context, Learner Information, Assessment, Query, Catalog Information, Locator, Learning Content, Multimedia.

This architecture, describing the design and components of high-level architecture, is education irrelevant, content irrelevant, culture irrelevant and platform irrelevant. We have adopted architecture model as concept model of learning system. Based on this concept model, we have designed abstract framework and core interface.

2.2 Abstract framework

Based on the System Architecture standard, Learning system architecture and service interface standard design the architecture and service interface of learning system, as shown in Figure 2.

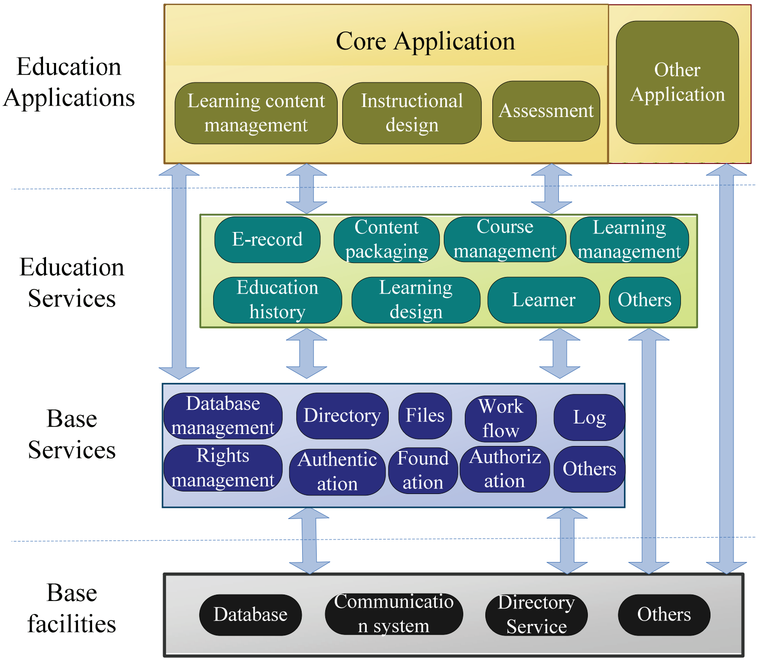

Fig. 2. Digital education leaning platform system layered architecture

a) Infrastructure layer: provide end-to-end transaction processing and communications services for education service and infrastructure service, including a variety of hardware and software, such as database management system, operating system, directory servers, application servers, network environment, etc.

b) Basic service layer: is integrated service could be used education service rather than digital educational platform. Basic service could use other basic service, so one service could be used in any other services.

c) education service layer: provide core education application with integrated services necessary for digital educational platforms. A core education could use one or more basic services, which might use infratructure functions cross layers. Distributed education services communicate through infrastructure.

d) education application layer: this layer is some core applications and other applications, which are used in proper education service and presented to users, such as learning content management system, evaluation system. Appication could use apply one or more education service, and could use infrastructure service cross layer when neccesary. As to other applications, which could use necessary services in infrastructure, but the composition of system should be hidden to the users anytime.

UML diagram shows the relation among these layers:

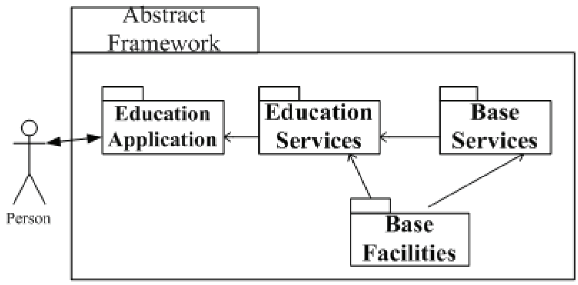

Fig. 3. UML graph

From the above layer structure, we find that this learning platform system reflects the hierarchical system, as well as service-oriented design principles. And the third education service layer supports the present e-learning recource standard, such as content packaging, learning design services, they all support CELTS and IMS standards.
One of the system architecture design principles is adopting abstract services to describe proper e-learning system function. One service is used to complete one functional requirement, that is, package a logical unit, service is the basic unit constructing educational application software. After the service is hidden in the service access point (ASP), and could only be accessed through SAP, API could be one way of accessing SAP, such as Java API. The services of e-learning architecture could be described as followings:

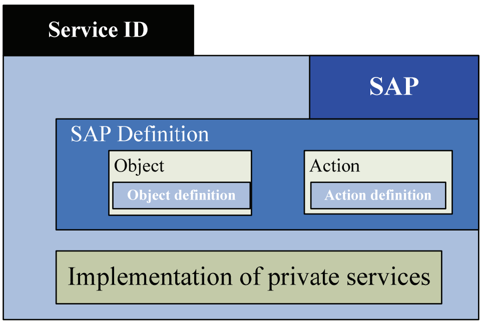

Fig. 4. abstract service

Service has clear defined SAP, and each service has and only has one SAP. SAP in accordance with its composition of behavior and object should be defined. SAP include one or more object, and each object usually has more than one operation. This means that each service (including education service and public service) has to use this abstract service to define. In most cases, services will interact with each other, such as an education service uses public service. This interactive service is that service calls the SAP of required service.

2.3 Core Interface

In order to facilitate the reuse of services, we design standard interfaces for the core services.

a) Education services layer

For an education system, education service layers have educational standard support, that is, this layer each service is generally required to follow corresponding standards. Such as content package service needs to follow the content package standard. For the educational service layer, it should include the followings:

1. Content package service: in view of standard content package, this service manages all the learning content with unified format, including delivery, reading, analysis, packaging and other functions.
2. Course management services: responsible for the management of curriculum-related content, including the creation of curricula, courses storage, query, display, and etc., as well as import and export of courses.
3. Members management service: provide members management-relevant function. In abroad sense, an individual member or a group can be called as member, and a group could be member of another group. And member information describes member role.
4. Packet Services: mainly related to the system packet management function. This service could be used to group members, and also could be used to group learning resources. So grouping is managed as a independent service rather than as a special case of member, which could give grouping behavior more space during the learning process.
5. Testing service: in view of a certain learning objectives, measure learners' learning results, which including generation, storage, retrieval of test questions, as well as organization and evaluation of test.
6. Instruction design service: provide generation, display, analysis and retrieval of instruction design services. Instruction design service is based on corresponding norms, and support the norms.
7. Sequencing service: encapsulate operation and data model which is related with sequencing activity. CELTS, IMS and SCORM all have the sequencing standard, to meet the different standards' need, sequencing service should provide sequencing rule model, sequencing activity, sequencing engine and sequencing analyze interfaces.

b) Basic service layer

Basic service layer need to provide functions commonly required by education service layer. The design of these services is based on education service layer, but the result of the design is not only limited to support of education service. The basic service layer includes:

1. Certification service: this service is used to obtain certification information from users, confirm the authenticity of users' identity, and allow users to log on the system.

Other services or application could check or operate the status of users' certification, ignoring the details of certification process. This service is built on all kinds of certification establishment. Many agencies have already had or are trying to build their own center certification. Technically speaking, we have examples like Kerberos, X.509, and single-point embedding technology based on cookie, such as webISO.

2. Authorization service: this service provides service of building and querying authorization information for other services. Authorization information mainly provides a user the authorized information.
3. File operation service: this service provides operation interface for platform-independent file access.
4. Database service: this service provides database related access interface.
5. XML service: this service provides XML operation related interface, including XML analysis function. Since most semantic information of normative text can be bound to XML, XML service could further make XML mapping as object directly used by developers.
6. Digital rights management service: this service provides model related to authorization information used by learning object. And it also provides management function, including provision, control, tracking and management of copyright information.
7. Log service: this service provide log function, being used to track and record relevant information and events of other services. System maintenance and monitoring might need to use log. And log could also be used for performance analysis, data collection and statistics.

Based on the service layer relation and logic function analysis, we develope a complete set of interfaces for each service for the "core interface", and develope "Learning system architecture and service interface" standard, provide architecture design proposal for developers.

3 Key Implementation Technology

For a learning system, the most important part is learning resource management and learning process management. Next we will analyze the key implementation technology of these two parts.

3.1 Supportive of Resource Sharing

Learning resources management is the essential part of e-learning systems, by which we can describe, organize and share learning resources. There are many standards used to manage learning resources, such as LOM and CP standards. LOM standard is the foundation of learning resource management, it is mainly used to describing learning resources. CP standard can be used to organizing learning resources to be a knowledge unit or a course. The common target of these two standards is sharing learning resources, so we can exchange and use learning resources under different platforms. To achieve this target, we choose XML as primary binding format.

3.1.1 Persistence of XML

XML is chosen as binding format by many e-learning standards, that is because of the good expansibility of XML, and as a kind of plain text format, we can process and transfer XML files easily.

Generally speaking, we can store XML files in three ways: file system, relational database (RDB) and XML database. XML files can be transplanted easily under file system, but searching an XML file is difficult. To be stored in RDB, XML content can be stored as long text format. And we can store some commonly used properties in a separate table in the database to improve searching speed. RDB is also easy for importing and exporting XML files. If XML database is used to store XML files, we can use XQuery to locate, update and delete corresponding XML files, and this method is the fastest and most convenient. XML database also has functions to import and export and has good transportability.

We also have to process XML files in programs, getting or storing elements content in XML files. To achieve this target, we choose Castor XML and JiBx tools for implementation. By these tools, we can marshal almost any "bean-like" Java Object to and from XML.

3.1.2 Standard Transformation

Different learning resource management systems are very likely based on different standards. For example, SCORM, Blackboard, Moodle and Sakai are mainly based on IEEE LOM standard to manage LOM objects. At the same time, many other systems are using similar standards, such as CELTS LOM standard or IMS MLR standard. Among all these standards, differences are inevitable, which makes it necessary to find ways to easily transform among similar standards. So we designed transformation tool to transform different LOM standards.

As a lot of standards have chosen XML as primary binding format, so the transformation between different standards is mainly transforming XML files, which can mapping one element in a standard file to another response element in other standard files. XSLT (Extensible Stylesheet Language Transformations) is adopted to transform among different metadata models. As described in Figure 5, we can convert the original CELTS LOM into IEEE LOM or MLR by XSLT Processor.

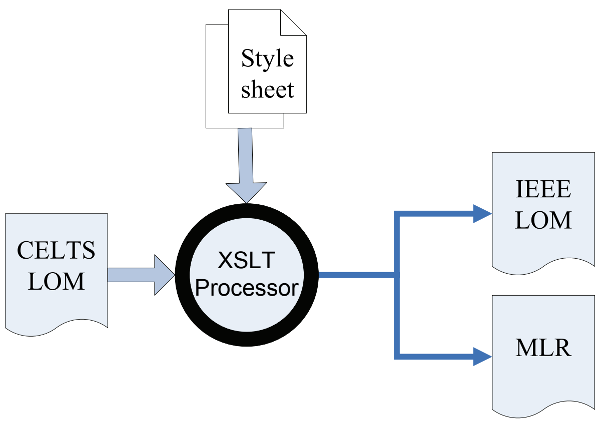

Fig. 5. Process of Standard Transformation

XSLT is an XML-based language used for the transformation of XML documents into other XML documents. It relies upon the W3C's XPath language for identifying subsets of the source document tree. For example, if we convert “identifier” element in CELTS LOM standard to “ResourceIdentifier” element in IEEE LOM standard, we can use the following XSLT code.

```
<xsl:for-each select="//general/identifier">
          <ResourceIdentifier>
                    <source>
                              <xsl:value-of select="catalog"/>
                    </source>
              <value>
                        <xsl:value-of select="entry"/>
</value>
          </ResourceIdentifier>
</xsl:for-each>
```

In the code, we can use “select” statement to query an XML element, and we can also fetch the element value by using “xsl:value-of” statement. Next step we can read pending XML file and XSLT file by java language, and with xalan package (supported by jdk1.4 version and above) , we can get a MLR instance.

So in of the steps above, the most important step is finding mapping rules between different standards, and writing them into XSLT file, and finally we can use JAVA language to get the converted file.

3.2 Supportive of Learning Process

In an advanced learning system, users cannot only manage and share resources, but also can study and discuss. This needs learning system to be able to manage learning processes. The learning process here is not just reading materials or posting a question in a forum, but also collaborative learning, personalized learning process design, role plays and etc. For a learning system, we need to design functions to support the management of collaborative learning and personalized learning flows, and we also need to handle complicated elements in learning design.

3.2.1 Collaborative Learning and Personalized Learning Flows

For supplying a better learning experience, we focus on designing a human-based learning environment. We believe that if we involve the students to the process of creating, improving and populating instructional design, there will be a remarkable growth in their learning motive and enthusiasm which not only helps them to achieve better learning outcomes, but also the teachers to better adopt their design to learners’ requirements. We mainly use collaborative learning and personalized learning flows to achieve this purpose.

The base form of collaborative learning is learners working as a group to complete a learning activity. For a collaborative learning flow is mainly composed of the following parts: participator role, learning grouping (organization structure) and the information flow and transmission in the minute work. Compared to traditional e-learning, collaborative learning has introduced the concept of role. The enthusiasm of learners can be greatly improved by the rational allocation of roles, and in the process of collaborative learning, the supervision mechanism in the group can let learners put enough energy in learning activity. Personalized learning means satisfying individual requirements in the learning process, and improving learners' effect. When someone is studying, he may have such needs: raise up questions about unclear knowledge points, pointing out the errors in courseware, posting his experience about some knowledge point. Although there are some e-learning systems can meet these needs, users have to leave there studying interface, which means users' learning is interrupted. If we integrate all these functions in the learning interface, users' learning process won't be interrupted and users are encouraged in participating these activities. To meet these needs, the personalized learning flow is designed as below:

Fig. 6. Personalized learning flow design

3.2.2 Handling Elements with Description Patterns

When systems have to handle XML elements, they usually use castor tool to marshal java elements from and to XML elements, and then the system present the interface for users to edit or view, this method is sufficient for handling elements of fixed types. But in the process of editing learning design, the types of elements are not fixed. For example, an element can be "Boolean" type or "String" type, for the former type, the interface has to show a group of two radio buttons, and for "String" type, a text field has to be shown to users. So in the learning design platform, castor XML isn't enough for handling elements.

We propose to use description patterns to solve the problem above. Simply speaking, description pattern is used to describe an attribute whose type isn't fixed, and unify the front-end display of elements of numerous types. The process of handling elements with description patterns is shown as below:

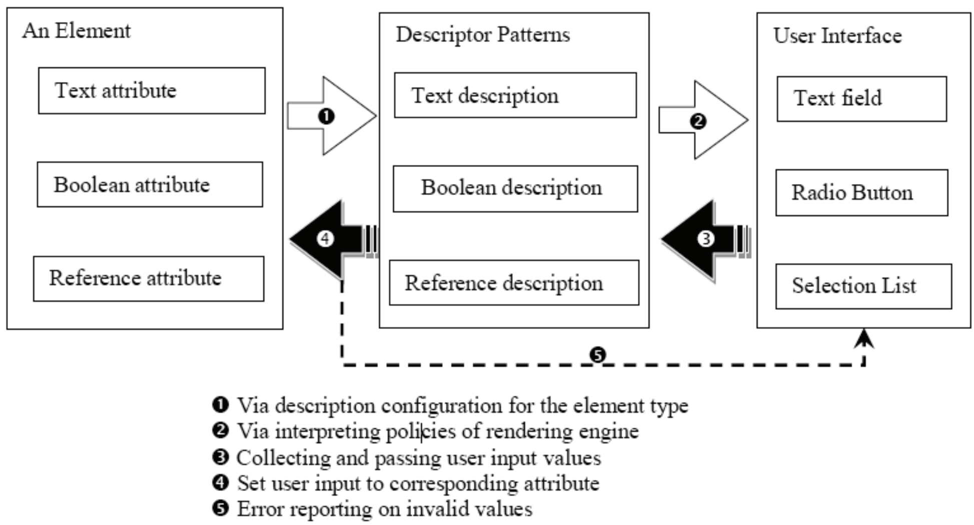

Fig. 7. Generating attribute sheet for an element

For a request element, the system first obtains the description pattern for it, and then it builds the input field for each pattern. For example, to present a text attribute description, the system may dynamically create a text filed in the property sheet. And for a Boolean description pattern, it creates a group of two radio buttons or a selection box with two options. After the author modifies some of the attributes, the system passes each modified attribute value to the corresponding description pattern and tells them to set the new values.

4. LOM Editor

LOM editor is designed and developed based on CELTS LOM standard. Since LOM standard is used to describe learning object information standard, LOM management tool is the most basic part of education system. LOM management system has the following functions:

1) Generate XML document meeting LOM standard based on data provided by users, and store in database.
2) Modify the specified XML file.
3) According to users' requirement, query specific LOM elements (such as title, author, and etc.) from database storing XML file.

During the developing process, we have applied RDB as a tool storing XML file, and chose JAVA as developing language. We first determine the implementation of underlying function:

1) Define all LOM elements by JAVA, for example, title of LOM is a multi-language string types, including language attributes, as well as string attributes. When using JAVA, definition includes title type with two attributes and some attribute operation functions.
2) Castor tool realizes the mapping from XML file to JAVA elements, which could allow elements in XML file exchange with corresponding JAVA elements in step 1.

3) Define the interfaces interactive with database. In order to operate database more conveniently, we apply hibernate technology. The reasons for choosing hibernate are 1) system could replace database more easily. For example, we only need change configuration files, don't need to re-write code when replace database from Oracle to Mysql; 2) hibernate allows storage and retrieval without writing database operation sentences, could be easily developed.
4) Database table design. Besides design of a separate table for storing XML document, we put some frequently query attributes in the separate database table. These two tables connect through foreign key attribute of database. The reasons for storing attributes separately to one table is by this way the retrieval could be faster, otherwise, when query system need first convert XML file to JAVA elements, which wastes.

We can summarize the design steps by using the chart below:

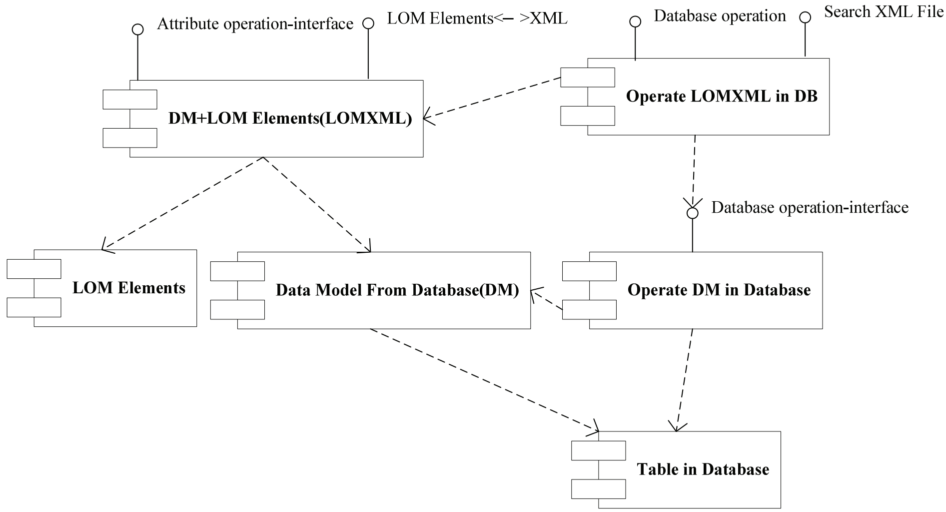

Fig. 8. LOM management tool underlying function design

Based on the above underlying function design, we have applies J2EE to realize the interaction between surface and under layer. The surface calls the under layer interface function through users operation. The editing interface of LOM is shown in the graph below, LOM object could be generated by filling table in the graph.

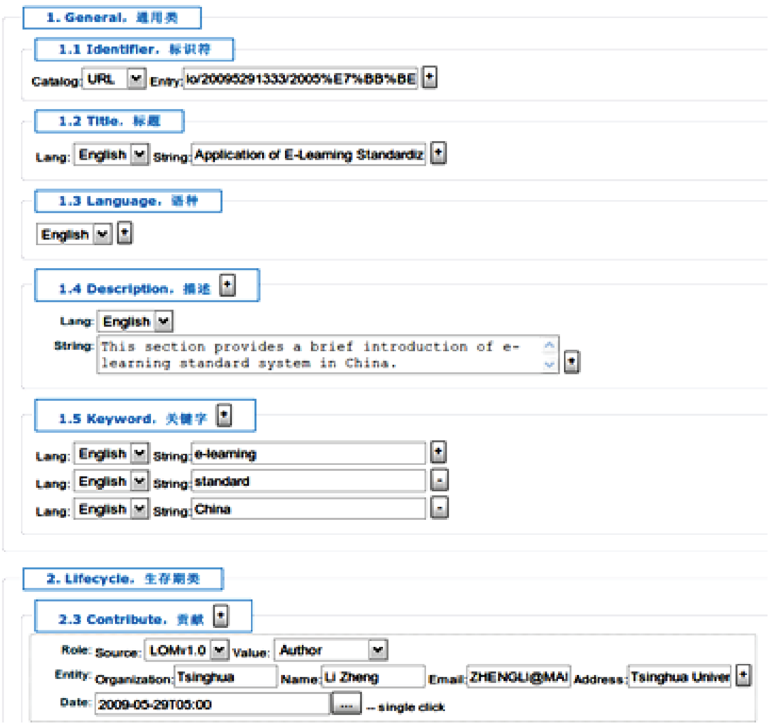

Fig. 9. LOM editor editing interface

5. Content Package Management System

Learning object, the smallest reusable unit in modern e-learning system, could be generated by LOM tool. Content package service is another education core service based on that. This service is designed and developed based on CELTS CP standard.

The function of content packaging is that it defines a unified data model, allowing learning resources could be organized randomly. This newly organized learning resources (here called learning content) could be copies, transferred, purchased, implemented and used independently, and could be further organized into bigger unit, which enhances the interoperability of learning resources and increases the efficiency of learning resource production.

Content list, the main part of content package management system, includes the following four parts:

1) meta-data components: overall description of content list.
2) Organization structure part: description of one or more means of leaning content organization from content list.
3) Resource reference part: reference of all the actual resources and all the necessary media resources in content list, and also include metadata describing resources and reference of external files.
4) The content list: zero or multi-nested content list.

Content list combined with physical data construct a complete learning content. During this process, the most important part is the generation of content list. As LOM tool, learning content package tool, based on WEB, applies J2EE technology, and uses content package service interface API.

The content package list data uses XML format, stored in a relational database. The core of the system is similar to LOM tool, including two parts:

1) content package standard API: abstract data part of content package service – including definitions of all involved data structures, corresponding XML operation interfaces realized through XML bounding norms based on content package and interactive interfaces of relational database system. For this part, the design of API is basically the same as API of LOM.
2) page logic control modules: process and control various operations of content package and make page logical respond, mainly used in functions like responding to users' add, edit, delete the node, and etc.

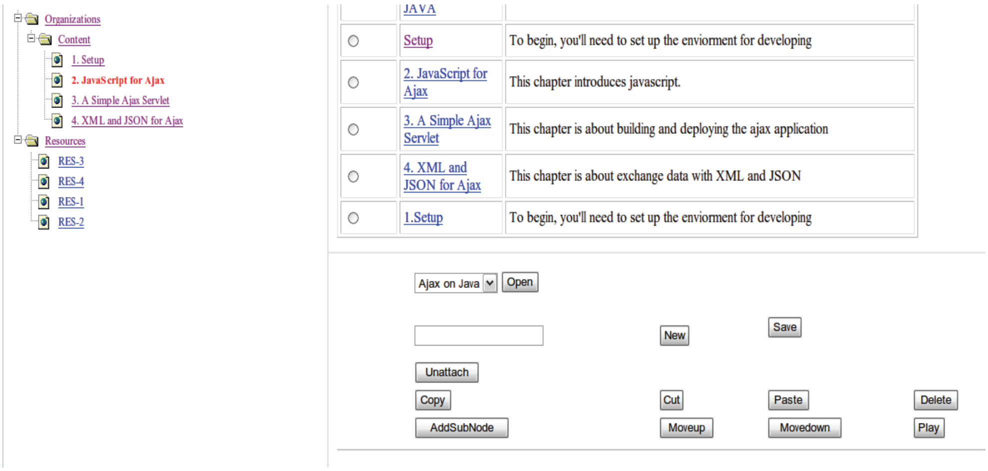

Fig. 10. the content package editing interface

System provides users with various editing function in view of content list (as shown in above graph), including:

1) Add sub-node: add a new sub-node under the current node.
2) Edit the node: change the name of the current node and the corresponding parameters.
3) Delete the node: delete the current node and the whole content under the current node.
4) Save: save content list as XML format and provide download link.
5) Upper and lower move node: change node order
6) Copy, paste: copy, paste nodes, including the contents under the node.
7) Play: play files described by the current node, such as HTML, Flash, PowerPoint, etc.
8) New: create a new content list.

In the process of editing, system would provide real-time content list view to users. After editing, users could browse the content list in XML format.

6. Learning design support system Information

Support to learning design is the important base for learning process management. Leaning design including organization of education resources and also have learning activities and participants' role design. We have achieved the management of collaborative learning flow and personal leaning flow based on leaning design support.

6.1 System layered architecture and components proposal

Learning design platform could be an independent system, and also could be a bigger component of learning platform. So we need to make it not only could be exist independently, but also easily integrated. The whole platform is designed in accordance with "Learning system architecture and interface" standard, which is layered architecture, as shown in Figure 11, the dotted lines between services present call relation.

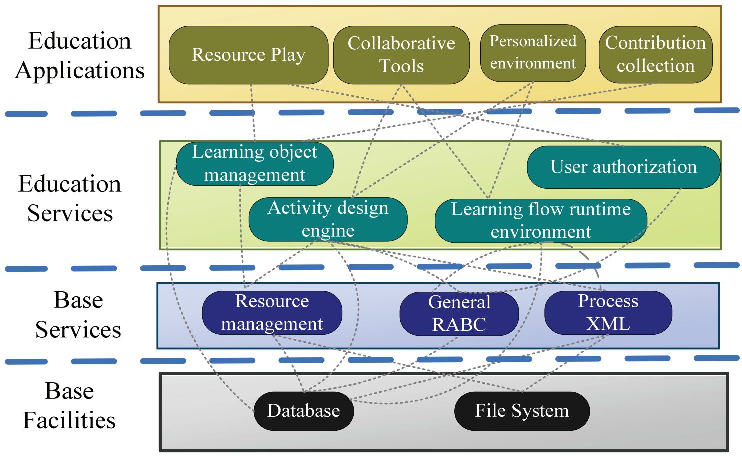

Fig. 11. Layered architecture design of learning design platform

From the above architecture, we find that in addition to specialized services like learning design, some other services, like LOM service, certification and authorization of participants, have been already exist. In order to promote reuse of e-learning service in different systems, we have adopted service-oriented approach to design all kinds of services of the above layered architecture.

6.2 Data Exchange

In the service-oriented system, either call service or service return results, they both need data exchange. In the service-oriented design, there are commonly two means of exchanging data.

1) Web Service and its description language WSDL, this service adopts XML as data exchange format, and provides a method of packaged service including registration, discovery, call and the combination. Since XML has poor support in HTML

application environment, this method is not friendly to JavaScript, and could only obtain native support form high version Flash.

2) the way HTTP request +JSON, it applies JSON as data exchange format, high efficiency, which obtain good support in JavaScript and Flash, more practical, but lacks unified service description method, and when used alone could only through specific technical documents coordination.

From the above analysis, we find that Web Service form is more suitable loosely coupled systems, but JSON is more suitable for tightly coupled systems. We have proposed that the above two call means should be provided at the same time to a set of interfaces of one service. Since JOSN lacks unified service description method, we have adopted WSDL to describe HTTP request +JSON service. Compared with Web Service, except the different access points, other attributes (operation name and parameters) are all the same.

6.3 Implementation proposal of front-end system

Since the system need visual management of information entities, in the browser application, we have chose RIS (Rich Internet Application). Ajax and Flash are two technique routes of RIA. In this system, the main framework is achieved through Ajax framework Cappuccino, but the monitor dynamic graph is realized by Flash. And RIA applies asynchronous data transmission, just to meet the need of service-oriented data provision method. So these two technologies are very suitable for front-end system development.

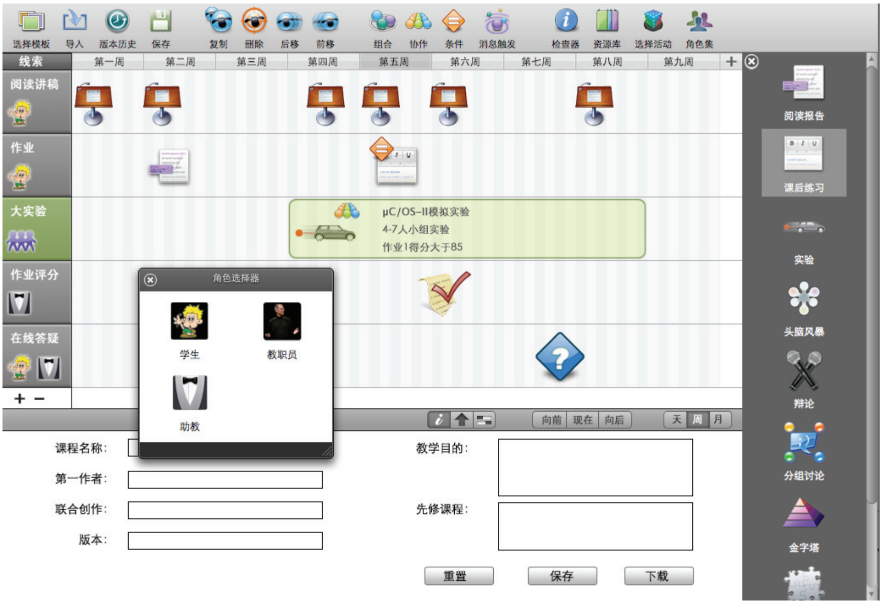

Fig. 12. learning process editing interface

Cappuccino framework could help developers build local-level application in browser, which is the ideal choice of developing relatively complicated deign and process environment in view of learning flow. The framework design Objective-J language, which could be mix-used with JavaScript, completing a challenging task to traditional Ajax. In addition to solve the complicated interface display, Cappuccino and Flash exchange data with Backend Server by using JSON, which increase the efficiency of data transmission, and achieve the greatest decoupling between front-end and backend server. For example, the editing interface of leaning flow is shown a Figure 12.

In the Figure 12, the right side has some default activities, including experiment, group discussion, and book report. The activity operation includes copy, delete, import and export, and each activity could be gave a role, and the dialog is the role selector. In the design process, users could edit the learning flow through drafting, and could create role and event according to their own need.

7. Summary

This chapter gives a brief introduction to e-learning standard situation and the implementation technology of standard. It focused on learning resources standardization and management technology, and learning process management technology based on learning design standard. The implementation technology is only a sample of Chinese e-learning standard implementation. In different learning systems, there are different proposals for resources standardization. But effective management of personal learning process, based on instruction design standard, has not been implemented in various learning systems. The learning design support system is only an attempt.

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Managing relevant learning objects' assessments: the right place at the right time

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1. Introduction

Annotations are essential when content, form and description of learning objects have to be improved: assessments help teachers to build new and enhance existing resources, whereas suggestions for use allow avoiding former pedagogical mistakes. Reviews submitted by subject matter experts, together with students' comments, represent a crucial source of information to improve pedagogical resources during the re-authoring process.
Learning objects and metadata are often stored into a Learning Object Repository (LOR) that facilitates their distribution and reuse at a wide scale; course designers and teachers can browse repositories to find existing learning resources that match with their pedagogical objectives, and reuse this material into their curriculum. However, this kind of system does not allow collecting relevant annotations because LOR are dedicated to storage and description, they provide no pedagogical features. Annotations are thus not present or not objective, because they are most often restricted to text notes provided by the author of the resource himself. Instead, assessments and suggestions for use become relevant when learning objects have been used in a real learning context, that is when teachers and learners have exploited the pedagogical resources: the feedback step comes later than the diffusion step in the learning object and metadata lifecycle (Catteau et al., 2006).
Since Learning Management System (LMS) represents the most popular system deployed within public and private institutions to deliver learning services, works presented here stand on two main proposals: the collection of annotations through LMS, and their storage within LOR. Communication between these two kinds of systems is based on a standardized and open architecture allowing LMS users to transparently manipulate resources stored into LOR (Broisin et al., 2005), whereas an extension of the Learning Object Metadata standard (IEEE-LTSC, 2002) allows describing global and specific as well as quantitative and qualitative annotations. Assessments and suggestions for use are thus gathered when they become relevant and stored where they have to reside, and can be widely shared and exploited to facilitate several learning processes such as curriculum designs, re-authoring or learning object retrieval. An implementation focusing on Moodle and the Ariadne Knowledge Pool System validates our approach.

2. Learning Object Assessment

Quality represents a growing interest within the research community, as the number of works and tools focusing on this area demonstrates it. Even if it may be unduly risk averse (O'Reilly, 2002), peer review is commonly operated by research councils in order to ensure scientific quality. In a pedagogical context, because students can learn from their reviewers' comments, peer review is often used in learning processes (Furman & Robinson, 2003; Gehringer, 2003). Students can even be empowered to take on the role of the teacher to carry out the correction process (Coit & Stöwe, 2006). To promote enhanced teaching methods, techniques and strategies, the North Dakota State University implemented a policy of cooperative peer review teams. The program, including peer meetings, syllabus review, and classroom observations, was widen to the whole teaching process (McIntyre & Mehta, 2003). We focus our work on peer reviewing and user comments collected during the feedback step. They are only a part of the quality approach and must be considered as a summative evaluation of a ready-to-use LO. Our work also includes LO suggestions for use that will help teachers building a learning design.

2.1 Existing Reviewing Systems

A system such as MemoNote (Azouaou & Desmoulins, 2006) provides teachers with a personal memory composed of annotations they have made on documents during their various teaching activities. Nevertheless, these annotations are not added into a LOR and cannot be widely shared. On the other hand, the e-learning research and assessment network allows up to four assessors to submit into the LOR quantitative and qualitative peer reviews according to several criteria (Kumar et al., 2005), as shown on figure 1.

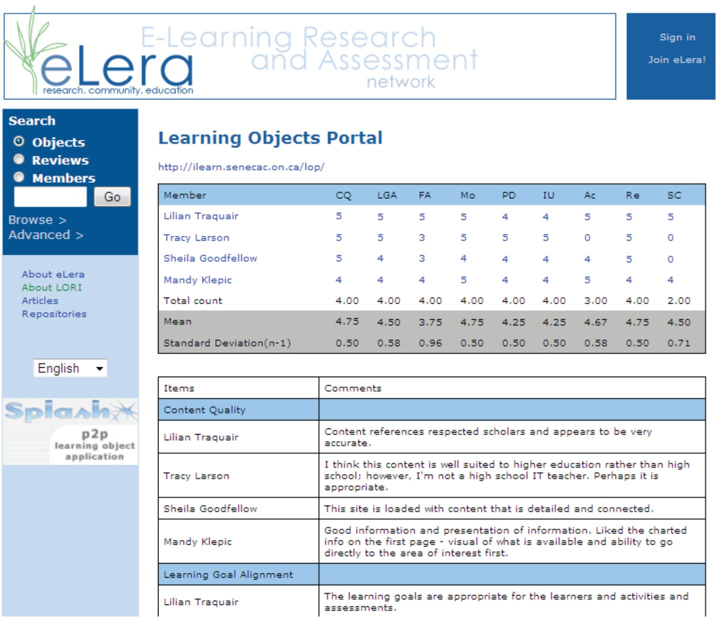

Fig. 1. LORI qualitative and quantitative assessment example.

Boskic noticed that most of LOR doesn't support quality evaluation, while a few of them include peer reviews and/or suggest a feature for users' comments (Boskic, 2003). Table 1 depicts the results of a study related to features provided by five LOR implementing quality evaluations. Qualitative reviews or comments are always present, whereas quantitative reviews (e.g. five-point scales) required for quality-based sorting (Vargo et al., 2003) are not implemented in two repositories. LORI (Kumar et al., 2005), MERLOT (Multimedia Educational Resources for Learning and Online Teaching, 2009) and Wisconsin Online (Wisconsin Online Resource Center, 2009) distinguish different types of assessor such as subject matter expert, instructional designer, learner, etc. Moreover, criteria used for LO evaluation differ from a LOR to another, according to assessor and LO types (McMartin et al., 2004; SREB Educational Technology Cooperative, 2009; Vargo et al., 2003).

<table>
<tr><th>LOR</th><th>Quantitative Review</th><th>Qualitative Review</th></tr>
<tr><td>Evalutech (SREB Educational Technology Cooperative, 2009)</td><td>NO</td><td>Peer review by domain expert</td></tr>
<tr><td>Harvey Project (OpenCourse.Org, 2009)</td><td>NO</td><td>Peer review + Classroom testing</td></tr>
<tr><td>LORI (Kumar et al., 2005)</td><td colspan="2">Peer review (up to 4 assessors)</td></tr>
<tr><td>MERLOT (Multimedia Educational Resources for Learning and Online Teaching, 2009)</td><td colspan="2">Peer review (2 domain experts)
Member comments</td></tr>
<tr><td>Wisconsin Online (Wisconsin Online Resource Center, 2009)</td><td colspan="2">Public comments</td></tr>
</table>

Table 1. LOR implementing quality evaluations

2.2 Issues

The previous section pointed out some difficulties that must be solved in order to offer an efficient LO assessment mechanism:
- despite the need for sharing and reusing this information, most of LOR presented in table 1 store peer reviews, comments and suggestions for use in a specific database, they are not included into metadata;
- specific web systems have been elaborated to manage assessments, they most often differ from the system used to learn and teach.

To tackle these issues, our framework stands on two main proposals: the storage of annotations within metadata (and therefore into LOR), and the collection of annotations through a LMS.

3. Extending the LOM standard

3.1 The LOM annotation category

The Learning Object Metadata is the most widely-used standard to describe learning objects into a LOR. It offers an Annotation category in order to "enable educators to share their assessments of learning objects, suggestions for use, etc." (IEEE-LTSC, 2002). As shown on figure 2a, a LO annotation is composed of:
- the entity (LOM 8.1) having created the annotation, described using the vCard format;

- the creation date (LOM 8.2) of the annotation, expressed with the DateTime format;
- the description (LOM 8.3) as a LangString represents the content of the annotation.

These descriptors are part of several LOM application profiles, they are mandatory in CanCore (Friesen et al., 2004), recommended in UK LOM Core (UK Metadata for Education Group, 2004), and optional in many application profiles such as SCORM (Advanced Distributed Learning, 2004) or LOM-FR (AFNOR, 2006).

An annotation can be used to describe learning objects assessments or suggestions for use. Each quantitative and/or qualitative annotation is made at a specific time by an entity (e.g. a user, an organization) matching with a specific type of assessor. Annotations can represent a suggestion for use, may be global to the whole content or specific to a criterion. They are useful mostly for a target audience (e.g. a learner, a teacher).

But the LOM standard doesn't take into account neither the role of the entity, nor the type of the annotation (global, specific criterion or suggestion for use), nor the target audience. Moreover, the description element (LOM 8.3) is well-adapted for qualitative review but not for a quantitative one.

3.2 The extended LOM Annotation Category

The lacks mentioned above to describe a LOM annotation bring us to propose, as shown on figure 2b, several modifications to the Annotation Category:

- the extension of the LOM 8.1 structure in order to get a complete Contribute set that includes an Entity together with its Role,
- the Annotation Type element that specifies whether the annotation is global, related to a specific criterion, or describing a suggestion for use,
- the Quality Level element for providing information about quantitative evaluation,
- the Target Audience element that specifies whether the annotation is for learners, teachers, authors or everybody.

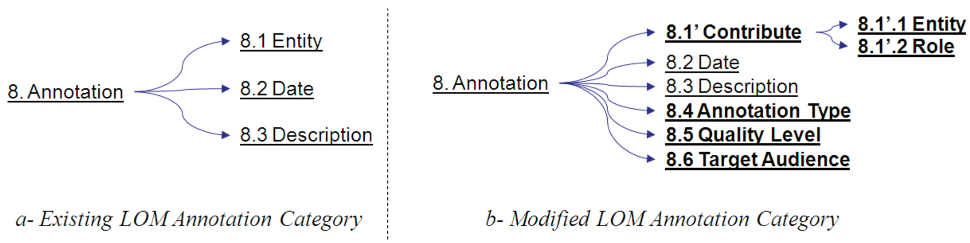

Fig. 2. The existing and modified LOM Annotation categories

These enhancements make it possible to fully describe LO assessments using the LOM metadata standard, but a main drawback remains: the difficulty to collect and store this information. On one hand, few LOR allow users to freely modify metadata (including annotations) of an existing learning object, and LMS are more adapted to LO assessments than LOR on the other hand. Thus, the next section introduces the annotation management service that allows, from a LMS, to add annotations into the metadata of a learning object stored into a LOR.

4. Closer to the End User

4.1 The Original LOV Design

The Learning Object Virtualization (LOV) architecture (Broisin et al., 2005) is based on learning technology standards and allows for learning objects virtualization: it offers both a single view of the whole set of resources stored into several heterogeneous LOR, and an easy access to those resources through the use of LMS. This framework illustrated on figure 3 offers a transparent communication between LMS and LOR and allows to (a) query the LOR from the LMS and to retrieve learning objects metadata, (b) download the matching documents on the local host, (c) import the matching documents into the dedicated space of the LMS in order to deploy this resource within a learning design, and (d) index new learning objects into a LOR starting from a LMS. Nevertheless, the original framework does not provide any service related to LO assessment.

4.2 Annotation Management Service

As illustrated on figure 3, the Annotation Management Service (AMS) has been introduced into the Virtualization layer. It allows LMS users to submit annotations and to store these assessments into a LOR. The nature of this service makes it only apply to learning resources imported from a LOR into a courseware. Indeed, resources that have been directly uploaded to the LMS by users are not described by metadata, and can't be stored into a LOR.
When an assessment is submitted, data specified by the assessor are transmitted through the AMS to the appropriate LOR. In order to make the process smoother, the service allows for automatic metadata generation by exploiting the learning context of the LMS: entity and role are automatically produced.

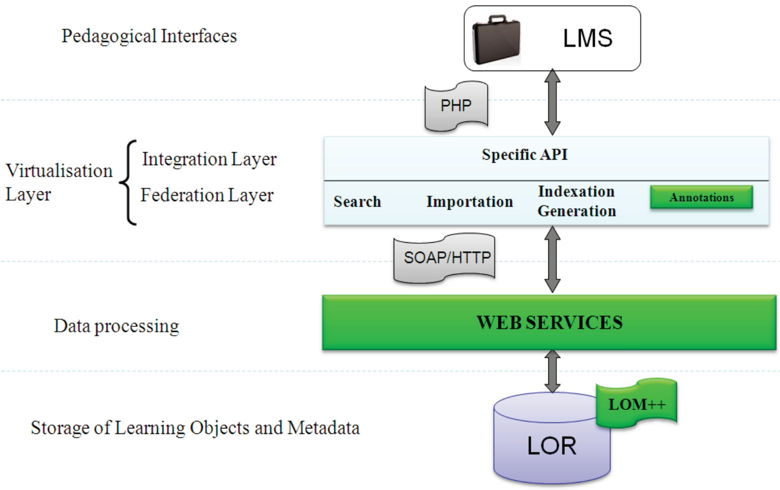

Fig. 3. The improved LOV architecture

The introduction of the AMS into the LOV architecture presents several benefits:
- it allows users to add an annotation when it becomes relevant, that is after the LO exploitation within a LMS;

- it enables various users, distributed on several LMS, to share annotations stored on multiple LOR;
- criteria used to evaluate a learning object can be customized within the LMS depending on the user role.

Moreover, the storage of annotations within a LOR allows improving the Search Service of the Virtualization layer. Indeed, a teacher editing a courseware and searching for existing learning objects is now able to consult annotations associated to these resources. It thus helps teachers and tutors to:
- Build a learning design or courseware by improving the learning object selection process: editing teachers can sort learning objects according to a quality-based mechanism that takes into account global or personalized criteria weights.
- Avoid pedagogical mistakes during the resource exploitation, and to be aware of the specific challenges or strengths undertaken by the resource.

5. Implementation: Moodle and the Ariadne repository

The original LOV architecture has been implemented with two LMS (INES and Moodle), and the GLOBE repositories (GLOBE, 2009) including MERLOT, ARIADNE, EDNA and NIME. The AMS focuses on the cooperation between Moodle (Moodle, 2009) and the LOM-based ARIADNE Knowledge Pool System (KPS) (Duval et al., 2001): annotations are generated from Moodle and stored within the KPS. Because the M in Moodle stands for modular, the new features presented here have been added to the existing LOV module for Moodle, and have only required ten development days.
Roles natively defined by Moodle are the followings: administrator, course creator, editing teacher, teacher, student, and guest. The role “subject matter expert” has thus been created in order to allow peer reviews. On the whole, several types of actors can submit annotations, as depicted in figure 4.

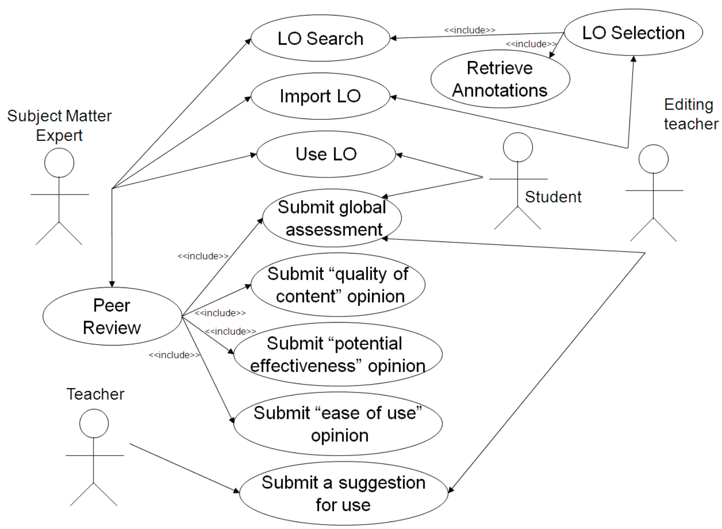

Fig. 4. Annotation use case diagram

Fast global quantitative evaluations can be made by users via a graphical star rating system illustrated on figure 5. Detailed evaluations consist in filling in one or several forms that include:
- the annotation type which can be global, matching with a suggestion for use or specific to an evaluation criterion. The first implementation suggests criteria defined by MERLOT: Content Quality, Effectiveness, Ease to Use (McMartin et al., 2004);
- the description of the qualitative evaluation;
- a graphical five-point star rating system related to the annotation type. When the annotation type matches with a suggestion for use, this rating system becomes incongruous and is de facto disabled;
- the target audience by selecting everybody, author, learner or teacher option.

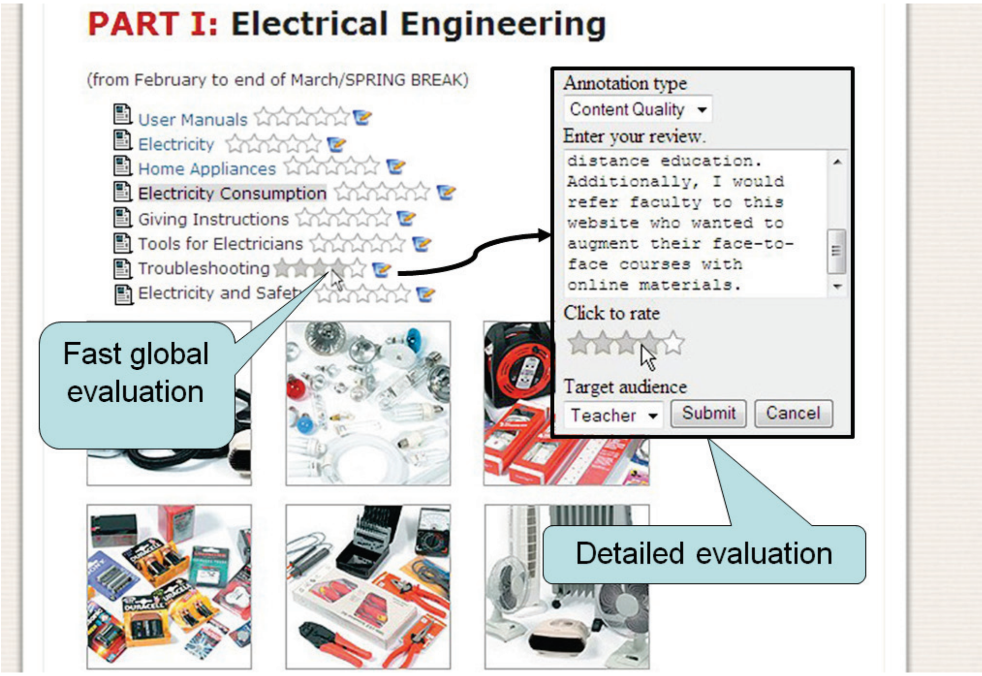

Fig. 5. LO evaluations within the LMS

Each user can submit and modify one annotation per annotation type for a same LO. There is no limit to the quantity of users storing annotations for a same LO. Let us note that the Contribute and Date elements of the LOM Annotation category don't appear on figure 5. Indeed, the vCard entity together with the role can be deduced from the LMS profile of the user, whereas the date can be easily generated.
Annotations submitted by users are transparently stored within the KPS. The UML diagram sequence illustrated on figure 6 represents the required operations to achieve this process:
1. A user submits an annotation through the Moodle interface.
2. Moodle delivers the annotation to the AMS.
3. This last generates the vCard and role of the user, and consults the LO properties in order

to extract the location of the LOR responsible for its management, together with its matching identifier. Those properties are specified by the Importation Service (see figure 3) during the importation process: it keeps the relationship between the target LOR, the LO and its identifier within the LOR.
4. The AMS sends both the annotation and the LO identifier to the Ariadne Web Services (AWS) responsible for interacting with the repository. The SOAP protocol is used to ensure communications between these entities.
5. The AWS add the annotation to the metadata item describing the matching learning object and stored into the KPS.

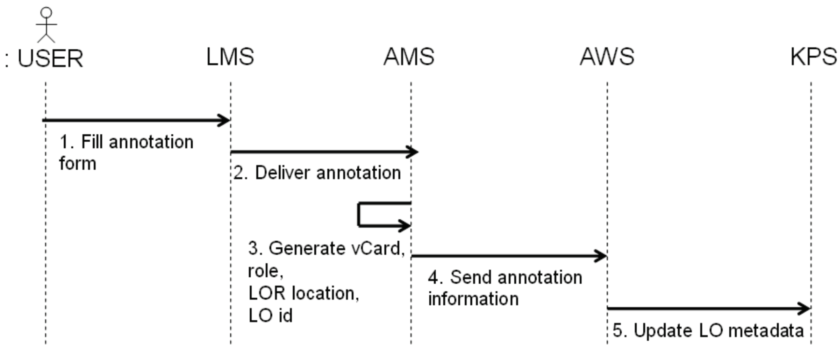

Fig. 6. Annotation submission sequence

The AMS is now deployed within the International E-Miage (IEM) learning environment, a digital campus that delivers degrees to French and foreign lifelong learning students (Cochard & Marquie, 2004). All experts, tutors, and learners located in the various IEM exploitation centres are thus able to submit their own annotations, and to benefit from assessments suggested by the whole community. First results will be collected at the end of the semester and will help us to enhance the AMS according to users' requirements.

6. Conclusion and Perspectives

We presented in this paper an open architecture that facilitates learning objects assessments and suggestions for use. This framework allows users to submit annotations directly from a LMS, and to store these annotations into a LOR for share and reuse purposes. Thus, annotations are submitted and retrieved when and where they become relevant. They can come from various LOR and be used in multiple LMS.
The Annotation Management Service has been successfully implemented for a specific LMS communicating with a LOR, and has just been deployed within the various exploitation centres of an international digital campus. In order to widely benefit from this work, both the modifications applied to the Annotation Category of the LOM standard and the vocabulary used for roles, annotation types and quality levels should be adopted by consensus. Other metadata standards such as ISO MLR are being elaborated; a proposal will be suggested in this direction. Even if success and efficiency of learning objects assessments strongly depend on end users' motivation and involvement, the huge number of MERLOT statistics about peer reviewing and user comments makes us confident about this approach.

The vocabulary of annotation types should automatically be adapted to the user role: a subject matter expert should fill in each criterion of a peer review, whereas other actors may submit global evaluations. This would allow to improve the LO selection process by attributing different weights to each criterion. Moreover, it should also be useful to customize evaluation criterion according to the learning object type: a slide is not annotated and evaluated as if it were an experiment. Some specific criteria should thus be defined for each existing type of learning object.

Some systems allow annotations to be made forthright on documents by teachers or students during their various pedagogical activities. As future works, we plan to consider in situ annotations in order to encourage users to generate annotations. Indeed, time is needed to consider a learning object from a higher point of view and to conceive a general annotation, whereas an annotation related to a specific image or paragraph can be achieved while reading the learning resource (Marshall, 1997).

Finally, we want to investigate deeper the opportunity to offer to end-users a personal annotation feature. Indeed, some annotations make only sense for their author (e.g. "not understood, should go over the basics"), whereas some others have to be shared with the whole community.

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Learning paradigms through fundraising systems: The RoboBeggar and the InfoKiosk cases

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1. Introduction

It has become common practice for many organisations that need to raise funds for humanitarian aide and charity to utilise electronic fundraising systems to reach potential donors. These fundraising systems can be classified into those that are Internet-based (i.e. virtual and/or informative online systems) and those that are hardware with embedded operating systems (i.e. robots or Automatic Teller Machines (ATMs), with or without multimedia integrated systems). While the designers of fundraising systems are mostly concerned with the actual process of raising funds by these means, they tend to pay less (if any) attention to the impact that the learning behaviours and ethical convictions of donors support conscious and motivated donation. The fact that designers seldom take the value and function of user-centred designs and the dynamics of elearning into account in the fundraising system that they devise, stimulated the authors of this paper to explore a range of pertinent questions in the field of hardware embedded systems in educational technology. They have asked these questions in order to identify the interactive paradigms and rules that govern the effective design of elearning fundraising technology. The authors are all experienced in the application of elearning to human-machine interactions for the purpose of identifying those elements that best support the cognitive and learning processes of novice ICT users.

This chapter offers an analysis of the results that were obtained from four research projects that investigated two prototype computer embedded systems: the RoboBeggar (La Russa et al., 2005), a gynoid robot, and the avatar-assisted InfoKiosk (La Russa et al., 2008), a multimedia pillar kiosk (see Figure 1 below for a photograph of the two prototypes). The anthropomorphic robot and the pillar kiosk were analysed and assessed in terms of how efficiently they performed their tasks of interacting with human donors and potential donors, and the extent to which they were able to influence human behaviour in their favour. Both of these systems used elearning modules that allowed people who had decided that they wish to make a donation, to make direct money transfers to the charity concerned by simply using their bankcards. This chapter compares the elearning methods of the two systems with the cognitive and learning processes of those who used the systems to make donations. This chapter also examines and analyzes the objective and subjective data (including user feedback) that the researchers collected from all the test cases.

Fig. 1. The RoboBeggar (left) and the InfoKiosk (right) – terminals of the two fundraising systems used for automated computer-based fundraising discussed in this paper

The efficacy of the fundraising systems that form the basis of the human-machine interactions are then assessed by the researchers on the basis of the data thus analyzed. A set of design guidelines has been specified in this chapter for the use of software programmers and engineers, anthropomorphic robot developers and fundraising organizations in order to serve as a basis for the design and development of effective elearning interactive fundraising systems (anthropomorphic robots or simple computer-embedded systems). The design of robotic or computer embedded elearning fundraising systems' programs can benefit from a structured and methodical approach that takes into account the design flexibility that is provided by these two presented prototype cases. Because the researchers adopted a Object Oriented Design (OOD) and Object Oriented Programming (OOP) to approach these problems, it was possible for them to redefine both of the two systems' program modules on the basis of user feedback and the interactions that took place between users and the hardware (related metadata was also provided by each system's software). The adaptability and flexibility of the programs that constituted the operational base for these two systems enabled the researchers quickly to incorporate the data that emerged from the learning processes of frequent users, thus enabling them to refine the systems until they operated with maximum efficiency.

By using newly emergent data, it quickly became evident to the researchers that donors clearly preferred to use and interact with the InfoKiosk in church environments rather than the RoboBeggar. This was vitally important information because it was already known that the RoboBeggar was the more noticeable and visible instrument for donation collection in other (non-church) environments. It might therefore have been logical to suppose that the RoboBeggar would also attract more attention and donations in ecclesiastical environments. But, for some reason, the opposite was true. This chapter presents and discusses the reasons and motivations for the positive and negative impacts made by different systems in different environments. The conclusions that were drawn from this data served as a basis for constructing a set of design guidelines for the designers of interactive elearning fundraising systems.

2. Fundraising in the third sector

During the past few decades, marketing and communication specialists have paid an increasing amount of attention to the possibilities inherent in fundraising by means of the systems mentioned above. At the heart of this activity have been attempts to define reliable criteria for soliciting strategies (Hart et al., 2005; Patterson & Radtke, 2009). During this same period, a large number of field studies and reports have been sponsored by fundraising organisations and other interested parties in the hope of identifying the conditions that promote or hinder fundraising activities, as well as related trends, needs and sector investments, and the expectations and expenditures that define this field of research (RNID a, 2008).

The amounts that are collected by fundraising organisations vary for each country. According The Charity Commission of England (Facts & Figures, 2009), the annual growth rate in fundraising between September 2008 and March 2009 was 6.8%, and although this figure has been showing a tendency to decrease, it is still in keeping with the total amount of money (UK£ 49.943 billion) collected throughout the world by 168,500 charitable and humanitarian organisations by 31 March 2009 (the cut-off date for this data). According to *Giving USA* (Bond, 2009), donations in the United States in 2008 reached a total of US$ 307.65 billion (a drop of 2% from the total amount collected in the previous year). The use of mobile phones for fundraising (which is called *mobile fundraising*) in the United States has also started to produce good results, with the total amount of about $500,000 thus. Although this figure is still far lower than the amount collected by more traditional methods of donation solicitation, it nevertheless represents 0.0016% of the total amount that was donated as a result of formal fundraising activities in the United States in 2007 and 2008 (Hiley, 2009). In order to obtain an accurate understanding of how vast the amounts are that are accumulated in the United States as a result of fundraising activities, it is enough to mention that the amount collected as a direct result of fundraising activities collectively constituted 2.3% of the Gross Domestic Product (GDP) in 2007, and is expected to represent 2.2% of the GDP in 2008 (Bond, 2009). Because it is possible to raise large amounts of money by means of fundraising, many organisations organise fundraising training courses to teach and train personnel in this activity (Murray, 2009). This is still happening in spite of an

increase in recent years in the number of management problems experienced by fundraising organisations with regard to their reserves policies and the degree of transparency with which they operate (Ainsworth, 2008).
It is worth noting that the use of "cold" door-to-door fundraising techniques is still widely used by many organisations, and, according to the Public Fundraising Regulatory Association (PFRA), this method of fundraising can still produce excellent results (Lake a, 2009; Lake b, 2008; Jordan, 2009). Ironically, it is the continued use of this traditional door-to-door technique (which is regarded as a tried-and-tested method that delivers good results) that accounts for the less-than-expected amount of interest in Internet fundraising methods, and various other online and offline techniques (Lake c, 2009).

2.1 The needs of the fundraising sector: money – but not only money

The needs of the fundraising sector cannot be comprehended only in terms of the ultimate purposes of the fundraising or the means that are used to pursue fund solicitation. The very nature of the fundraising organisations themselves and the degree of efficiency with which they operate, are also matters of great concern to these organisations. Most fundraising and non-profit organisations tend to use their own resources and expertise to reach potential donors, and they base their strategies mainly on their own past successes and failures. Because past successes dictate future methods for most fundraisers, they tend to keep approaching the same donors and to stick to the same methods of soliciting – thereby forfeiting whatever opportunities for improvements, expansion and increased efficiency that are currently offered by more advanced technological systems (Hart et al., 2005) and the advice of experts in this field (Patterson & Radtke, 2009). Studies have even shown that some organisations forfeit the advantages that could accrue to them from the publication of budgets and annual reports. Such reports and information are valuable because they increase transparency and trustworthiness by providing certified information about operations and plans for future strategy planning (Ainsworth, 2008).
While it is impossible to quantify exactly the total amount of money that is needed by non-profit organisations that intervene in critical situations and ameliorate a variety of urgent problems in the fields of health, social services, culture, law, politics, humanitarian aid, philanthropy, religion and the environment (Simon, 1995), it is nevertheless possible to define how much capital has been expended and to what extent the annual amounts that had been raised have diminished from year to year (see Bond, 2009). Reductions in amounts raised from year to year place an enormous strain on non-profit organisations and make it very difficult for them to maintain the quality and scope of their operations from one year to the next with fewer resources. It is interesting to note that annual reductions in the amount of money collected through fundraising affect mainly the e-fundraising sector (electronic fundraising that is based on Internet services or mobile systems). These (electronic) forms of fundraising have suffered far more from reductions in expected targets during the last two years than have traditional face-to-face (or door-to-door) fundraising methods. It has been hypothesized that face-to-face fundraising methods have been far more effective in raising more funds for their organisations because of their consistent investment in the training and preparation of volunteer fundraisers (Jordan, 2009).
In 2003, the United Nations (UN a, 2003) published guidelines that recommended certain standards and norms for the development and publication of data emanating from non-profit organisations. This report includes recommendations about the necessity for detailed

data about non-profit organisations, their activities and how volunteer activity should be divided to reflect national components. Although the data in this handbook is over a decade old, it nevertheless offers essential insights into the way in which voluntary work should be organised. In the years between 1995 and 1997 in Finland, the percentage of the population that made voluntary donations was 33%. The average for the European Union was 32%, and the average for the United States of America was 49% of the population (UN b, 2003).

Experts and analysts in this field agree that non-profit organisations have been aggressively positioning themselves in commercial settings (Weisbrod, 2000) because the benefits that might accrue to them from doing this have not escaped their notice. The advantages of being present and active in commercial environments and the benefits that can accrue to fundraising organisations from transforming themselves from non-profit organisations into profit-making organisations that function in competition with traditional businesses and shops, have now been widely accepted (ThirdSector, 2009). It remains to be seen whether fundraising will continue to remain at the high levels achieved in previous years by non-profit organisations once they become thoroughly commercialised and so possibly less deserving of support in the eyes of their established donors.

The administrative costs and the costs of promoting and expanding fundraising activities can exert a decisive effect on the organisational structure of fundraising organisations. The running costs of very large non-profit organisations in the United Kingdom vary from between 23% and 25% of their total income (Unicef UK, 2009; RNID b, 2008), while the equivalent amount for similar fundraising organisations in the United States is about 18% (Bradley et al., 2003). According to Bradley et al., the administrative and running costs of fundraising organisations could be reduced by 5-10%, with an equivalence in total savings for all such organisations of up to $100bn. The debate on how to effect savings is certainly not yet over. There is, for example, ample scope for internal structural reforms to their systems that many organisations could carry out without any outside assistance, that would substantially reduce costs and increase efficiency.

Finally, according the report entitled *Toward a New Asian Development Bank in a New Asia* from the Asian Development Bank (Panitchpakdi et al., 2007), 90% percent of the population in countries that are now reasonably stable will experience widespread *severe* poverty by 2020. This report is a warning to donors to prepare themselves for the advent of these conditions. The United Nations report entitled *The Millennium Development Goals Report 2008* (UN, 2008) emphasises that the fight against poverty in developing countries will require not only political will and determination but also *adequate funding* in the long run. While this United Nations report emphasises that both private and non-governmental organisations play a crucial role in a campaign against poverty, it also recognises that the actual amounts currently being collected are still inadequate for the purposes for which they are needed.

The revenue collected by fundraising organisations has to be adequate to finance the following activities, processes and assets:

1) Logistics
2) Administration
3) Technology
4) Personnel training
5) Budgeting
6) Investment goals

Our interests for the purposes of this paper and for future research are centred mainly on **technology** (the need to devise and develop additional forms of fundraising technology that will empower the work of fundraisers) and **investment goals** (the need to support current modes of fundraising by integrating them with various tried-and-tested procedures of elearning).

2.2 The need for fundraising: Some global reference figures

According the United Nations publication entitled *The Millennium Development Goals Report 2008* (UN c, 2008), there were last year (2008) a total number of 42 million displaced people throughout the world whose lives had been disrupted by various kinds of conflict and persecution. The United Nations itself was active in caring for 16 million of these refugees. When one examines what this publication as to say about the employment rates from various regions of the world, the following figures emerge: in the developing regions of North Africa, Western Asia and Southern Asia, the employed female population stands at only 22%, 25% and 34% respectively, as against the male employment rate of 70% (for the countries of North Africa and Western Asia), and 78% (for the countries of Southern Asia). These figures make it clear that the employment ratio of females in these regions is, on average, over 40 points lower than that of men in the same countries, while there is, on average, a difference of 20 points between male and female employment rates if one combines the figures for the remaining developing regions. The report notes that the creation of works that are specifically reserved for women and that are supported by local existing institutions would increase the employment rate of women and that this would enable these women to meet their family responsibilities more effectively than they do at present.

One in five of the workers from developing countries currently lives in extreme poverty because of low salaries and because about half of the jobs they have are temporary, ad hoc, transitory, frequently exploitative, and without guarantees or state regulation of any kind. When one analyses what the report has to say about nutrition, one notices that the number of undernourished children under the age of five has dropped from 33% (in 1990) to 26% (in 2006). This figure of 26% corresponds to over 140 million children (UN c, 2008).

Education in developing countries is also affected by poverty. The United Nations report mentioned above (UN c, 2008) shows that only 65% of children from the poorest strata in society in the countries surveyed had ever attended primary school as opposed to 88% of those from the richest strata of the populations concerned. In addition, a total of 84% of children in urban areas attended a primary school while only 74% attended such a school in rural areas. Even in refugee camps, only 6 out of 10 children are enrolled for primary education. In developed countries in 2006, primary school enrolment rates for girls was equal to that for boys (namely, 100% for both genders), while in developing countries the rate was 94 for each 100 boys who were enrolled (UN c, 2008).

While the mortality rate for children under five was 0.6% in developed countries, it was 8% in developing countries (UN c, 2008). Of the 500,000 women who died in 2005 (UN c, 2008), childbirth or in the six weeks following delivery, 95% of these deaths occurred in developing countries. While the number of women who die from complications incurred during pregnancy in developed countries is 1 out of every 7,300, the equivalent fatality rate in the sub-Saharan region (the developing region with the most fatalities during pregnancy and delivery), is 1 out of every 22 women. But what is of greatest concern for those who campaign for the treatment of HIV/AIDS patients, the proportion of population in developing countries who needed HIV retroviral therapy in 2007 was 31% while the equivalent figure was 22% in 2006 (UN c, 2008). These figures speak for themselves.

2.3 Learning in fundraising

The data and information provided by fundraising organisations together with available reports and reviews of their activities, indicate that such organisations are becoming more and more aware of the importance of motivating donors so that they will be willing to at least maintain the level of their past donations, even in the unfavourable economic climate that is currently afflicting the world. On the one hand, it is necessary for organisations to focus on the public perception of the charitable or humanitarian work that they undertake as well as on their status as reliable and trustworthy organisations, so that they will be in a strong position to continue soliciting funds from donors (Simon, 1995). On the other hand, it is vital to reinforce the perception of donors that it is their contributions that enable the recipient organisations to continue with the implementation of their humanitarian activities. It is this perception on the part of donors that motivates them to continue making donations from one year to the next (Huang et al., 1995; Ajzen, 1991). The more donors can be made to feel that they are playing a vital part in the maintenance of the organisation to which they contribute and in the realisation of its goals, the more likely they will be to continue to support the organisation as long-term, stable donors. Research has indicated that if current donors are given informative, periodic information in a suitable format about the progress, achievements, hopes and intentions of the recipient organisations, they will be more likely to continue their support in the future (Ajzen, 2006). It is the purpose of this paper to point out that fundraising organisations can maximise their donations by using appropriate methods of solicitation if they implement those learning principles that have been proved to be effective in motivating people either to become donors or to continue making donations to those fundraising organisations that they have supported in the past.

Most fundraising organisations have well-established procedures for reinforcing favourable donor behaviour on the part of their benefactors or on the part of potential donors. These procedures vary according to whether donations are solicited on the Internet or as a result of personal, face-to-face solicitation activities. It has already been established that the potential for reinforcing favourable learning behaviour on the part of donors or potential donors is far more effective when the solicitation is made online. The reason for this is that information that is entered online can be processed for more quickly than information obtained from donors who are making donations as a result of a personal, face-to-face encounter.

2.3.1 Differences in motivational potential in online and face-to-face fundraising

Most of the major fundraising organisations that operate online (such as, for example, the RedCross, 2009; UNHCR, 2009; Unicef, 2009; GivingUS, 2009; UICC, 2009; MSF, 2009) seek to reinforce favourable donor attitudes by providing their donors with carefully selected descriptions, figures and statistics at summarise their achievements and their future goals and needs. In some cases (such as those in FELM, 2009 and Unicef CH, 2009), graphics and animated interfaces are utilised to reinforce the benevolent intentions of current donors and motivate potential donors to become permanent benefactors of the organisation. But even when the quality of information is as sophisticated as this, the organisations concerned are still not benefiting from the kind of immediate feedback on donor behaviour and preferences and the various modes of interactivity that have been shown to be extremely effective in motivating current and potential donor behaviour. In most cases in which donation data is collected and meticulously processed before it is passed on to current and potential donors, no (or minimal) emphasis is placed on determining and responding to the personal preferences and wishes of donors.

The proper utilisation of certain human factors is fundamental in effective face-to-face fundraising. In many cases, it would seem to be is more effective to invest in the training of skilled human donation solicitors rather than to rely on the undoubtedly positive effects of proven online learning strategies – while both of these methods produce far better results than the kind of traditional solicitation methods that rely on standardised brochures or regressed in people to commit themselves to future donations by means of their signatures on a pledge.

Research conducted by Lake (2008b) and Jordan (2009) has demonstrated that face-to-face solicitation of donations is more effective than solicitation by means of online approaches in times of economic recession such as that which currently holds the world in its grip. This has been attributed to the value that donors place on the human interactions that they experience, as well as on the greater availability of volunteers and the ability of human donors to adapt their approaches during the interactive process. It is evident that the "human touch" is highly effective in augmenting the provision of data and information that is offered to potential donors in pamphlets, brochures and other kinds of publicity material. It has been hypothesised that online systems are not less effective because of the computer illiteracy of potential donors or their inability to grasp the significance of the information that they receive, but because the absence of immediate human contact, interactivity and the warmth of face-to-face encounters diminishes the impact of the information that is offered by soliciting organisations. Even though most fundraising organisations have long been aware that they have not yet maximised the potential of their donors (i.e. the amounts that individual donors would be willing to contribute under different circumstances), they had no idea about what they should do to remedy the situation. There are a number of academic studies (such as those of Thorme & Root, 2002; Pritchett, 2002; Mondi et at., 2007) that demonstrate (1) how motivation is closely related to learning, and (2) how goals that are relevant to the interests and concerns of learners, improve the quality of learning behaviour.

3. Existing technologies that promote fundraising goals

Many countries support the fundraising efforts of non-profit organisations by making direct contributions to their budgets or by creating tax-related mechanisms for those who wish to donate funds to an organisation of their choice. In some countries, for example, individuals and corporations are encouraged to indicate their desire to support particular non-profit organisations. Their government then makes a *pro rata* donation from their tax to the organisations concerned. Apart from the well-known formats of face-to-face and mail-dependent solicitation systems (even though the latter have proved to be expensive, ineffectual, cost-inefficient and repellent to potential donors), more and more fundraisers are making use of a variety of e-fundraising methods. Existing e-fundraising methods (according to BlackBaud, 2009; Kipnis, 2009; Andresen & Mann, 2007) can be categorized (for the purposes of this study) into those that are:

1. media-based
2. Internet-based
3. sponsor-supported
4. telephone-based

In the section that follows, the technology utilised by each of these methods will be described in turn.

3.1 Descriptions of the technology utilised by each of the above-mentioned methods

3.1.1 Media-based technology

Medi- based technology uses mainly radio and television programmes or inserts. While the fundraising organisations themselves usually pay the cost of transmitting the programmes concerned, many radio and television channels offer a certain amount of free broadcasting time to approved organisations. The audio and audio-visual programmes and inserts (most of which are short commercials that appeal for donations with which to fund the activities of the group) are professionally designed and produced in order to make the best possible impact on potential donors. These appeals for donations have come to be known as *aid solicitations*, and they are inserted into particular kinds of programmes in order to achieve the greatest possible impact. Agencies of governments will also, in some countries, offer various kinds of assistance in order to achieve an optimal distribution of these solicitations. Occasionally, humanitarian organisations will utilise CDs or DVDs to get their message across to the public because these options are less expensive than straightforward advertisements that are inserted into scheduled programmes.

3.1.2 The Internet

Internet-based methods for soliciting donations tend to use the following three main methods of attracting voluntary workers and accumulating capital:

(1) They appeal for online donations.

(2) They offer online subscriptions that entitle respondents to membership of an organisation, a periodic newsletter and active support from the organisation for a specific length of time.

(3) They appeal for committed individuals who will be prepared to donate specific, regular amounts that will help the organisation to get its head above water in times of unforeseen need or crisis.

While many Internet-based systems are frequently simply a kind of electronic carbon-copy of what appears in the organisations' journals, they also are able to include far more data than can be contained in journals. The Internet-based format includes articles, fundraising figures, pictures and photographs, online videos, statistical graphical data that indicates the extent to which goals of the organisation are being achieved, and links to other relevant websites. They also offer secure access to donation pages and the opportunity to leave messages and comments. In some cases, organisations offer small gifts in exchange for donations. Donors thus receive small but useful gadgets or other desirable objects as an expression of thanks for their generosity. This exchange of symbolic gifts for donations has been found to be effective because it increases the sense of relationship that donors have with the organisation to which they have contributed.

3.1.3 Sponsor-supported methods

Sponsor-supported methods are usually embodied in the following two forms: (1) Hidden support methods. These methods are not necessarily hidden from view (although they can be at the discretion of the owner of the media or the sponsor of the provider). They are based on the calculation of a percentage of the commercial profits that devolve to the fundraising organisations involved. (2) Expressed support methods. In these cases, the commercial or legal entity aims at achieving a synergy between its own online products and the fundraising organisation concerned.

3.1.4 The *telephone based* soliciting.

Telephone-based soliciting has recently been opposed by a number of consumer organisations, and seems to be falling gradually out of favour. Telephone contact is nevertheless still used for making direct contact with potential and actual donors, and also for gently reminding established donors that their donations might be overdue. Telephone surveys are also used for investigating specific problems, and for attempting to gauge (by means of Gallup poll-type surveys) the kind of future support that an organisation might expect as they engage in strategic planning. According a recent survey (Harvey, 2009), telephone soliciting is the third-least cost efficient method for soliciting donations, ahead of the direct mail method and the use of newspaper advertisements.

3.2 How these forms of technology are used in fundraising campaigns

Large and well-established fundraising organisations (such as UNICEF and the Red Cross), that are already well known to the majority of the public, find it easier on the whole to use various forms of media technology and to benefit from their uses. Such organisations are supported by large numbers of established donors because the range of the operations is far wider than those of smaller, local organisations. But these smaller organisations can make effective use of local media and online programs to generate support for the causes.

While the Internet is widely used by all fundraising organisations in developed countries, the quality of their services and the methods that are used on websites do not vary much in proportion to the size of the soliciting organisation. All organisations – whether large or small – tend to approach their clients in the same way. Their websites offer online opportunities for donors to make contributions, to subscribe to membership of the organisation, and to recruit volunteers who are freely willing to serve the organisation in whatever capacities the organisation needs (Kipnis, 2009). Nowadays it is usually only small- and medium sized fundraising organisations that make use of the telephone for direct soliciting, and then only rarely. Because so many of these small- and medium-sized have been disappointed by the amount of money that they are able to raise by using technology- and Internet-based appeals, they are turning more and more to face-to-face methods of soliciting without actually closing down their online solicitations sites.

3.3 The failure to apply research findings to online learning processes

The methods that fundraisers use to condition their donors by applying what is known about human learning and conditioning processes are very similar to those used by non-fundraising organisations. The commercialisation of the media throughout the world has exerted a strong influence on the methods selected by non-profit-making organisations to achieve their aims. These organisations use tried-and-tested techniques on their websites to attract the attention and cooperation of potential donors by combining statistical data with images, text, video and other online methods. Unfortunately, however, they frequently fail to consider the *saturation* point (the point at which a generic user has absorbed the maximum amount of data that they can handle at any given time) and the *immunisation* point (the point at which users develop a strong resistance to the messages contained on the site). There is an ongoing discussion among academics about the way in which technological fundraising strategies could be changed for the better. Some feel that there is a strong need to reach people individually and to motivate them to enrol as future donors while at the same time inspiring established donors to continue making donations. Others feel that what is already known about advanced elearning techniques is not being adequately applied to the actual methods that are being used online to solicit donations.

4. Modern learning paradigms that are relevant to fundraising technologies

While most fundraising organisations use widely accepted methods for approaching and motivating donors, most tend to underestimate the communication possibilities inherent in certain modern forms of technology. The fact that many fundraising organisations have begun to operate as profit-making organisations that sell their products seems to have made them oblivious or one of the most important ethical imperatives for fundraising organisations, namely, educating their donors in the importance of the moral dimensions of charitable donation as well as the necessity for the services that they provide to those who cannot provide them for themselves. More attention is thus devoted to planning strategies to accumulate the funds that they need to maintain the organisation and its work at the expense of teaching their donors about the importance and value of giving to charitable and humanitarian causes as a moral activity that is valuable in itself. A typical scenario encountered by online users who access fundraising organisation websites is the following:

1. A main page that contains a number of links by means of which the user can access other categories of information.
2. An assemblage of a pictures, figures, videos and diagrams that explain how the most recent solicitation campaigns have fared together with extensive articles that are concerned with the issues that would be of interest to those who are most likely to become donors.
3. Site maps that direct a concerned user to explanatory information that describes the history and mission of the organisation as well as information about the past and present activities in which it has engaged.
4. Link(s) for accessing a secure donation page on which those who so desire can record their personal data and commit themselves to making various kinds of donations as well as offering whatever other voluntary services the organisation may need to further its aims.

It is evident that this kind of website structure and layout strongly resembles that of a well-organised book that is intended to provide students with the greatest amount of relevant information in the briefest possible format. The title page thus serves to introduce the reader to what he or she might expect in the book. The links on the website are equivalent to the table of contents that describe the chapters. The articles on the site are equivalent to the chapters of the book. The site map serves the same function as the index. Photographs, pictures and figures serve the same function in both formats. The secure donation page on the website is equivalent to a card inserted in the book, that solicits funds to cover production and distribution costs. Just as books that are unwieldy, unattractive and poorly organised are unlikely to attract readers, so a website that is poorly organised, confusing and unattractive will attract a few readers and even fewer donors. A table of contents that contains incomprehensible and poorly constructed chapter and section headings, will immediately alienate the average reader. Content that fails to stimulate interest will not motivate readers to further investigate what the book has to offer. Just as a reader who is intriguing by all the factors mentioned above will become more involved with the actual content and purpose of the book, so a reader who is antagonised by all the negative factors referred to above will quickly lose interest in whatever the book has to offer – however valuable it may be. The parallels between an effective book and a website that attracts and holds the attention of an online viewer, are helpful for understanding what it is that is required to make a fund-soliciting website effective.

Some organisations, such as those that partly or wholly use the informative graphic interface of FELM (2009) and Unicef CH (2009) are largely successful in educating donors in the value of their contributions for alleviating distress and furthering the work of humanitarian and charitable organisations. But such websites represent only a small fraction of those that are designed to motivate new donors and persuade established donors to maintain their support. The vast majority of fundraising organisations tend to rely on the conscience and compassion of potential and established donors to motivate them to give or to continue giving. In so doing, they place an inordinate emphasis on the kind of information that is contained in graphs, numbers and statistics – information that is mostly indecipherable and incomprehensible to the majority of non-specialist donors. This kind of approach is naïve and shortsighted and is bound to be ineffectual in the long term. Organisations that rely on such uninspiring, conventional and traditional methods of motivating donors will probably encounter great difficulty in increasing the amount of their donated capital and the number of their participant donors in the long run (Ajzen, 2006).

When we assess the value of modern learning paradigms in the fundraising sector, it is vitally important to emphasise the fact that technology will completely transform learning processes in the education industry within the next five years. Much progress has already been made in the transformation of education in highly developed countries, and, in the absence of catastrophic unforeseen circumstances, we will witness a period of exponential growth in the use of elearning as elearning as it replaces conventional "talking head" lecture-room teaching and learning in the education system (Glenn, 2008). For this reason alone, it is both naive and shortsighted to expect that there a similar transformation is unnecessary in the world of fundraising technologies. It is fact vitally important to the survival of fundraising organisations for those who design their methods and approaches to make full use of the proven successes of elearning methods in the academic world. If fundraisers incorporate the lessons pioneered by elearning experts into their fundraising approaches, they will be able, not only to educate their donors in the moral and ethical value of donation as a humanitarian activity, but will also be able to motivate established donors to remain on the donor list and to increase their donations as and when they can. Any failure to understand the way in which people have become accustomed to being approached in this electronic age is bound to undermine the financial health and the administrative viability of donor organisations in the years to come.

5. RoboBeggar and InfoKiosk: description and analysis

The architecture of the InfoKiosk software that was installed in the multimedia kiosk is a variation on the original software that was used for the gynoid RoboBeggar (see Figure 1 above for photographs of both the RoboBeggar and the InfoKiosk). An anthropomorphic avatar was integrated into the software of the InfoKiosk system by the creation of a frame distribution in the user interface (De Carlo, 2007). This enabled the necessary modularity changes and updates to the software elearning components, and these factors ensured that all the advantages of Java easy *object oriented programming* would be preserved. The software components that were removed from the InfoKiosk included the microcontroller of the motor (because the robotic hardware had already been removed), and the internal Internet browser software. While the RoboBeggar robot interacted with users by means of movements, verbal communications and touch-screen responses, the InfoKiosk interacted with users by means of a touch screen, verbal communications, and the actions and reactions of the avatar. The modules that were deactivated in the InfoKiosk were still present (though dormant) in the software and were thus ready for possible reactivation should it become necessary to construct a robot that required the RoboBeggar software or the hybrid version of the software in the InfoKiosk.

It is necessary at this point to say something about the Java program that is part of the two fundraising hardware systems. The software of both the RoboBeggar and the InfoKiosk fundraising systems connected the various modules which, in turn, interacted with one another by means of a message-passing mechanism. The main module of the system was the *kernel module*, which was responsible for the behaviour of the system because it regulated the function orders and commands. When the whole programme was loaded into the system, all of its components, as well as the configuration of the system, were stored in XML files. These included the sound responses, the repertoire of movements performed by the robot, and the different attitudes and responses that the avatar was able to convey to a user. The InfoKiosk software was finally reconfigured so that it could run from within any directory and maintain stable databases.

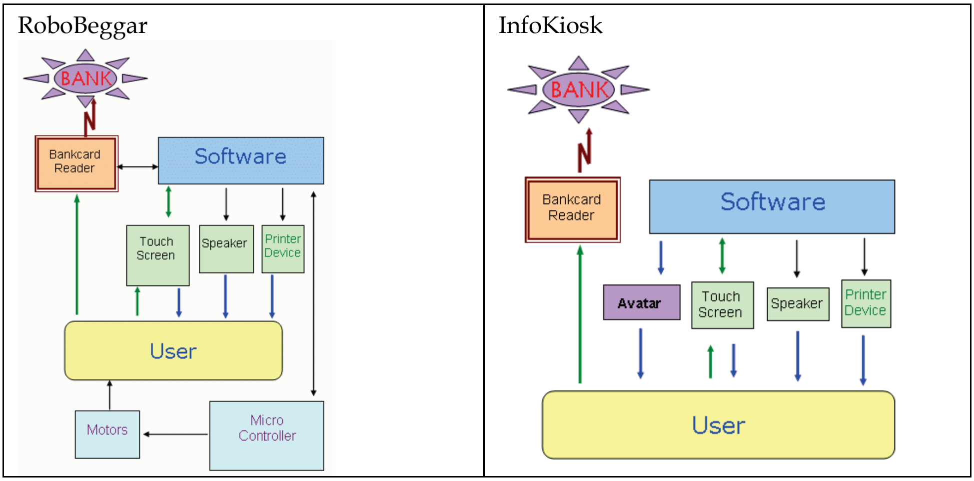


Fig. 2. The respective structures of the RoboBeggar (left) and the InfoKiosk (right)

5.1 RoboBeggar architecture

The RoboBeggar was an interactive automated robot designed for various fundraising purposes and elearning activities (La Russa et al., 2005). Elearning modules were integrated into the software so that possible donors might become sufficiently motivated and intrigued to make donations. The robot consisted of a complex combination of software and hardware devices that included:

- Software (to manage and control the whole system)
- A touch screen (so that users could enter their inputs into the software)
- Servomotors (to move the robot's head and limbs
- A microcontroller (to control the robot's movements)
- Speakers (for enunciating vocal communications to the users)
- A printer (to provide users with a receipt describing their completed bankcard operations)
- A bankcard reader (so that the users' accounts could be charged according to their instructions)

The servomotors controlled the movements of the head, the arm and the hand. The robot itself was able to move through 6 degrees of mobility (DOM). The software controlled the movements of the robot by means of a microcontroller that was connected to the system through a serial port (COM1). The robot could make a range of appropriate pre-recorded vocal responses about its purpose and donations through its loudspeakers. The touch screen presented a selection of data, pictures and information relevant to the fundraising targets to its users. Since the successive actions of users were tracked through their interactions with the touch screen, the software was able to count the amount of idle time and the time that passed between any two events initiated by a single user. The bankcard reader, which was provided with GSM transmission for the communication of data to banks by means of secure servers, was connected to the system through a serial port (COM2). The bankcard reader was therefore capable of reading the bankcards' magnetic tape and charging the required amount to the donor's bank account via the GSM connection. The printer, which was integrated with the bankcard reader but which was easily detachable so that it could operate through an external standard printer, provided the donor was a receipt after the money transaction had been completed.

5.2 InfoKiosk architecture

The InfoKiosk software was based on the core software that we had already used for the RoboBeggar because it was also designed to solicit donations for different purposes by using elearning modules and vocal communications (La Russa et al., 2008). The virtual avatar software was therefore adapted from the robotic program. This software was then installed into a multimedia pillar kiosk that was about 80 cm in diameter and 160 cm tall, and which was equipped with electronic components and multiple connectors (Figure 1).

Interactions with users occurred by means of a touch screen. During interactions with users, at the user interface always portrayed an image of the anthropomorphic avatar so that it could function as the "ego" or virtual personal identity of the InfoKiosk. The main purpose of the avatar was to encourage users to interact generously with the system by creating a friendly, amusing and interesting interface during the donation solicitation process and during that time that the donor passed through the various stages of the automated learning program. The successive phases of the interactions generated by the InfoKiosk were basically very similar to those used by the RoboBeggar because they both used similarly structured e-learning modules (screenshots with associated vocal messages and graphical information). Even though some users remembered the RoboBeggar from their previous interactions with it, none were able to recognize the similarities between the user-interface software employed by both systems. The microcontroller and the motors in the original architecture were rendered dormant even though they remained present in the code of the common software. Figure 2 presents a graphic representation of the architectural structure of the InfoKiosk. Figure 3 (below) are screenshots that capture the appearance of the avatar and the way in which it was presented to users.

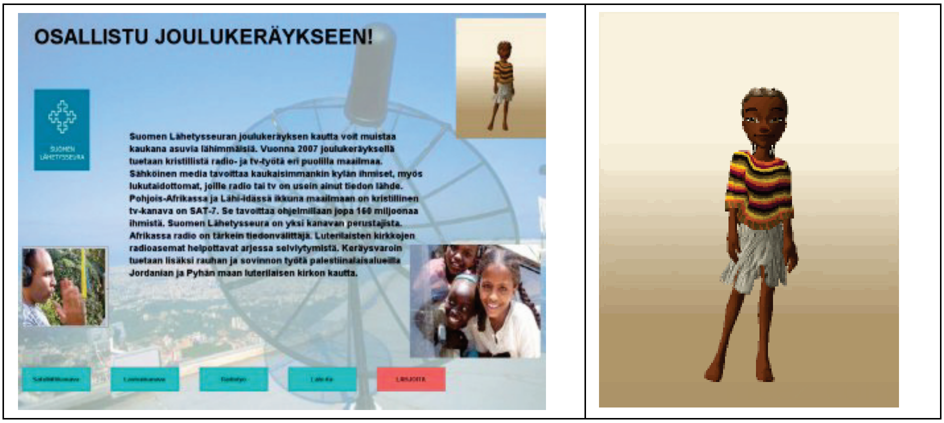


Fig. 3. A main window of the InfoKiosk user interface (left), and appearance of the avatar (right)

5.3 Analysis of the data from the test cases (trial runs)

Multiple Choice Questionnaire (MCQ) forms that were designed to provide the researchers with additional data for use in analysis and evaluation, were offered to people who approached the fundraising systems during their trial runs. The questionnaires were similar for both systems, and consisted of questions that provided information about:

(1) Gender
(2) Age group
(3) The functionality of the RoboBeggar/InfoKiosk (seven questions)
(4) The effectiveness and influence of the RoboBeggar/InfoKiosk (four questions)
(5) User evaluations and assessments (five questions)
(6) The donation system application (four questions)

A blank space was included in which users could write any additional messages they wished to send to the researchers and/or the designers of the RoboBeggar or InfoKiosk. A message in large bold letters at the bottom of the first page of the questionnaire requested users to record any additional personal observations, contributions or comments on the reverse side of the questionnaire form.

In order to avoid confusion or interpretative errors on the part of the researchers, users could respond in one of two possible ways according the type of question being asked (Uebersax, 2006):

(1) They could express their opinion in terms of the following scale:
1 = My opinion is completely different.
2 = My opinion is largely different.
3 = I cannot decide on an answer (I am unsure).
4 = My opinion is largely the same.
5 = My opinion is exactly the same.

(2) They could choose one of the following three options:
- No.
- I cannot decide (I am unsure).
- Yes.

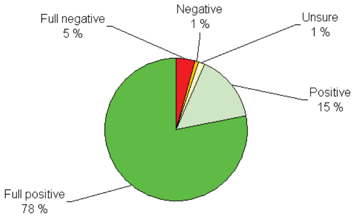
The comparable data collected during the trial runs of the RoboBeggar and the InfoKiosk is represented in parallel diagrams in Table 1 (below). The data is presented by means of percentages of total answers obtained in response to specific questions or statements. The RoboBeggar and InfoKiosk trial runs were undertaken in Finland between 2003 and 2008. These trial runs or test cases were conducted at the following places and on the following occasions (La Russa et al., 2008):

1. *Large Non-Profit National Meeting Case*. June 2003. Thousands of people attended this meeting. Its purpose was to attend to various matters concerning the activities and business of a large non-profit national organisation.
2. *Bank Hall Case*. September 2003. The purpose of this meeting was to consider matters relating to fundraising campaigns in developing countries. We placed the RoboBeggar inside a bank hall through which hundreds of people were passing by.
3. *Cancer Campaign Case*. February 2004. The purpose of this meeting was to consider matters relating to a fundraising support campaign on behalf of a national non-profit cancer-fighting organisation. We play the RoboBeggar in a mall where thousands of people passed by.
4. *Developing Countries Case*. December 2004. The purpose of this meeting was to launch a non-profit organisation to support various causes in developing countries. We placed the RoboBeggar in the entrance hall of a modern church which was attended by hundreds of people every week.
5. *Work With People Case*. December 2007 to January 2008. The purpose of this meeting was to support the campaigns of a non-profit organisation that was engaged in humanitarian work with people in developing countries. We placed the InfoKiosk in the entrance hall of the same modern church building that was used in the case of the *Developing Countries Case* (#4 above). Hundreds of people attended the meeting.

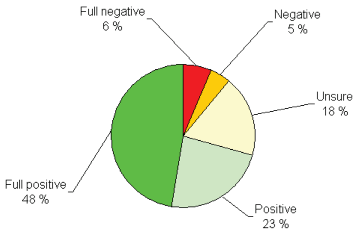
We analysed the data so that we could obtain a clear idea of how the two systems performed when faced with similar fundraising goals and similarities in objectives and achievements. The graphic below (left) presents data collected by the RoboBeggar during the *Large Non-Profit National Meeting Case* event that was made available for interaction with meeting participants throughout the whole course of the event. The graphic below (right) presents data collected by the InfoKiosk during the *Work With People Case* events that took place in a church that volunteered the use of its buildings for the occasion (La Russa et al., 2008). We took deliberate steps to ensure that the structure of the elearning modules remained structurally similar in both systems so that we would be in a position to make valid comparisons between the different sets of data at a later stage. In some cases, users took the opportunity to make a variety of personal comments and remarks. Even though some users remembered the RoboBeggar from previous interactions, they failed to recognize that the user-interface software that was used in both was in fact the same software. Additional data included data obtained from Focus Group interviews and observations of the behaviour of users as they interacted with the two systems.

Feedback from the RoboBeggar test cases

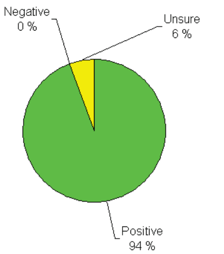
Overall opinion on the functionality of the RB



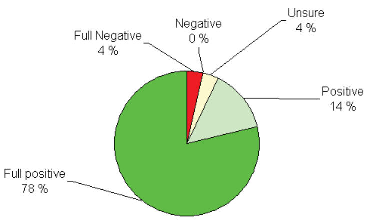
Overall opinions on the impact of the RB



Did the RB succeed in its tasks?

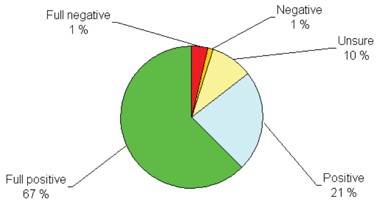


Donating was fun with RB

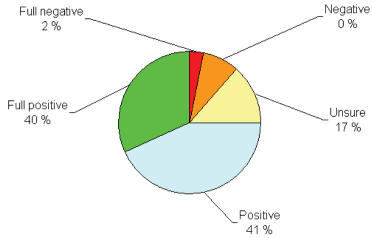


Feedback from the InfoKiosk test cases

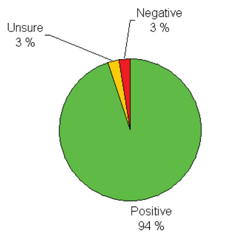
Overall opinion on the functionality of the IK



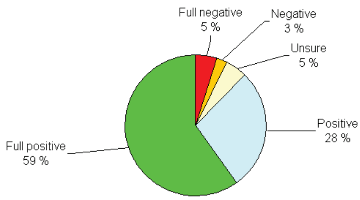
Overall opinion on the impact of the IK



Did the IK succeed in its tasks?



Donating was fun with IK



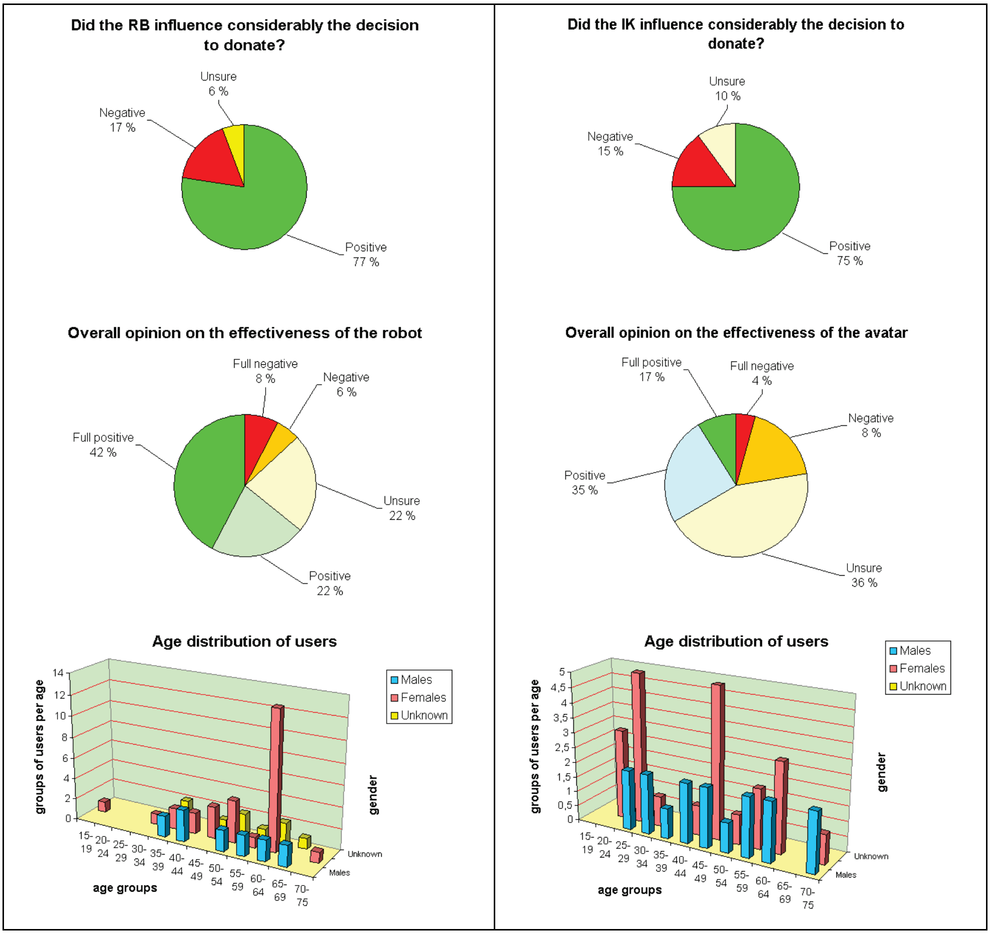
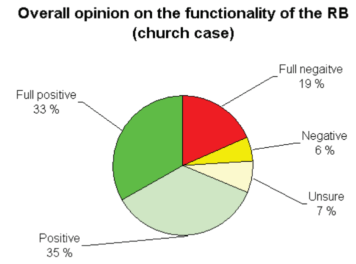
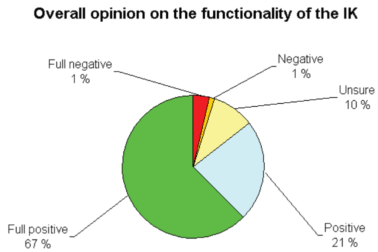


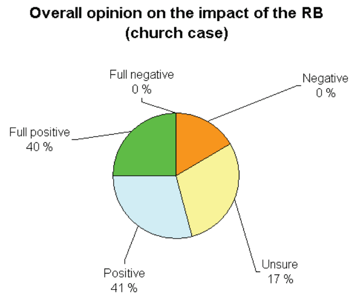
Table. 1. An analysis of the data that was obtained during interactions between the RoboBeggar and the InfoKiosk and their respective users

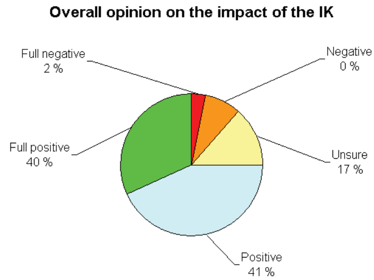
We set up the RoboBeggar and the InfoKiosk on the same premises (Figure 1 shows how they looked when they were on the same location) so that we would be in a position to detect differences in their performances under similar circumstances. Table 2 (below) sets out the most significant differences between the two systems from an analysis of the feedback data in adjacent columns (below).

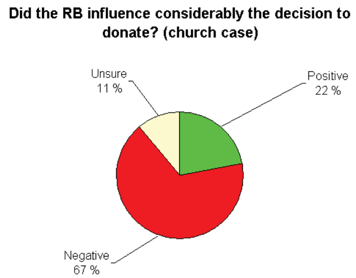
Data relating to the RoboBeggar when it was set up in the same premises as the InfoKiosk	Data relating to the InfoKiosk when it was set up in the same premises as the RoboBeggar











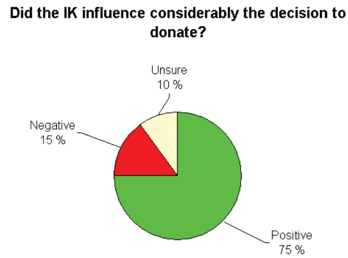


Table 2. An analysis of comparative data when the RoboBeggar and InfoKiosk were set up in the same environment

The most striking differences were observed in the reactions of people to the two systems when the RoboBeggar and InfoKiosk were set up on the same church premises and when the RoboBeggar was set up in other (secular) environments. The cognitive reactions of the donors were for some reason more pronounced when they used the InfoKiosk on the church premises than when they used the RoboBeggar in the same location. The RoboBeggar performed well in other locations and during other events, it did not perform as well as the InfoKiosk under similar church circumstances.

All in all, these elearning-based fundraising machines proved to be both efficient and effective in soliciting donations if they were set up in appropriate environments. The InfoKiosk in the *Work With People Case* (in the church environment) outperformed the RoBobeggar in the *Developing Countries Case* (in the same church usage) because of its non-intrusive hardware (even though the two systems were utilising practically the same software structure and very similar elearning modules). The data shows that people reacted negatively toward the RoboBeggar because of its humanoid appearance. Our personal observations on these two test cases also confirmed that the humanoid appearance of the RoboBeggar made many people who approached it feel uneasy. The people who used the anthropomorphic robot were at the opinion that the anthropomorphic robot would be more appropriate for locations other than church premises. People felt reluctant to interact with the RoboBeggar on the church premises because of what they felt were the spiritual implications of *human beings* interacting with *humanoids*. The cultural and religious education of the members of this church (i.e. their conviction that a church should only be used by living people), made them feel acutely uneasy about permitting a robot that mimicked human behaviour to perform in a sacred environment. On the other hand, those who were brave enough to use the RoboBeggar for the donation purposes on the church premises evidently appreciated its performance, the service that it made available, and its learning features. But even these people retained a *negative attitude* toward the robot (as is evident from their feedback and comments). The people who attended the church somehow perceived the RoboBeggar as some kind of threat to the supremacy of *human* self-consciousness and uniqueness. The InfoKiosk, by contrast, was perceived as a neutral tool that in no way mimicked human behaviour or consciousness, and they therefore raised no objection to its presence and purposes – even though the software that activated both systems and the routines through which it took all donors were, for all practical purposes, identical. Not even the avatar-like features of the InfoKiosk seemed to bother them.

6. Discussion

Our observations of the behaviour of the people and users of the two systems confirmed that the InfoKiosk was regarded as less intrusive and somehow less threatening than the RoboBeggar. At the end of each of the seven church services after which users were given opportunities to interact with and utilise the InfoKiosk, no one showed any signs of repulsion or uneasiness in the presence of the InfoKiosk or any uneasiness with the way in which it worked. (The InfoKiosk, exactly like the RoboBeggar in the test case *Cancer Campaign Case*, called out to people to approach it and to begin to use the donation system that it contained.) We noticed that people moved around the entrance portal of the church without creating any empty space around the InfoKiosk, while, in the case of the RoboBeggar that was set up in the *Developing Countries Case*, people created an empty space with a radius of about 2-3 meters around it. The only exceptions to this were made by the children who, by contrast, used to approach the RoboBeggar joyfully and playfully out of simple curiosity. We also noted that, during some events, many people were clearly delighted and positively curious about the InfoKiosk – despite the fact that they were obviously in a hurry to leave the place.

The focus group interviews that were conducted with the cooperation of church pastors, deaconess, partners, local workers and event organizers, confirmed the live observations that we made in the *Developing Countries Case* and the *Work With People Case*, namely that people felt relaxed and in no way disturbed in the presence of the InfoKiosk (the only exception to this was that some workers collided a few times with the InfoKiosk because they were either distracted or because they had not yet become accustomed to its presence and location). Those who most enthusiastic about the InfoKiosk were the children. They asked numerous questions about the InfoKiosk and its functions, and the InfoKiosk screensaver (an animated rotating globe of the Earth) became occasions for learning and discussing some of the basic facts of geography). They also wanted to know how they could access the learning modules. This behaviour of children was similar toward the RoboBeggar during the *Developing Countries Case,* and they demonstrated a great deal of curiosity about the mechanical components of the robot.

Apart from the Multiple Choice Questionnaire, people returned some written comments during the trial runs in order to contribute to the systems' assessments and further design. Most of the comments concerned the use of bankcards (people were unsure about whether they could use a debit card in place of a credit card), and some were uncertain about how to operate the bankcard reader (they were uncertain about the direction in which they should swipe the card and how quickly or slowly they should do this in order to make contact with the machine). Some users complained about the fact that the text was too small for their visible acuity in the visual learning modules. In other cases, people made suggestions about how the instructions could be rephrased or corrected in the text of the learning modules. A few users asked for more donation options or access to similar non-profit fundraising organizations to which they wished to contribute. Similar comments were made in the focus groups. We were struck by the fact that people did not attach much importance to the presence of the avatar in the InfoKiosk, but that their attention was more absorbed by various aspects of the learning modules.

The fact that the systems were capable of talking back to donors and users constitutes a milestone in the design and production of machines that utilise human-machine interaction for fundraising purposes and behavioural studies. We fully expected that no one would try to talk directly back to the InfoKiosk, and no one did. But in the case of the RoboBeggar (La Russa & Faggiano, 2004), this happened quite often. While some people have expressed doubts about whether the avatar can help to realise donation targets or stimulate the donation process, an analysis of existing data shows that, in the current state of the art, there is no clear advantage in using avatars in integrated elearning fundraising systems. While the mean average donation for the RoboBeggar (in the *Large Non-Profit National Meeting Case*) was 12.6 €, the mean average donation obtained from the InfoKiosk (in the *Work With People Case*) was 10.9 €. In 2007, the local mean average donation obtained by non-profit organisations (for whom the *Large Non-Profit National Meeting Case* and *Work With People Case* were organised) by utilising the usual (conventional) channels and methods of fundraising, was 5.8 € (Kirkko, 2007). These figures speak for themselves.

7. Conclusion

There is a technological gap that the fundraising organisations should strive to reduce and, if possible, eliminate, and that is the use and integration of advanced elearning technology in their modes of solicitation and strategy planning. Although volunteer work and activities might be partly effective in augmenting below-par e-incomes during times of economic depression, it is our conviction that the neglect of the vital role that elearning can play in motivating donors and encouraging them to continue with their donations, will ultimately subvert and endanger the good relationship that traditionally prevails between donors and the non-profit organisations that they support.

Our research demonstrates that the actual design of the interactive elearning tools is vitally important to motivate and support donors in their conscious process of giving. It is quite possible to substitute self-motivation for face-to-face activity by making use of specifically designed fundraising systems that facilitate positive interactions between donors and solicitation systems. We also demonstrated that the cognitive attitudes of users can be significantly reinforced by intelligent systems that promote optimal donor behaviour on the part of the donor. Such systems need to be designed on ad-hoc basis because of the attitudes and prejudices that people tend to develop by identifying strongly with particular places and circumstances in which certain kinds of behaviour are regarded as appropriate or inappropriate (La Russa et al., 2009).
We also advise designers to use modularity and platform-free software because it is important to reduce costs and the necessity for maintenance in the design of the elearning modules. The design of software based on Java Object Oriented Programming has proved to the very profitable in terms of time saving and the rapid development of new modules and components. The proper design of specific fundraising campaign systems therefore requires experts who are experienced in both elearning and human-computer interactions. Human-machine interactivity (such as refined in computer embedded systems like the RoboBeggar and the InfoKiosk) must be carefully reviewed so that it can be refined and so that the interaction between human beings and the systems concerned can be made as efficient as possible. The modularity of the components is absolutely essential if one wants to design time-saving systems. It is also necessary to pay careful attention to the way in which the surveying tools are organised (this caveat includes the collection of metadata).
The research that we conducted reveals that anthropomorphic robots (such as the RoboBeggar) can be very effective with and attractive to that part of the public who are potential donors, and that they are extremely effective in stimulating affective reactions (La Russa et al., 2009). They do, however, need to be located and used in *open* public (secular) places where their presence will not be regarded as somehow intrusive and inappropriate. We have already indicated how the anthropomorphism of the RoboBeggar can stimulate adverse reactions in sacred places and spaces. In such cases, alternative non-anthropomorphic systems (such as the InfoKiosk) can be used as an effective substitute – provided that those elements that might be regarded as too human, are thoughtfully eliminated. For practical reasons, the dimensions of the fundraising tools need to be suited to the intended usages, the places of collection, and any other predictable working conditions. The best way to create a functional elearning integrated fundraising system is to apply the ADDIE methodology (Analysis, Design, Development, Implementation and Evaluation – Kruse, 2009), and to keep one's focus as a designer on the primacy of the envisaged user's needs and expectations, and not to allow one's own expectations and assumptions to dictate the process (Norman, 2002).
Most online systems will, in the near future, benefit from the use of touch screens. It is much easier to access and use software by means of touch. The time is not far off when most systems will be directed by simple human interactions such as the touch of our fingertips, and the use of the mouse and the click will become largely redundant.

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Learning in Bioelectronics

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1. Introduction

This chapter presents the mobile content evolution of a bioelectronics course, laboratory works, students impact and evaluation feed-back of a new discipline implemented since 2006 in a Faculty of Electronics from Romania. The BioNEC course, entitled Biodevices and Nano-Electronics of Cells, is dedicated to the Biosensors, Biosignals and Biomodeling, accordingly with the nowadays scientific trends. Placed at the cross-point between Biology-Medicine and Electronics Engineering, this course intends to familiarize the future engineers with the new products and applications in bio-engineering.
Electronics benefits on the largest nowadays interdisciplinary system (Nuxoll & Siegel, 2009). The relationship with biology was obviously from twenty years ago, when the integrated biosensors were firstly developed in a microelectronic foundry. In this way, news devices appeared like, IMmuno-FETs with Antibody membrane covering the gate metal, or ENzyme-FETs with a key enzyme entrapped in the Gate of a FET transistor, (Xu et al., 2006). The MOS technology down-scaling allows the integration on the same chip of the biological receptors with the adjacent electronics as Lab-On-Chip. These pieces are included in the "Biodevices" part of the course. The Biosensors act for in vitro analysis and the Implantable Devices act for in vivo applications. Also, in the last year were taken into account special macro-electrodes for non-invasive medicine or micro- electrodes for cells investigations. Among the south-eastern countries, Romania already presents a high morbidity of the metabolic diseases and diabetes over the european countries average, (Ionescu-Tirgoviste, 2007). Therefore, a special attention must be paid to the medical equipments of monitoring for the chronic diseases, (Pearlman et al., 2008).
The above discussion highlights the importance and the real possibilities to build up bridges among micro-nano-electronics, complex biosensors, neuroscience, prosthetics, tissue engineering, genomics, cellular electrophysiology, electrical trans-membranar transport, in an interdisciplinary system. Hence, the necessity of a bio-engineering course in a nowadays faculty of electronics is obviously, probably with the same intensity as in a Faculty of Medicine.

2. The bioelectronics links

The social studies predict an increment of the society mean age, especially in Europe. Therefore, there will be an important growth of the chronic diseases, consequently with an increased cost of the medical assistance. The health assurance companies and public sanitary services have noticed in the Price Waterhouse & Coopers Report "Healthcast 2010", three main directions: (1) Electronic Healthcare; (2) Genomic Perfection; (3) A rise of the individual access to the medical decisions and sanitary services via web and Telemedicine. On the other hand, the bioengineering systems must protect the peoples themselvs, respecting the medical ethics, the person privacy and security. Therefore a nowadays bioengineering course could be oriented to those manufactured tools that directly serves only to the medical act: medical tests, patient monitoring, drug delivery and not only to protect the assurance companies.

The chapter will answer to the following items:

1. The Bioscience overview: opportunities for different "Bio" Courses implementation, in the Engineering Faculties in agreement with the local research and industry branches and university profile.
2. The related disciplines for the implementation of a Bioelectronics Course in a faculty of Electronics.
3. Links for the BioNEC course in our faculty.
4. Evolution of the BioNEC content from a year to another.
5. Applications – labs and projects; our contributions.
6. The evaluation and the students feed-back.
7. The BioNEC research Group developing around this course.
8. Proposal for new directions in the Bioelectronics Learning.

These points concern the possibilities of a bioelectronics course implementation in others educational centres, adding together advantages and disadvantages, difficulties and suggestions.

Our learning contributions are: (a) new proposal - BioNEC course implementation - in a Faculty of Electronics is a successful contribution in the international context, taking into account that this acceptance arisen during the minimization of our, university degree from 5 years to 4 years and Master studies from 2 years to 1,5 years. (b) an adaptive content of the course was respected. (c) our net course contribution is related to Biosensors, Biotransistors, modelling of the electronic behaviour at cellular level, ionophore channels and nanopores simulations in Atlas software, non-invasive biosignal recording for cord, brain and others organs; all these sections don't overlap on others disciplines, neither on the classical Medical Electronics Department from our faculty (focused on apparatus, imagistic and bioinformatics).

Difficulties are: Poor endowment of the labs, lack of some apparatus (e.g. patch-clamp installation, etc). All the master students are engineers and have jobs simultaneously with courses. They cannot attend to all the courses and they came exhausted to assist the course after 18.00 p.m. An unsuccessful approach was to extend the bioengineering course to other Departments from Politehnica University of Bucharest, due to the lack of funds. The weekly schedule for BioNEC is 2 hours for course and 2 hours for applications – quite short to cover the Bioscience with its subsidiary Bioelectronics explosion form a year to another. Therefore the learning was more focused in the lasts years.

Unexpected pleasant reactions were related to the biological phenomenon, adjacent biochemistry, or cellular electrophysiology or medical terms, insertion for a better comprehension of a detection circuit or a biosensor technology. I was afraid to not be out of the Electronics Faculty requirements. But the students encouraged me to teach them about these complementary bio-medical aspects, where they have a high affinity for information. So, don't be afraid to teach biomedical knowledge in Technical Universities.

3. The related disciplines and strategies

3.1. Adaptive course versus research branch

To implement a bioelectronics course, firstly must be evaluated the best direction in a university. Around an electronics materials group the following related disciplines are involved: micro and nanostructured materials, microfluidics, electrical charged fluids, biochemistry, electrochemistry, biophysics and biology with a good jointure to proteomics, biomaterials, biocompatibility. Around an electrical devices and circuit group another bioelectronics course could be succesfully promoted, with related disciplines like: microelectronics, micro-nano-technologies, electronic devices and circuits, related micromechanics (e.g. MEMS, NEMS), with good results in biosensors and biodevices.

Around an electrical signal processing group could be developed a bioengineering course using previous disciplines like: mathematical modeling, statistical methods, electronics apparatus, electrical biosignals analysis in order to process the recorded signals from cells, organs and body. A stong medical engineering group could develop, new electrophysiological methods, clinic or laboratory investigations, new diagnosis protocols, using links with diabetes science, gastro-enterology, neuroscience, pathologic anatomy, medical imagistics, tissue engineering, minimum invasion surgery.

For a general bioelectronics course implementation, some priors disciplines or chapters are imperiously necessary: physics, electrochemistry, mathemathics, signals theory, electronic devices, circuits, microelectronics technology. Then, depending on the course direction, others adjacent disciplines must be previously studied (e.g. a sensor course with MEMS elements must precede a biosensor and biodevice course).

A main problem must be highlighted: in a technical university usually is very difficult to introduce a pure biological discipline to precede the bioelectronical course. Therefore the fundamental biology knowledges accumulated from the high-school period are enough for beginning. We introduced all the related biological and medical knowledges inside the bioelectronics course in this way. Both technical staff of university and students requirements were satisfied.

All the developments in bioelectronics were based on the classical electrical models for the integrated structures functions. Unfortunately, some intermediates stages regarding the biological phenomenon comprehension were lost sake the financial reasons and time consuming. For instance the Huxley equivalent circuit with two simples diodes used to model the Action Potential, propagation through the neuron membrane can be now better replaced with others devices, as SOI-MOSFETs with under-threshold and over-threshold conduction regime, (Ravariu[a] et al., 2006).

Therefore, our BioNEC course wish to establish some physical models for all the non-linear components comprised in a biosensor that must be finally integrated in a global model, in the first part. In the second part, considering the previous models and accumulated experience, some extensions to medical applications are approached: electrical signals recording that accompany the internal organs or muscle contraction – an approach from macro to micro and nano scale.

The modeling of cellular or tissual electrophysiology was impossible due to the high complexity of the living being. Modeling means first of all measurements, then a deeply insight of the phenomenon to understand to whom physical, chemical or biological laws they submit. To directly translate the biological language into a mathematical one is difficult. The fuzzy approach of mathematicians provided stochastic database diseases-symptoms-patients, unacceptable from individualized healthcare point of view. Therefore, we consider that a parallel aproach, using the experience from electronics, which started from the behavioral description of a digital system and descended step by step to circuit level, then to transistor level, up to physical phenomenon description inside the nanotransistors, can be a successful way in biomodeling, due to the well-known and reach experience accumulated in the electronic device area. The biomodeling utility can be expressed in some parameters extraction with high impact in the diagnosis and individualized treatments (the slope or amplitude of an ECG can be easily put in touch with a pathology). The gradual approach from BioNEC course: starting with the well-known MOS, SOI transistors models, continuing with the more complex integrated biosensors structures to highlight the concentration-current dependence, some extensions to the single cell modeling is possible (Ravariu[b] & Botan, 2008), e.g. the math model of the non-linear electrical conduction thru synapses, is a convincing argument to successfully move toward the cellular and tissual electrophysiology modeling.

3.2. Links for the BioNEC course in our faculty

In 2005 the announcement of a bioengineering discipline, entitled “3B course“, was proposed in our faculty and presented with the ocassion of ICL Conference, (Ravariu[c] et al., 2005). The electrical engineer students had the following related disciplines: electronic devices (pn junction, biodevices, contact metal-semiconductor, in II-nd year), physics (semiconductor physics, thermodynamic, cappilarity, in I and II-nd years), electrochemistry (Nerst relation, electrodes, in I-st year), programming (C++ language, in I-st year), microelectronic technology (depositions, diffusions, implantations, etching, in I-st and III-rd year), mathemathics (numerical methods, in II-nd year) and biology form the high-school.

The “3B” course was projected in a new manner: a course with an adaptive contents by the students feed-back; the contents must be adapted to the market and research trends. The evaluation consists in a homework with a high degree level for students. For instance, a student who studies at the communication department will be focused onto the bio-signals transmission or ECG-EEG parameter extraction. They will especially assist to those parts of the cours that covers the bio-signals collecting and processing. If a student is interested by the signal transmission at cellular level, his final work could be a software that simulates the inter-neuronal pulse propagation; he will deeply study the cellular electronic emerging toward neuro-electro- physiology.

3.3 A course motivation

This “3B“ course in conjunction with electrochemistry is easily associated to an electrical engineering specialization due to the implementation of these integrated biodevices in a microelectronics foundry. Another reason is the electrical behavior at the cell level: all cells are electrically charged in cytoplasm and present trans-membranar ionic conduction. The third reason consist in the trends for the electronical devices and sensors toward mixed bio - electrical devices. These tendencies are clearly shown in the changes of topics at a traditional Conference of microelectronics from USA : IEEE Nanotech – MSM *in 2000*: Semiconductors and Microelectronics, Advanced Packaging and Interconnects, MEMS, Smart Sensors and Structures, Advanced Lithography and Photonics, Biotechnology, Microfluidic Systems, Environmental Monitoring and *in 2005*: Quantum Effects, Quantum Devices (Ravariu[d], et al., 2005), Spintronics, Advanced Packaging and Interconnects, MEMS, Smart Sensors and Structures, Advanced Lithography and Photonics, Biotechnology, Genomics & Proteomics, Microfluidics & Lab on Chip, High Throughput Screening, Point of Care Diagnostics, Molecular Modeling, Protein Engineering, Structural Biology, Bioinformatics. A similar deviation occured with the ICNT – International Conference on Nanoscience and Technology from 2006 to present, (Ravariu[e] et al., 2006).

4. Evolution of the BioNEC mobile content

The BioNEC course is dedicated to the Biosensors, Biosignals and Biomodeling aided by electrical engineering. Placed at the cross-point of Biology and Electronics Engineering, this course, was firstly named "the 3B Course", but lately was accepted with the BioNEC acronym. Till now the BioNEC course keept his promise to be an interactive, an adaptive learning environment, which can be extended in the next future toward the great public, removing the psychological walls among a biologist, an engineer or others specialists.

In order to simplify the term, in the following discussion we will refer by the notations BioNEC1, BioNEC2 and BioNEC3 to the BioNEC course learned in the university year 2006-2007, 2007-2008 and respectively 2008-2009. In all these three years, the course schedule has 2 hours weekly, during 14 weeks. The main course sections are:

Chapter 1. Introduction in bioengineering.
Chapter 2. Biosensors.
Chapter 3. Biodevices.
Chapter 4. Biosignals.
Chapter 5. Nano-Electronics of Cells.

The first chapter had the following evolution:

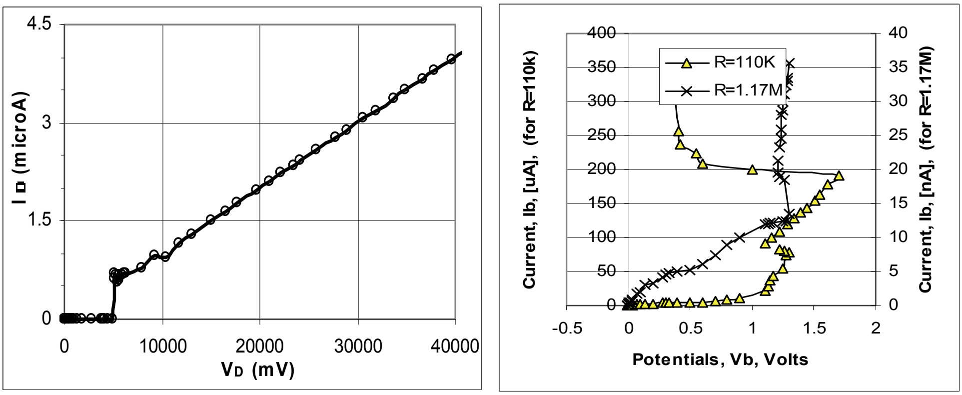
- BioNEC1 describes the chemical and physical signal reception in the living beings as: "From the living cells to the biosensors principles". The motivation is related on the wealth course content about biosensors in the first year, besides to a pedagogical method to draw attention to something new, never before studied in a technical faculty. After one year, the space devoted to biosensors decreases and this presentation, strictly related to the reception and receptors, was moved at the second chapter beginning.
- BioNEC2 replaced the first chapter content with "News challenges in Bioengineering". The aim was to describe the entire topics of bioelectronics with its latest challenges, to capture the student's interests, to demonstrate them the large spectrum of interest in the nowadays academic space and to show them what slice of domain we are learning in our BioNEC course. On the other hand, I let them to elect a project them from the entire domain of bioelectronics in order to test their preferences and interests.
- BioNEC3 generalized the first chapter content to "Bioscience sections". I consider to introduce at the first course as much as possible material about the entire bioscience because the links among biology and sciences increase so much in the lasts years, so the BioNEC course with 2 hours x 14 weeks becomes insignificant. Therefore, I use the opportunity of the first course at least , to connect the students to the huge Bioscience domain, starting with Bioelectronics, Biomechanics and Bioinformatics enveloped in Bioengineering and continuing with the Biochemistry and Biomaterials, Biophysics and Biotechnology, and finishing with the extensions of the medical sciences toward technique, like medical imagistic, nano-cellular imagistic using AFM, neuroscience, nano-tools for manipulation in

genomics or proteomics, electrophysiology – from body to cell, prosthesis and in vivo devices, minimal invasion surgery, tissue engineering, nanomedicine.
In the second chapter the biosensors were studied; this activity will continue to rest in the top of the interests because our master study direction is about “Microsystems” and comes from the “Micro- Opto- Nano- electronics” specialization direction. The semiconductor technologies, the etched architectures in silicon, MOS devices, nanomaterials and microsensors are disciplines previously studied.
However, some deviations occur from a year to another. BioNEC1 approach: Biosensors – definitions & classes; transducers; receptors; small scale integration on biochip; specific technological steps for the biosensor manufacturing; transducer function modeling - from a chemical signal into an electrical signal; many examples of biosensors. An excess of information occurs about many types of transducers: optical, thermal, electrochemical, mechanical, biological intact in Ist year. The time constrains make me to remove the technology for biosensors that passed to another separate discipline, to include here the mechanism of reception in biosensor borrowed from living cells, and only to mention all the transducers and receptors types with a wealth examples of biosensors in BioNEC2. In this case too, the quantity of information was exaggerated. I consider that the deficiency comes from the axiomatic aspect of the course. All assertion must be admitted. The time for explanations, for links with the related disciplines was completely insufficient. Therefore, in the place of a wealth documented chapter about biosensors, without comprehension fundament, in the BioNEC3 stage I opted to restrict the Chapter 2 only to the electrochemical transducers, with a deeply insight on the metal-solution contact, which they never studied before in the Electronics Faculty. The focusing on the electrochemical transducers is justified because they represent the majorities transducers, encountered in conductometric, amperometric or potentiometric biosensors.
In the BioNEC1 stage, the third chapter contains elements about Bio-FETs Family, implantable devices, example of MEMS devices manufactured in the Si-technology (Grundbacher et al., 2009). In the first year the target was to disseminate as much as possible the Bio-FET devices to convince the audience about the possibility to apply the classical knowledge about MOSFETs to unsuspected applications from bioelectronics. As a fact, the, Ion Sensitive-FETs, Membrane-FETs, IMmuno-FETs, ENzyme-FET, Microbial-FETs, DNA-FETs were briefly depicted. The didactical materials concerning the implantable devices, prosthesis, insulin micropump were poorly. Thus, these devices were removed in BioNEC2. All the Bio-FETs transistors were equally approached in the IIst year with the same consequent disadvantage: crowding of information lead to low efficiency in learning. The BioNEC3 course rename the Chapter 3 from “Biodevices” to “Bio-FETs” and was focused mainly on ISFET, ENFET and those Microbial-FETs that involve just a metabolic ion detection with electrodes. In this way, the Chapter 3 becomes related to the Chapter 2 and is approaching the most encountered biodetection method that use the Field Effect Transistor with the analyte transformation into ions easily to be indexed in the gate space of a MOSFET. A short presentation of the kinetic modeling of an enzyme assisted reaction provides the key element to understand the BioFET principle that is missing in an Electronics Faculty curriculum.
The Chapter 4 started in the BioNEC1 case with the Biosignals transmission at cellular level. At that time, the notion of signal in biology was introduced as a variation of a chemical concentration versus time. At the beginning of the chapter 4, in the first year, the evolution

of the matter from inorganic stage to the self-organized stage inside cell was introduced. This presentation had a good impact among engineers accustomed with Si and C as semiconductors, to discover the new alphabet of the living matter formed by 20 essentials amino-acids from C, O, N and H elements. This presentation occurs in every handbook of medicine at the beginning. Unfortunately the main enemy was the time. For this reason BioNEC2 and 3 can't sustain this presentation. The resting transmembranar potential (RP) and the cellular membrane depolarization up to the action potential (AP) as a consequence of an external stimulus recognition was learned. Starting from the cellular electrical signal studied at BioNEC1, the electrophysiological signals at the body level were added in BioNEC2, only as project theme and in BioNEC3 as theory, too. The cropping of ECG, EEG, EMG signals, cutaneous recording, modeling of the normal or deviated signals, specific amplifiers and filters used in electrophysiology and signal processing techniques were introduced in the BioNEC3 stage.
The Chapter 5, entitled "Nano-Electronics of Cells", intends to bring closer the extension of nanoscience from biology to engineering. Finally this chapter offer solutions, explanations and tools for the future medicine in its effort to observe the diagnosis and to start the body restoration from the cellular level.
BioNEC1 spoke about nano-structures inside the cell, electronics phenomenon at membrane level and ionophore nano-channels. BioNEC2 enhanced the content with the trans-membranar electrical conduction modeling by Huxley circuit, simulations and modeling of the biosignal propagation, applications for the neuronal cell. This chapter had the maximum mobile content, in respect with the latest news collected from the web sites and accordingly with the encouragements constantly received from students. BioNEC3 comes with a new excitable cell for study: beta cell from the endocrine pancreas, responsible for the diabetes installation. Here the stimulus is biochemical (glucose) and the reply is electrical as in the neuron case: an action potential that depolarizes the membrane from -70mV to -30mV.
In both years, at the beginning of the BioNEC course, the students asserted a better affiliation to the Biosensors and Bio-FETs, probably due to a better relationship of these chapters with previous disciplines. Also in the firsts 1-2 courses they were very reserved versus the Chapters 4 and 5. But every year, the Cellular Nano-Electronics and intercellular biosignals produced the maximum impact on the students at the end.

5. The applications: lab and project

The applications consists in three laboratory works and three project meetings, the seventh metting being reserved for lab evaluation. The laboratory precedes the project and is destinated to closely accompany the course with some, experimental and simulation demonstrations. The experimental part is related to some previous experiments, coupled with knowledges borrowed form the "Electronic Devices" laboratory.
The first lab consists in the electrical characteristics measuring, for some biodevices with neurotransmitter solutions, Figure 1.a., in the same manner as for the pn junction. Figure 1.b reveals a new result for a two terminal biodevice with a hormonal solution (methyltestosterone). The non-linearity observed at this device is obvious. Another aspect is the curves reproductibility that is higher for methyltestosterone, versus neurotransmitters like adrenaline, (Ravariu[f] et al., 2007).

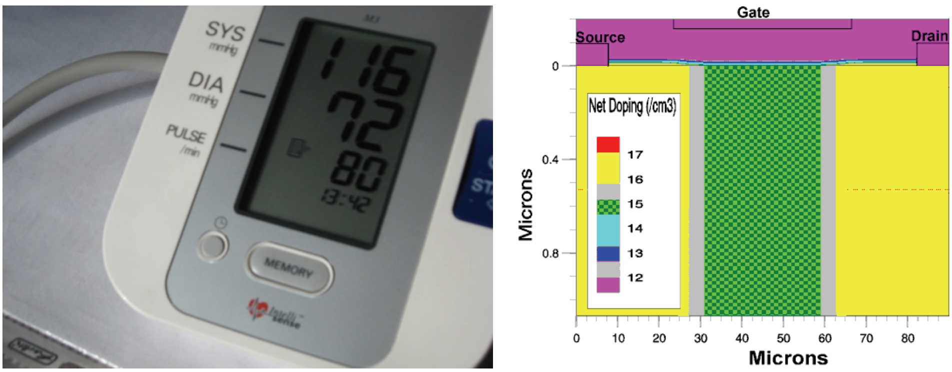


(a) (b)

Fig. 1. The current-voltage response of a test biodevice with: (a) oily testosterone solution; (b) adrenaline aq. solutions for a series resistance R=110kΩ or R=1.17MΩ

In the second lab the students learn to use some basic sensor and have to navigate on web in order to be familiarized with products, companies, and latests news in biosensors.

At the beginning of the second lab they learn to use a tensometer, Figure 2.a, with the normal and limit range for the human blood pressure or pulse, besides to a glucometer that includes a glucose biosensor as tester.



(a) (b)

Fig. 2.(a) The blood pressure measuring. (b) The doping concentration in a simulated BioFET

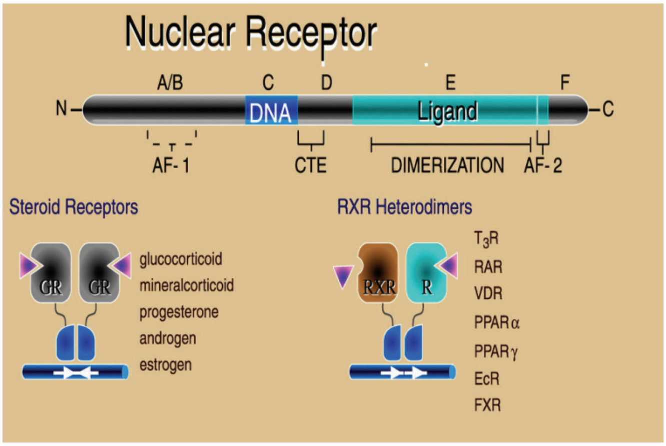


Fig. 3. Nuclear receptors are a class of proteins found within the interior of cells that are responsible for sensing the presence of steroid or thyroid hormones

In this picture for instance, the systolic pressure is 116mmHg, the diastolic pressure is 72mmHg and the puls is 80 / 1 min. Then will find out the work principle for some biosensors (metabolism sensors, afinity sensors, immuno sensors, microbial sensors). Every student will be deeply focused just on one type of sensor at the end of the lab. For instance the BioFET analysis can't be performed with the university endowment, and a theoretical study is poorly. Therefore some examples revealed on simulations become useful, Figure 2.b, because appeals to the visual memory – one of the most efficient gate of learning.

The scope of the internet navigation isn't only scientific, but in order to confront the results, to find out the latest news and products, to fill the market tendencies and to establish possible contacts with others research groups. This domain implies strong cooperation from different areas.

The third lab is destinated to the nano-electronics of cells. The students can select one theme at the beginning of the lab and the work is individual. This method has two aims: (1) to let a, large domain to be investigated in a short time on many directions, thinking that the students will discuss about their interesting informations after the classroom and (2) to find out the students interests in this huge domain, thinking that they have a keen filling of the academic trends, jobs opportunities, news in a domain. In this way, we hope to enhance next year the BioNEC course and labs by the students feed-back.

In the third lab they independently study about the signal transmission in cells, second messengers, endocrine, paracrine, juxtacrine biosignals; they can see some short films, microscopic images and they save in their file the results.

As an example, a student provides a wealth material about the nuclear receptors (Gronemeyer et al., 2004) – specific for steriods and lipophilic substances that penetrate the bilipidic cellular membrane, Figure 3.

The practical skill are continuing to be developed within the project. The students have the opportunity to select every theme that belong to Bioelectronics with the teacher supervision. The project subjects changed from a year to another. The themes were selected in the field of sensors, test biodevices, short software for diagnosis, or investigations in medicine (Ravariu[g], 2008).

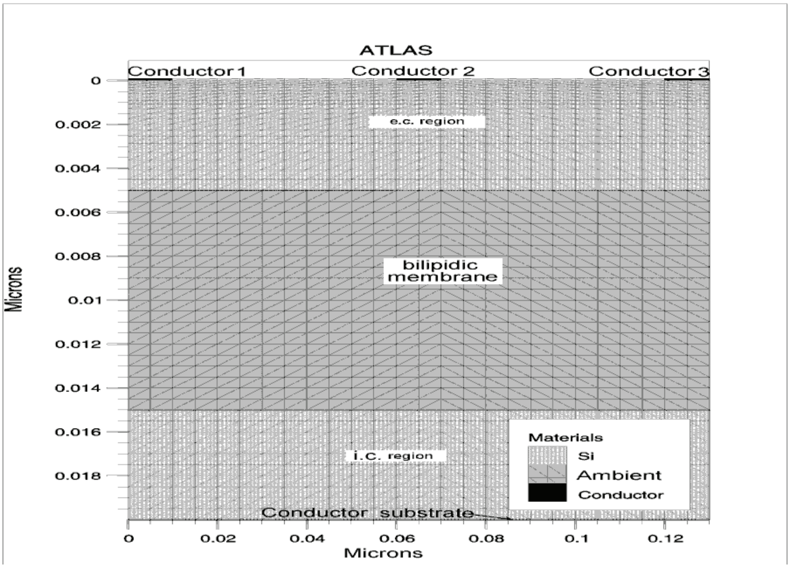


Fig. 4. Variant of membrane in vicinity of the e.c. and i.c. environment, beside mesh

As a first example is given a device simulation software available for biostructures analisys. Some simulations in the semiconductor devices environment software are available to test the potential distribution over the bilipidic membrane under Resting potential or Action Potential. In order to simulate the membrane as insulator, surrounded by the intra-cellular i.c. and extra-cellular e.c. environments with semiconductive properties, the structure from figure 4 can be adopted. The membrane was defined in the statements:

region,, num=1, y.min=0.005 y.max=0.015 material=ambient (lipid)

material permittivity=4.8 region=1

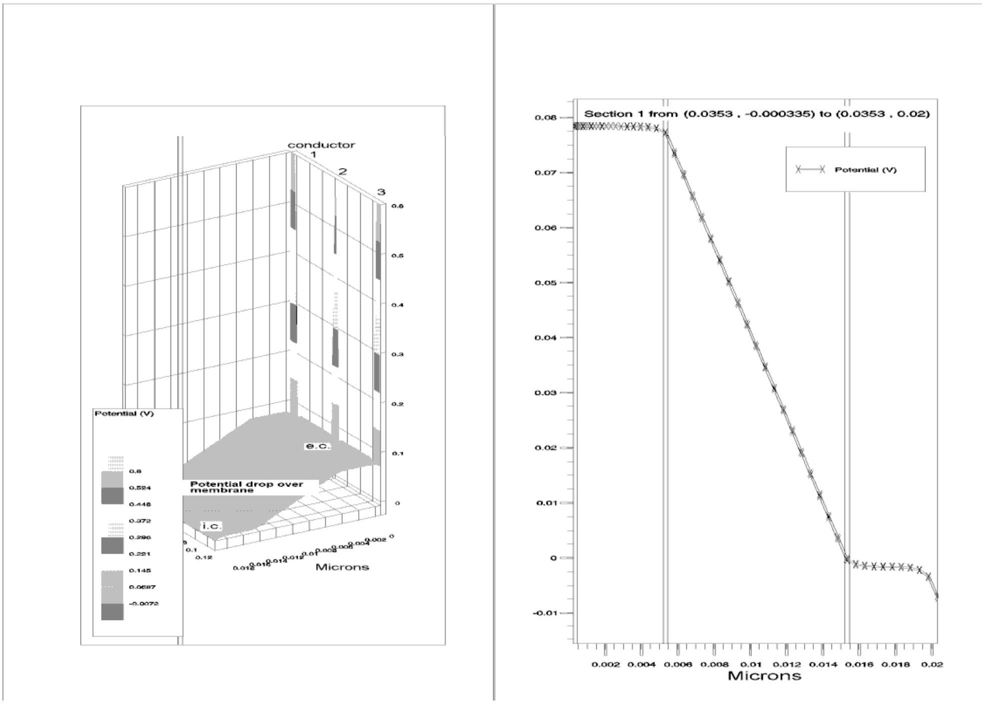


Fig. 5. Distribution of potential 2-D (left) and 1-D (right), when the Resting Potential PR = -0,078mV is spreading from the e.c. environment, toward the bilipidic membrane, up to the, i.c. environment

The Atlas library offers a finite list of semiconductors. Therefore, the i.c. and e.c. environments were simulated by Silicon layers with doping concentration about $9x10^{19}cm^{-3}$, accordingly with the K^+ concentration ~ 150mM, that means $150x10^{-3}$ mol/dm^3= $6,023x10^{23}$ x 150 x 10^{-3} ions / 1000 cm^3 = $9x10^{19}$/cm^3 positive electrical charges per 1 cm^3, equivalent with $9x10^{19}cm^{-3}$ holes concentration in semiconductor:

dopin uniform conc=9e19, p.type reg=2

Three electrodes are defined instead of three adjacent ionic channels: conductor 1, conductor 2, conductor 3, against the conductor substrate, Figure 4 and 5.
The electrical potential distribution is numerical computed by the Poisson equation solving, Figure 5. This figure reveals the additional effect of the contact metal-semiconductor, besides to the transmembranar potential drop.
These simulations can reveal the dielectric properties of the membrane in absence of some adequate endowments tools.

Fig. 6. First window opened by the patient, Step 1; at the end must "Continue"

As an alternative example, figure 6 presents the first window opened by a software, regarding a web-assisted diagnosis page, useful for human medicine, (Ravariu[h] et al., 2008). In order to produce a web Virtual E-Healthcare point, the following tools for a web application were used by students: PHP, MySQL, JavaScript, HTML and CSS.

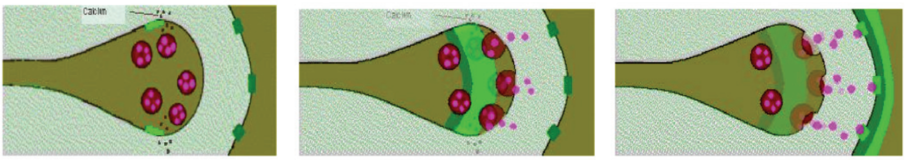


Fig. 7. Intermediates steps for the inter- neuronal electrical pulse transmission

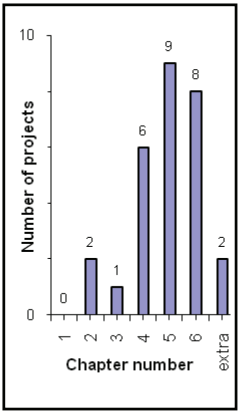
Another example, given by a student project from BioNEC2 stage, is representing an animation soft-ware for a better biological phenomenon learning in the nerves terminations. When the action potential – green zone – open the Ca-channels, the neurotransmitter exocytosis occurs, Figure 7.
These fields are preserved in the BioNEC3 stage, but the preffered topic is destinated to electrophysiology, starting with the electrical conduction in neurons and synapses level, noise rejection, filters used in physiological measurements.

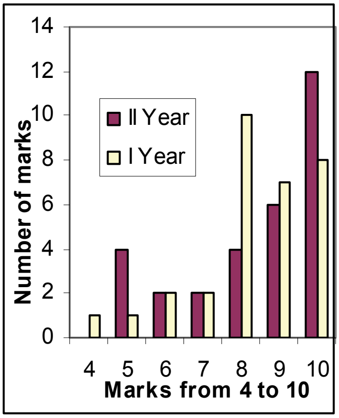
6.The evaluation

The finnal mark represents an average between the score obtained at a final theoretical test (50%) and the score from the lab and project (50%). Sometimes, the project score was additionally awarded with some specials results as papers or communications of their materials in journals and conferences. In the theoretical test, the students have at least one free subject from one chapter. For instance, if the imposed subjects cover the Biosignals and Biodevices chapters, the free subject can be selected from Biosensors and Nano-electronics of cells.

6.1 The impact among students

At the beginning of the course, the students asserted a better affiliation to the Biosensors and Bio-FETs, due to a stronger relationship of these chapters with previous knowledge. Figure 8. a comparatively presents the preferences among topics from the selected subjects at the Project Homework of our students from BioNEC1 and BioNEC2 generation. Obviously, the Cellular Nano-Electronics produced the maximum impact on the students, (Rusu et al., 2008).





(a) (b)

Fig. 8. (a) The number of projects affiliated at some BioNEC topic (see the Chapter 1…5 contents at section 4 in this chapter). (b) The obtained marks

6.2 The evaluation results

The final score of evaluation consists in two percents: the project homework bring 40% and the writing exams 60%, Figure 9.b. We take into account the life problems of our students and let them to select the preferred domains in homework. Due to the free-choose subject from exam that doesn't cross with the imposed others, we had the opportunity to observe from their feed-back, the deficiency and strong points of the course. Strictly from the BioNEC course contents, the main deficiency is a quite exhausting approach. Therefore, more focused subjects were teaching in IInd year. The main attraction is the Cellular NanoElectronics. With the occasion of this part, they discover many bridges between biology and electronics, invisible at the beginning. For instance they don't expect to meet electrical conduction with a threshold electric field (~10^7V/m on a 7nm bilipidic membrane) to transmit the incident stimulus in the excitatory cells, likely in MOS devices. The electronics absolvent's rapidly find out the common language with nano-biology.

7. The BioNEC research group and perspectives

Around the BioNEC course, a research platform was developed, as a BioNEC group in the Faculty of Electronics. Besides to the Politehnica team, some external partnerships reinforce the research capacity, (Ravariu[i] et al., 2008). We discover a huge interest among the clinicians to find out the latest news in technique. In the Annual Congress of the Romanian Medical Association, they made us a constant chapter: biotechnologies, where they annually invited students from BioNEC course to present them some technical novelties.
Inside of this BioNEC group, some new tools to investigate some biological medium were developed: nanoporous material for new metabolic biosensors, the analysis of the non-linear responses of biosensors with tools borrowed from microelectronics – Non-Linear Electrical Conduction Theorem, a biodevice for neural cells investigations, specific biosensors technologies, (Ravariu[j] et al, 2006), (Babarada, F. & Ravariu, C., 2004).

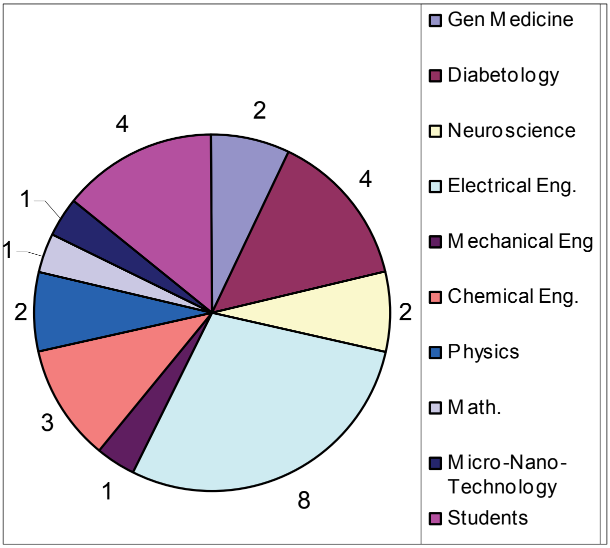


Fig. 9. The domains covered by specialists as percent area

The human resources in the BioNEC research platform consist in : 2 correspondent members of the Romanian Academy, 1 professor, 3 associated professors, 1 Principal Researcher I, 3 Principal Researcher II, 4 Scientific Researchers, 1 resident physicians, 1 young researcher debutant, 7 PhD students, 3 students, 2 masters students. They have the affiliation: P1 – Politehnica University Bucharest, P2 – Institute of Microtechnology, P3 - Institute V. Babes of anatomo-pathology, P4 – University of Medicine and Pharmacy Carol Davila Bucharest, P5 – private company. Figure 9 presents the complementary specialities covered by the persons with the BioNEC group affiliation.
International cooperation in research is stimulated in the BioNEC platform, by immediate links with similar area research centers: Carinthia University of Applied Sciences, Villach, Austria, Dept. of Medical Physics, School of Medicine Patras, Greece, EPFL Lausanne Swiss, Cambridge University, UK, multiple medical research internationals institutes of Diabetes.

The research directions available for the entire BioNEC platform are: monitoring in electrophisiology, cellular siganal recording and processing, Langerhans islands isolation for characterization and transplants, intercellular communications, biomodeling in living structures, contributions in neuroscience, e-healthcare and the list is opened.

8. Conclusions

Which are the targets of a Bioelectronics course? Firstly, a quantitative investigation in medicine, new tests, new medical protocols for diagnosis. Secondly, to prepare our students for the next future, that belongs to a convergence among sciences.
On the other hand, the internationals reports alert us that in the next years the medical assistance responsibility will move toward patients. Hence, the Learning process must be extended from the universities boundary toward the great public – the main beneficiary in the future.
A Bio-electrical engineering course was presented: BioNEC - Biodevices and Nano-Electronics of Cells. The course content is adapted accordingly with the students interest (e.g. market trends, possible jobs, academic area, some companies development). In the future, this course can be a started point for a large people scholarship.
The modern medicine is resting slave to a qualitatively description till nowadays. To succesfully pass toward a quantitative approach implies a strong collaboration with a physicist group. From electronics and electrochemistry, the bioscience gains the experience and those tools necessary to model the biological phenomenon; but their efficience must be immediately verified, in a collaboration with physicists and patients.

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Guidelines for Designing and Teaching an Effective Object-Oriented Design and Programming Course

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1. Introduction

Teaching Object-Oriented Programming (OOP) to novices is without doubt one of the most challenging topics in Computer Science Education. Extended research has been carried out, which focuses on:

- proposing and/or evaluating teaching approaches (Bennedsen & Caspersen, 2004; Brusilovsky et al., 1997; Chang et al., 2001; Nevison & Wells, 2003; Proulx et al., 2002), such as "objects-first", "model-first", and using coding patterns,
- devising educational programming environments and tools (Allen et al., 2002; Buck & Stucki, 2000; Cooper et al., 2000; Kölling et al., 2003; Sanders & Dorn, 2003; Xinogalos et al., 2006a), and
- studying students' understanding and misconceptions of object-oriented programming (Carter. & Fowler, 1998; Fleury, 2000; Fleury, 2001; Holland et al., 1997; Ragonis & Ben-Ari, 2005a; Truong & Bancroft, 2004; Xinogalos et al., 2006b).

In most cases this research has been carried out with the form of a pilot/empirical study or an experiment in the context of an OOP course. There is little evidence of evaluating an OOP course as a whole: teaching approach(es) used; sequence of concepts presented and organization of lessons; programming environment(s) and educational tools used; students' difficulties and misconceptions recorded and didactical situations/activities for dealing with them. Consequently, the problem for those struggling to design an effective OOP course for their students remains.

In this chapter we present the long-term evaluation and refinement of an OO Design and Programming course, which was initially exclusively based on the well-known environment of BlueJ, the book "Objects First with Java: A practical introduction using BlueJ" (Barnes & Kölling, 2004), the established guidelines for teaching with BlueJ (Kölling & Rosenberg, 2001) and the results of the research regarding the teaching of OOP. Although, the teaching approach adopted is not an empirical one, it was our belief that it should definitely be evaluated by recording students' achievements and studying their conceptions. This evaluation gave us invaluable insights into students' difficulties and helped us reform the course with increasingly positive results the last four years.

In the second section of the chapter we review the research regarding the teaching of OOP to novices that guided the design of our course. Specifically, we review the most important teaching approaches that have been proposed, as well as the educational programming environments and programming microworlds that have been devised.
In the third section we present the most important results, referring to the design of the course, from the long-term evaluation and refinement of the "Object-Oriented Design and Programming" course that is being taught for the last four years at a Technology Management Department. First, we describe the placement and the aims of the course, which played a central role in its design process. Next, we present the results of three distinct versions of the course.
In the fourth section we present some guidelines for designing and/or teaching an effective OOP course. These results are based on the rigorous four-year evaluation and refinements of the concrete undergraduate "Object-Oriented Design and Programming" course described, but are presented in such a way that can be exploited by CSE educators in various contexts. Specifically, we present:

- the proposed refined sequence of lessons. The fundamental OO software development tasks and programming concepts taught in each lesson, the tools used for teaching them and the time allocated for each lesson are presented.
- the advantages of three distinct, but complementary for our purpose, environments: objectKarel, BlueJ and JCreator that represent a programming microworld, an educational IDE, and a more professional programming environment respectively. Emphasis is given on presenting guidelines for making good use of the features of BlueJ and avoiding the underlying pitfalls of this or similar environments that give the chance of direct manipulation of objects.
- guidelines for teaching each one of the proposed lessons. The way the new concepts are presented, the most common difficulties and misconceptions which were recorded in our four-year evaluation of the course, as well as specific didactical interventions are presented.

Finally, we present our future plans that focus on developing even more appropriate educational material (i.e. examples, activities, assignments).

2. Literature Review on the Teaching of OOP

2.1 Teaching approaches

Teaching OOP to novices is widely known to be quite problematic. As the authors of the ACM Curricula report acknowledge, the objects-first strategy creates added difficulties to both the teaching and learning of programming (Chang et al., 2001). Various teaching approaches have been proposed for supporting the objects-first strategy and making the teaching and learning of OOP concepts easier and more effective. The most important are described briefly in the following paragraphs.
Presenting especially designed examples for avoiding common difficulties. Holland et al. (1997) suggest the presentation of examples and the assignment of exercises especially designed for avoiding misconceptions that have been recorded and cannot be easily shifted once acquired by students. For example, in order to avoid the misconception that "object" and "class" are the same concept, teachers should use examples where several instances of each class are used.

Using Graphical User Interfaces. Proulx, Raab, & Rasala (2002) state that teaching should begin with the concept of objects, which should have a noticeable behavior and should interact with other objects. The familiarization of students with the main concepts of OOP is accomplished through a series of labs and lectures that are based on using GUIs developed by Proulx et al. (2002) in Java. Although some researchers (Kölling et al., 2003) are opposite with the use of GUIs as a medium of teaching OO concepts, Proulx et al. consider their use necessary. In each one of the 4 labs described (Proulx et al., 2002) a different GUI is used with the aim of: (1) exploring the behavior of objects without making any reference to the source code (1st lab); (2) observing the changes of member data of the objects as a consequence of responding to actions that invoke member functions, and learning the syntax of such calls (2nd lab) ; (3) studying part of the source code that implements the GUI that is used, and making small changes (3rd lab); (4) extending an existing class (4th lab).
Using Case Studies. Nevison & Wells (2003) believe that teaching OOP should begin with teaching objects, as most of the instructors do. However, in order to present interacting objects the use of difficult/complex examples is acquired. Nevison and Wells suggest the use of case studies that give the chance to present complex examples at the beginning of an introductory programming course, as well as the ability to adopt an object-oriented approach to solving problems. The choice of a case study must be done carefully, which means that the complexity of the system that the case study describes favors the presentation of object-oriented concepts and the implementation of simple programs that can be used in an introductory programming course. Also, the case studies that are going to be used must allow the gradual presentation of concepts (one concept each time) through the development of a series of programs of increasing complexity.
Using Educational Programming Environments. Empirical studies and experience has shown that one of the most important sources of difficulties for novice programmers is the use of professional programming environments for their introduction to programming. This ascertainment has led many researchers in implementing educational programming environments. Educational programming environments give emphasis on the didactic needs of students rather than the professional needs of programmers. Kölling et al. (2003) in particular state that teaching OOP is difficult due to the lack of appropriate tools and teaching experience for the specific programming paradigm. The most important problems of the environments that are used for teaching OOP are: (1) the environment is not object-oriented; (2) the environment is complex; (3) the environment focuses on the development of GUIs and not on object-orientation.
In order to avoid these problems Kölling et al. (2003) developed the BlueJ environment. In contrast with the rest educational programming environments BlueJ is accompanied with a textbook (Barnes & Kölling, 2004; 2006) and an established set of guidelines for teaching (Kölling & Rosenberg, 2001). The approach proposed is an "objects-first", iterative (important concepts are taught first and often), **project-driven approach**. Students begin with a predefined set of classes, create objects and invoke the available methods, in order to study the objects' behavior. The predefined classes are used for presenting the syntax of Java. Next, students extend existing classes by implementing or adding their own methods. The next step is the definition of classes by students in the context of an existing project. Finally, students are separated into groups and implement an application.
Using Programming Microworlds. Programming microworlds are a special kind of educational programming environments. What differentiates them is the fact that they use

an educational programming language or a subset of a conventional language. Programming microworlds are designed and implemented entirely for didactic purposes and as a consequence they share some common characteristics (Brusilovsky et al., 1997): (1) they are, usually, based on existing physical metaphors and use an educational programming language; (2) they constitute integrated programming environments that are characterized by usability and incorporate various forms of educational technology for supporting students, such as software visualization technologies; (3) the problems solved are, usually, everyday problems. Teaching with programming microworlds focuses on concepts, and not on the syntax of the language. However, in some cases the programming language used constitutes a subset of a conventional programming language, and learning its syntax is part of the didactical process.

Using a model-first approach and coding patterns. The model-first approach considers conceptual modeling - which refers to the use of programming constructs for describing concepts, structures and phenomena-, as the defining characteristic of object orientation. Bennedsen & Caspersen (2004, pp. 478) summarize nicely the idea of this approach: "*Introduction of the different language constructs are subordinate to the needs for implementing a given concept in the conceptual framework. After introducing a concept from the conceptual framework a corresponding coding pattern is introduced; a coding pattern is a guideline for the translation from UML to code of an element from the conceptual framework.*"

2.2 Educational Programming Environments

Numerous educational programming environments have been developed for supporting students in their introduction to OOP. However, most of them have not been thoroughly evaluated and their usage maturity is small, with the exception of BlueJ (Georgantaki & Retalis, 2007). A brief comparative presentation of various educational programming environments based on the evaluation approach suggested by McIver (2002) is provided in (Georgantaki & Retalis, 2007). In the next paragraphs we briefly present five such environments taking into account the graphical interface, interactivity, visualization, compilation features, and generally the support provided for teaching the OOP paradigm.

BlueJ (http://www.bluej.org). The main window of BlueJ (Kölling et al., 2003) demonstrates in a visual way classes and objects, as well as the application' s structure in the form of a simplified UML diagram. The UML diagram used presents the names of the classes and their inter-relations. Students can use the interactive interface of BlueJ in order to construct objects, invoke their methods and inspect their state. The source code of each class is presented in a separate window, using limited highlihting of source code elements. The editor supports line numbering, indenting, and bracket matching. Syntax errors are presented in the bottom of the class' s window one at a time, while the line of the error is automatically higligthed. The error messages are explanatory enough, providing the possible reason that caused the syntax error. BlueJ incorporates a visual debugger that allows the student to insert breakpoints and then execute the program step by step. When the pop-up menu of a class or an object is used in order to construct an object or call a method respectively, the window of the debugger appears automatically. Information about threads, call sequence, static/instance/local variables is presented.

DrJava (http://drjava.org). DrJava (Allen et al., 2002) has a simple interface based on a "Read-Evaluate-Print-Loop" (REPL). In its single window students can develop, test and debug a program in an interactive, incremental way. The editor supports brace matching, syntax highlighting and automatic indenting. Students can type Java expressions and statements and see immediately the results, without the need for the main method. In this way, the idea that each individual unit of a program should be separately tested is reinforced. In the case of compilation errors, students can click on an error in order to highlight the corresponding line of the source code. DrJava incorporates a debugger, which is activated from a menu choice. Then the student can insert breakpoints and use the commands in the Debug menu to step into/out/over the execution of a method.

Ginipad (http://www.mokabyte.it/ginipad/english.htm). The editor of Ginipad uses colour for highlighting elements of the source code, as well as the function of code auto-completion. Classes, methods and fields are presented in a separate pane in a tree form, updated automatically, when the student edits the source code. Clicking on an element of the tree results in highlighting the corresponding code fragment in the editor. Ginipad supports interaction with error messages, but it does not incorporate neither a debugger nor the function of step-by-step execution.

JGrasp (http://www.end.auburn.edu/grasp/). The editor of JGrasp supports highlighting of source code elements using colors, as well as numbering of source code lines. What is more important is the generation of Control Structure Diagrams (CSD) intended to depict control structures, control paths and the overall structure of each program unit. JGrasp supports students in developing programs with templates for defining classes, methods and control structures. The description of the first compilation error, as well as the line of the source code that most likely caused it are both highlighted. JGrasp provides a visual debugger that allows students to set breakpoints and then execute the program one statement at a time. It also generates UML class diagrams for the classes of the current project. Furthermore, students can create instances from any class in the UML class diagram or Java. The instances of the classes are placed in an object workbench, as is the case for BlueJ too, and students can invoke their methods in isolation without having to write a main method. Students can also invoke class or static methods directly from the class diagram.

JCreator LE (http://www.jcreator.com/index.htm). The JCreator LE is the freeware version of the JCreator IDE used for learning purposes. The environment presents in different panes all the files of a project in tree form and an overview of the current class's structure in an expandable tree. It allows the addition of new classes to the project through templates and dialog boxes, as well as the addition of new methods to a class with the help of dialog boxes. JCreator LE gives the option of viewing line numbers in the selection margin, instant color syntax highlighting, auto-indent, word completion and code folding which allows the user to hide parts of the code. It does not have a tool for debugging and as a result does not support step-by-step execution. The version JCreator Pro (shareware) contains a debugger, step-by-step execution and visualization features.

2.3 Programming Microworlds

The most well known microworld is Logo, which was created by Seymour Papert. Although it was not designed specifically for the teaching of programming it appeared to be an effective tool for supporting it. However, the majority of the educational tools that have been developed in the context of this approach are based on the robots Karel (Pattis et al., 1995) and Karel++ (Bergin et al., 1997), which are used for introducing novices to procedural and object-oriented programming respectively. The metaphor used is that of a world of robots, that are assigned various tasks in a world comprised of crisscrossing horizontal streets and vertical avenues, wall sections (that represent obstacles) and plastic cones that emit a beep noise (beepers). For example, a robot might be assigned to harvest a field of beepers, to escape from a labyrinth and so on. Representative programming microworlds are:

JKarelRobot (http://math.otterbein.edu/JkarelRobot). JKarelRobot (Buck & Stucki, 2000) is based on robot Karel and supports three languages: Pascal, Java and Lisp. JKarelRobot uses Control Structure Diagrams (CSD) for presenting programs and gives the chance to develop flow diagrams for existing programs. The programs are executed step by step either forward or backwards. The restriction of this simulator, regarding object-orientation, is the fact that students can create just one robot. This might lead students to the recorded misconception that refers to the object-class conflation.

Jeroo (http://info.nwmissouri.edu/~sanders/Jeroo/Jeroo.html). Jeroo (Sanders & Dorn, 2003) uses as a metaphor a kind of an Australian kangaroo and a programming language related to C++ and Java. The user interface consists of a single window, while the environment supports the implementation of recursive methods. However, Jeroo has the following restrictions: there is only one class; students can create up to four robots; inheritance is not supported; students can extend the Jeroo class with void methods, but not with predicates.

objectKarel (http://csis.pace.edu/~bergin/temp/findkarel.html). objectKarel (Xinogalos et al., 2006a) is based on Karel++ and uses a programming language related to C++ and Java. objectKarel incorporates a series of e-lessons and hands-on activities for motivating students through the use of concepts before they are asked to implement them. Programs are developed with a structure editor, which has the form of a menu that is automatically updated with the names of new methods, and dialog boxes. Students can run, trace with a predefined speed or execute programs step by step (only forward). Also, objectKarel incorporates the technology of explanatory visualization, which means that students are presented with explanatory messages for the semantics of the statement being executed. Furthermore, it incorporates the ability of recording students' actions during program development (recordability). Each compiled version and the compiler output is recorded and presented with the form of a two level tree.

Karel J. Robot (http:// csis.pace.edu/~bergin/KarelJava2ed/Karel++JavaEdition.html). Karel J. Robot is a Java-based descendant of Karel++ that has been recently developed.

Alice (http://www.alice.org). Alice (Cooper et al., 2000) is a successful microworld, which is used for building virtual worlds with 3D objects. Alice is based on the Python (www.python.org) language and has an object-oriented flavor. Students create virtual worlds that are populated by 3D objects, such as animals and vehicles. Students control the appearance and the behaviour of objects by writing simple scripts – invoking methods and then they watch the animation.

3. The long-term evaluation of the OO Design and Programming Course

3.1 Description of the course

The "Object-Oriented Design and Programming" course described in this chapter is a third semester compulsory course at a Technology Management Department. The duration of the semester is normally 13 weeks and the course consists of a weekly two-hour lecture and two-hour lab. Prior to this course, students are introduced to "Computer Programming"

with C. This means that basic programming concepts, such as variables, constants, conditional statements, loops and functions, are considered already known. However, passing the “Computer Programming” course is not a prerequisite for attending the “Object-Oriented Design and Programming” course.
The goals of the “Object-Oriented Design and Programming” course can be summarized as follows: (1) focus on the fundamental OO software development tasks and programming concepts rather than the teaching of Java; (2) learn to read class documentation and use Java standard library classes; (3) learn to distinguish, use and extend elements of a given class (fields, constructors, accessor and mutator methods); (4) designing simple applications using the OO technique; (5) implementing programs.

3.2 Evaluation of a course based on an educational IDE

The course was taught for the first time the academic year 2005-06. Based on the aims of the course and the literature regarding the teaching of OOP we organized the course based on the programming environment BlueJ and the book "Objects First with Java: A practical introduction using BlueJ" (Barnes & Kölling, 2004).
The teaching approach of Barnes and Kölling seemed to fit perfectly with the main aim of the course, which is the comprehension of fundamental OO software development tasks and programming concepts rather than the teaching of Java. Specifically, both the environment and the book, and consequently our course, shared the following well-known guidelines for teaching Object Orientation with Java (Kölling & Rosenberg, 2001): (1) Use an Objects first approach; (2) Don’t start with blank screen; (3) Read code; (4) Use “large” projects; (5) Don’t start with main; (6) Don’t use “hello world”; (7) Show program structure; (8) Be careful with the user interface.
Heavily based on BlueJ, the accompanying text book and the guidelines mentioned above eleven two-hour lectures and eleven two-hour labs were organized with the following content: (1) Objects and classes; (2) Understanding class definitions; (3) Object interaction; (4) Flexible and fixed size object collections; (5) Using class libraries (i.e. HashMap, HashSet); (6) Testing and Debugging; (7) Designing classes; (8) Improving structure with inheritance; (9) Polymorphism and overriding; (10) Abstract classes and interfaces; (11) Static methods – the main method.
A vast amount of data was collected during the lessons from questionnaires, programming assignments carried out during lab sessions or at home, the final exams and conversations during lectures and labs. The rigorous analysis of the data identified several difficulties, which were categorized and subcategorized as follows (Xinogalos et al., 2006b):
Category 1 – “typical” difficulties encountered independently of the programming paradigm.
Category 2 – difficulties attributed to the special characteristics of OOP:
Subcategory 2.1 – constructors
Subcategory 2.2 – object instantiation
Subcategory 2.3 – “set” methods (mutators)
Subcategory 2.4 – “get” methods (accessors)
Subcategory 2.5 – method calling
Subcategory 2.6 – access modifiers
Subcategory 2.7 – object collections
Subcategory 2.8 – inheritance

Subcategory 2.9 – abstract classes/methods and interfaces

Despite these difficulties, students managed to carry out their assignments and comprehend basic OOP concepts. Furthermore, several difficulties and misconceptions recorded by Ragonis and Ben-Ari (2005a) in the context of a teaching based on BlueJ were not recorded in our course. This resulted in our decision to continue teaching the course with the same approach. However, it became clear that some adjustments should be made, since some difficulties were attributed to specific features of the course and BlueJ:

Feature 1 – emphasis on visualization and direct manipulation techniques incorporated in BlueJ. Several difficulties regarding "object instantiation" (subcategory 2.2) and "method calling" (subcategory 2.5) were attributed to this feature of BlueJ, such as: (1) omitting the type of the variable that keeps a reference to the object being instantiated due to extensive use of BlueJ' s pop-up menu for constructing objects; (2) calling a non-void method as a void method due to extensive use of BlueJ' s interface for invoking methods – even in the case of a non-void method the returned value is presented in a window and students do not handle it (i.e. assign it to a variable, use it in an expression). Ragonis & Ben-Ari (2005b) have also identified difficulties regarding the dynamic aspects of OOP that can be attributed to the extended use of the features of BlueJ.

Feature 2 – emphasis on existing projects. Students become accustomed to working with existing projects that have to be extended and face difficulties when they have to put everything together from scratch. Students face difficulties even with "set" and "get" methods (subcategories 2.3 and 2.4) and "constructors" (subcategory 2.1), since these code fragments are usually provided in the project and, although they see them, they rarely have to implement them. In the case of object collections (ArrayLists) students' difficulties are much more severe. Although students seem to comprehend the concept of object collections, they find it difficult, if not impossible, to manipulate flexible size collections for grouping objects (Xinogalos et al., 2006b).

Feature 3 – postponing the main method. Postponing the main method for the end of the course means that students have to use exclusively the interface of BlueJ for testing code, which leads in the difficulties mentioned above (see Feature 1).

3.3 Reformation of the course with the combined use of an educational and a professional IDE

Based on the results of evaluating the course the first year it was offered to students we re-designed it. The main adjustments that were made can be summarized as follows (Xinogalos et al., 2007):

- Students used the interactive GUI of BlueJ for creating objects and calling their methods in the first three lessons. In the 4th lesson students were taught the main method (11th lesson in the 1st version of the course) and started constructing objects and calling their methods by writing code.
- Students used the features of BlueJ with more caution. Students continued to use the direct manipulation features of BlueJ for experimenting with existing projects and debugging their own after the 4th lesson, but they were always asked to achieve the desired result by providing source code too. Furthermore, the environment of JCreator was presented to students and they had the choice of selecting the environment that fitted better to their needs.
- Students started to develop simple projects from scratch much earlier in the semester.

- We decided to omit the lesson about debugging (6th lesson in the 1st version of the course) and devote two lessons on object collections (ArrayLists), which turned out to be one of the most difficult concepts for students. Basic debugging techniques were presented in the context of one of the first labs and students were encouraged to study the corresponding chapter.
- Special didactical situations and assignments were designed based on the results of the assessment.

The evaluation of the re-designed course gave better results than the 1st version of the course. The evaluation showed that (Xinogalos et al., 2007):

- Some of the difficulties that were attributed to the emphasis given on the features of BlueJ (Feature 1) in combination with the late use of main (Feature 3) were eliminated. For example, in the 1st version of the course we found out that "some students do not declare the type of the variable that keeps a reference to the object they instantiate" (Xinogalos et al., 2006b). This difficulty was not recorded in the redesigned course. Furthermore, some difficulties regarding the dynamic aspects of OOP were significantly reduced, such as calling a non-void method from main as a void method.
- Some difficulties attributed to the emphasis given on existing projects were addressed satisfactorily. For example, developing projects from scratch early in the semester helped students face more effectively various difficulties, such us leaving the body of a constructor empty (subcategory 2.1), omitting the type of an object variable (subcategory 2.2), and directly accessing private fields outside their class instead of using "get" methods (subcategory 2.4, 2.6).

Although the re-designed course gave better results, is it obvious that several difficulties continued to exist. The third year of teaching the course no changes were made on its main features. The only change was a refinement of the assignments and the activities carried out at labs, based on the 2-year evaluation and experience of teaching the course.

3.4 Gradual exposure to OOP concepts with a microworld, an educational and a professional IDE

Although the re-designed course was taught with positive results for two academic years it is clear that students still faced various difficulties and there was still room for improvement. It is our belief that a major source for various students' difficulties is a flawed comprehension of OOP concepts. This is more intense when we have to deal with more advanced concepts, such as inheritance, polymorphism and overriding. This belief combined with the advantages of microworlds for introducing students to programming concepts (Brusilovsky et al., 1997) led us in studying students' conceptual grasp of OOP concepts in a course with BlueJ (the first course described in this paper) and a teaching with objectKarel. This study was based on a common test taken at the end of both teachings. The most important finding of this study was that the students taught with objectKarel were found to have a significantly better conceptual grasp of basic OOP concepts than the students taught with BlueJ (Xinogalos, 2008a).

The results of this study strengthened heavily our intention to devote the first two lessons (lectures and labs) for introducing students to the most fundamental OOP concepts with the programming microworld objectKarel (Xinogalos et al., 2006a). objectKarel uses a physical metaphor, that is robots carrying out various tasks on a restricted world. The environment incorporates a structure editor for developing programs, program animation, explanatory visualization features, and enhanced error reporting. The introduction to OOP with objectKarel aimed at:

- presenting in a clear and concise way the most fundamental OOP concepts.
- concentrating exclusively on the concepts, leaving aside the obstacles of learning the syntax of a programming language and struggling with incomprehensible error messages.
- using the technology of program animation and explanatory visualization for supporting students in comprehending the semantics of constructs and concepts and revealing misconceptions before they are established.

So, the 4th year (2008-09) of teaching the course the first two lectures and labs were based on objectKarel. In the 1^{st} lesson the concepts object, class, message/method, object instantiation and inheritance were presented. The 2^{nd} lesson was devoted to multilevel inheritance, polymorphism and overriding. In the 3rd lesson students were taught class definitions (2^{nd} lesson in the 1^{st} version of the course, the 1^{st} lesson was no longer needed).

Another change in the course was the sequence of activities and assignments used for comprehending ArrayLists. Carefully didactic activities/situations and assignments were devised: (1) comprehending the structure of an ArrayList by presenting simple programs and the corresponding object diagrams, and then having students draw object diagrams in order to simulate basic ArrayList operations; (2) filling in blanks that represent error prone elements in an excerpt of code, in order to think about specific concepts and constructs more consciously and comprehend them; (3) developing projects that use ArrayLists from scratch.

The evaluation of the course based on the combined use of the programming microworld objectKarel, the educational programming environment BlueJ and the professional programming environment JCreator gave even better results that the previous version of the course. Specifically, we found that (Xinogalos & Satratzemi, 2009):

- Students' active participation and achievements in the written exams improve, as the course evolves.
- The results regarding specific students' difficulties show a gradual improvement for most of the subcategories of difficulties, and in few circumstances slight variations.
- The interventions on the teaching of ArrayLists had positive results. Better results were recorded regarding basic operations on ArrayList collections: iterating an ArrayList collection, retrieving the objects stored in an ArrayList, accessing the private fields of the retrieved objects using "get" methods.
- The use of objectKarel for introducing students, at the very beginning of the course, to the most fundamental OOP concepts turned out to be a good decision. The main concern regarding the use of objectKarel was whether the knowledge acquired in its context would be transferred afterwards to Java. In a questionnaire about the use of the three environments, 69% of the students stated that did not face any difficulty in associating the concepts taught in objectKarel with the corresponding ones presented afterwards with the use of Java.
- Furthermore, more students participated in the lectures and the labs, completed the assignments and gained confidence in their ability to program, in comparison with previous years. In the questionnaire mentioned above, 91%of the students stated that the introduction to the main concepts of OOP with objectKarel helped them comprehend these concepts.

4. Guidelines for Designing and Teaching an OOP Course

4.1 Outline of the course

Based on the placement of the course (section 3.1) and its four-year rigorous evaluation and reformation, we have ended up to the series of lessons presented in Table 1. The course is based on the combined usage of three distinct but complementary for the goals of the course programming environments: objectKarel, BlueJ and JCreator. The didactical material is based on the material incorporated in the programming microworld objectKarel and the textbook "Objects First with Java: A practical introduction using BlueJ" by Barnes and Kölling (2006). In section 4.2 we present the rationale of using each one of the three programming environments, and in section 4.3 we present the most common difficulties and misconceptions as they were recorded in our four-year evaluation of the course, as well as specific didactical interventions, activities and/or assignments for dealing with them.

Lesson	Environment	Content
1	objectKarel	*Objects, classes, inheritance*: object, construction & initialization of an object, classes, messages/methods, attributes and behavior of an object, inheritance, superclass, subclass, inheritance hierarchy, UML class diagram
2	objectKarel	*Multilevel inheritance, polymorphism and overriding*
3	BlueJ	*Class definitions:* fields, constructors, accessor and mutator methods, return statements, parameters (formal, actual), variable scope/lifetime, conditional statements
4	BlueJ	*Object interaction*: abstraction, modularization, objects creating objects, multiple constructors (overloading), class diagram, object diagram, primitive and object types, internal/external method call
5	BlueJ, JCreator	*Static methods*: instance vs. static/class methods, the main method, executing without BlueJ, byte code, Java Virtual Machine
6, 7	BlueJ, JCreator	*Grouping objects in collections*: flexible size collections (ArrayList), fixed size collections (array), generic classes, iterators, loops (while, for, for-each)
8	BlueJ, JCreator	*Using class libraries*: Java standard class library, reading documentation, interface vs. implementation of a class, exploring and using classes (Random, HashMap, HashSet), access modifiers (public, private), information hiding, class/static variables
9	BlueJ, JCreator	*Designing classes*: coupling, cohesion, encapsulation, code duplication, responsibility-driven design, code reuse
10	BlueJ, JCreator	*Improving structure with inheritance*: inheritance, superclass, subclass, inheritance hierarchy, superclass constructor, subtyping, substitution, autoboxing
11	BlueJ, JCreator	*Polymorphism, overriding*: static/dynamic type, dynamic method lookup, super (in methods), protected access
12	BlueJ, JCreator	*Abstract classes and interfaces*

Table 1. Course outline.

4.2 Usage of programming environments in the course

The choice of a programming environment for introducing novices to OOP is crucial for the success of a course. However, this choice is not an easy one. Professional programming environments are not suitable for such an introduction, since they have too many options, use terminology that novices ignore, incorporate debugging capabilities that cannot be easily utilized by novices, and generally are designed to fulfill the needs of professionals. Programming microworlds and educational programming environments seem to be a better choice. Programming microworlds are, usually, used when the goal is presenting OOP concepts and not a specific OOP language. Educational programming environments, on the other hand, are used when the goal is presenting OOP concepts using a conventional language, usually Java. Needless to say, no matter what sort of educational tool is utilized for the introduction to OOP, the transition to a professional programming environment is necessary. The four-year evaluation and reformation of the course, as well as experience in teaching programming in other contexts, has shown that more than one tools are necessary in order to teach cognitive demanding topics, such as programming. The rigorous evaluation of the course established the following guidelines, regarding the choice and combined usage of complementary programming environments that fulfill different goals of the course:

- *Use a programming microworld for an initial, short presentation of fundamental OOP concepts*. The microworld used should, ideally, use an attractive and simple for students metaphor and GUI, and incorporate various forms of educational technology, so as to concentrate on the comprehension of concepts and not on syntax details. An ideal environment of this kind is objectKarel, which: (1) uses a simple metaphor of a world of robots that has features of video games; (2) incorporates hands-on activities, based on direct manipulation, program animation and explanatory visualization, for familiarizing students with concepts before they are asked to implement them; (3) includes a structure editor that guides students through the process of developing programs and eliminates the need to learn the syntactic details of the language; (4) supports an easy compilation process, interaction with compilation errors that describe the source of the error in natural language; (5) uses program animation and explanatory visualization in order to help students comprehend the semantics of OOP concepts and control structures. The most important reasons and at the same time advantages of using objectKarel, or a similar microworld, are the following: (1) fundamental OOP concepts are presented in a clear and concise way: objects are no more an abstract concept, but instead they are depicted entities that are manipulated by students; (2) students gain confidence in their ability to program and are not frustrated from the complexity of the real thing.
- *Use an educational programming environment for connecting the OO concepts presented in the microworld with their Java implementation*. We believe that the transition from the microworld to an educational programming environment will be much smoother than a transition to a professional programming environment. An appropriate educational programming environment will help students deal with difficulties located in: the syntax; the complexity of the programming environment; the lack of a structure editor; and most importantly in the conceptual change that is located in students' familiarization with developing programs that have a visual appeal. The environment selected must have a simple GUI that supports easy compilation, explanatory error

messages, debugging and visualization features. Visualization of classes and objects, interactivity and direct manipulation of classes and objects is extremely important. Students must be able to create objects and invoke their methods interactively without the need of writing a main method. The most well-known environment of this kind is BlueJ. However, such environments must be used with caution. The interaction and direct manipulation techniques provided by environments of this kind must be used for familiarizing students with OOP, but students should not rely on them for too long. Extended use of these features leads to misconceptions, especially regarding the dynamic aspects of OOP.

- *Use a professional programming environment for preparing the professionals of tomorrow*. It is inevitable that students will have to use a professional programming environment at some time. When this is accomplished in the context of an undergraduate course students gain satisfaction and confidence on their knowledge. Of course, this shift from the educational programming environment must be done at the right time. And the right time is when students feel confident enough for this transition. Since this time may vary for each student, we decided to present the professional programming environment to students at the fifth lesson. Students are guided through an activity in the process of writing, compiling, debugging and executing a project taking advantage of main functionalities of such a professional programming environment. In order to encourage students to use such an environment we give emphasis on features that provide help to them, such as: (1) the tree presentation of the classes of a project and the data/function members of a class that make navigation and exploration of a project easier; (2) the auto-completion ability; and (3) the enhanced highlighting of source code elements with colour. Furthermore, we provide them with a brief manual describing in steps the processes of writing, compiling, debugging and executing a project.

4.3 Guidelines for teaching the proposed lessons

Each one of the lessons consists, as we have already mentioned, of one two-hour lecture and one two-our lab. The teaching approach is heavily based on the approach of the textbook accompanying BlueJ (Barnes & Kölling, 2006):

- "*Objects-first*": students create objects and call methods from the first lessons.
- *Iterative approach*: all the main concepts are presented early and are revisited and examined in more depth as the lessons advance.
- *Focus on OOP concepts and not on the syntax details of Java*.
- *The lessons are organized based on the fundamental tasks of developing an OO application and not the constructs of Java*.
- *Project-driven approach*.

Also, elements of the "*model-first*" approach (Bennedsen & Caspersen, 2004) are applied. The typical procedure for presenting new concepts is the following : (1) a problem is described that requires the creation of a model of some existing, usually, model of a system; (2) basic concepts of the problem's domain and their relations are presented; (3) a cognitive model of the system is constructed and the parts from which the model is structured – and consequently the objects that comprise the domain of the problem- are recognized; (4) the cognitive model is presented with the form of a simplified UML diagram showing all the classes and their relations, (5) the classes are implemented, or their implementation is presented, introducing new concepts and constructs; (6) design and code patterns are presented for application in similar situations. In the next sections we present important information for each lesson: how are the new concepts presented; what difficulties have been recorded; and what didactical interventions have been devised for dealing with these difficulties. The projects used for presenting the new concepts are the projects that come with BlueJ (Barnes & Kölling, 2006). The name of each project and its chapter are referenced in parentheses.

4.3.1 Lesson 1: objects, classes and inheritance in objectKarel

The goal of the 1st lesson is the presentation of the most fundamental OOP concepts with objectKarel: objects, classes and inheritance. All the necessary didactical material (theory, activities) is incorporated in the environment itself. The activities incorporated in objectKarel play a central role in the lessons based on objectKarel, and both the lecture and the lab should – if possible – be carried out at the lab.

Students construct and initialize a robot (object) of the basic model (class) using a dialog box that guides them. Emphasis is given on the fact that a robot's state is defined by specific data values, such as its location (street and avenue). Although students do not declare instance variables (fields) it is explained that the initial state of a robot is stored in special variables, called instance variables, which are updated during program execution. Then, students click on buttons labelled with the names of the commands (messages/methods) recognized by a robot of the basic model in order for the robot to carry out a specific task and watch: (1) how the robot responds to each one of the available messages; (2) how the execution of methods alters the state of the robot (the values of fields are presented); (3) what is the syntax of the actions performed interactively in the language of robots. Although, students do not – as we have mentioned – declare fields, emphasis must be given by the instructor on the fact that: execution of methods can alter the state of an object, which is defined by the values of its fields; the behaviour of an object may alter substantially based on its state (Holland et al., 1997).

The presentation of the concepts "class and object" is followed by the presentation of a simple program that is solved using a robot of the basic class and the primitive methods defined in it. Despite the fact that the problem is conceptually simple, its solution consists of a large number of statements and students find it difficult to implement, debug and extend it. In the context of this situation students are presented with the ability to extend the capabilities of the basic class of robots by defining a new class that inherits the instance variables and methods of the basic class and extends it with the definition of new methods. The solution of the problem with a new class that takes advantage of inheritance is presented. This way, students comprehend the advantages of inheritance. Program animation and software visualization is used for executing programs in order to comprehend program flow, as well as to make clear that work in methods is done by message passing (Holland et al., 1997).

The simple metaphor and the hands-on activities of objectKarel give the chance to present the concepts in a clear and concise way, making it difficult for common misconceptions to arise. However, the instructor must carefully select assignments. For example, at least one assignment must involve the construction of multiple objects of a single class, so as to avoid the "object-class conflation" (Holland et al., 1997). Moreover, students can be given the source code of a program that uses an object of the basic class and duplicates code, and be asked to refactor the program using inheritance in order to improve it. Although, students find duplicate code easier than class reuse (Fleury, 2000), such an assignment helps them comprehend the true value of inheritance.

4.3.2 Lesson 2: multilevel inheritance, polymorphism and overriding in objectKarel

The same didactic rationale described in the 1st lesson is used: (1) students are presented with problems that can not be solved efficiently with the already known concepts, come to a dead end, and consider as a natural consequence the adoption of new concepts; (2) the hands-on activities incorporated in objectKarel are used.

In contrast with the concepts presented in the first lesson, the concepts polymorphism and overriding cause difficulties in some students. Students do not find if difficult to understand that we can have methods with the same name in different classes as Fleury (2000) has found, but find it difficult to distinguish between polymorphism and overriding.

In order to help students clarify the taught concepts, the instructor must devise a series of carefully designed assignments with increasing complexity. The assignments must involve the definition of classes that implement a multilevel inheritance hierarchy taking advantage of polymorphism and overriding. UML class diagrams must be utilized. At the beginning students can be given the description of classes and their relations, and next they can be given just the description of a problem and analyse it on their own.

4.3.3 Lesson 3: class definitions

In the 3rd lesson a simple class definition in Java is presented using the environment of BlueJ. The class simulates a ticket machine for train tickets (project ticket-machine, chapter 2). Students use the visualization and direct manipulation techniques of BlueJ in order to create multiple objects with different ticket values and invoke their methods. The *inspect* function is presented and students are encouraged to use it in order to inspect objects' state during method invocation.

This lesson is extremely important for two reasons: (1) the interaction and direct manipulation techniques of BlueJ are presented and students must learn to use them correctly and not excessively; (2) the connection between the OOP concepts presented in objectKarel and their implementation in Java must be made.

Several difficulties were recorded the first year of teaching the course and were gradually dealt with, due to special didactical interventions. Some of these difficulties are characterized as "typical" difficulties, which are difficulties widely known to instructors and independent of the OOP paradigm: they refer to parameters, return types and values of methods. Other important difficulties that instructors must have in mind are the following (categorized accordingly to the classification presented in section 3.2):

Subcategory 2.1 - constructors:

- Several students have difficulty in defining multiple constructors in a class (Carter & Fowler, 1998), and define just one constructor or give the constructors wrong names.
- The use of `this` is not easy for students. However, in cases where its use in a constructor was needed, students did not shadow instance variables as recorded by (Truong, 2004), but instead chose to change the name of the parameter so as to avoid the use of `this`.
- Students face difficulties in initializing the fields in a constructor. The most common errors are: assigning the value of an undefined identifier and not the value of the parameter; assigning incorrect constant values.

Subcategory 2.3 – "set" methods (mutators)

- Declaring as return type of a "set" method the type of the parameter (instead of `void`).

Subcategory 2.4 – "get" methods (accessors)

- Some students access directly private fields instead of using a "get" method, even when this is not allowed (accessing a private field outside its class).

Subcategory 2.6 – access modifiers

- Some students do not apply their knowledge regarding access modifiers in the context of reading or writing code, even though they seem to understand their meaning. This leads to errors, such as accessing directly a private field outside its class.

Also, some difficulties and misconceptions that come to surface later, usually the fifth lesson when students use the main method for testing a class instead of the GUI features of BlueJ, stem from the wrong usage of BlueJ's features in the first lessons. The most important difficulties and misconceptions that must be taken into account by instructors are (Xinogalos et al., 2007):

Subcategory 2.2 – object instantiation:

- Some students do not declare the type of the variable that keeps a reference to the object they instantiate, as a side effect of using the BlueJ's pop-up menu for constructing objects. The instructor must emphasize from the very beginning that for each object constructed, a reference is kept in a variable of the appropriate type. All this information is provided in the dialog box used for naming the instance and initializing it and students must learn to use it consiously and not mechanically. The instructor should also present the statement in Java for accomplishing the same result.

Subcategory 2.5 – method calling:

- Several students call non-void methods as void methods. This behavior is attributed to BlueJ's misleading way of executing methods using the pop-up menu: invoking a non-void method results in showing the return value in a dialog box. The instructor must emphasize the fact that the value returned when calling a non-void method must be appropriately manipulated by the program, for example the value can be printed in the terminal using a `System.out.println` statement, used in a condition or an expression and so on. The misconception that "calling a non-void method results in printing automatically the returned value" must be avoided from the very beginning.

The instructor should also take into account the difficulties regarding the dynamic aspects of OOP, which are attributed by Ragonis & Ben-Ari (2005b) to the extended use of BlueJ's features.

In order for the students to comprehend the concepts presented in this lesson and face their difficulties, they are asked to extract information from the ticket machine class regarding its fields, constructors and methods (name, return type and value, parameters, role) and fill in tables using paper and pencil. Next, students can extend the class. One of the first extensions must be adding a second constructor to the class, in order to detect potential difficulties with multiple constructors. Finally, the instructor must make sure that students have comprehended the relation between the OOP concepts presented in objectKarel and their implementation in Java. This could be done by asking students to define in Java a class simulating the basic model of robots, leaving out – of course – graphical representation issues.

4.3.4 Lesson 4: object interaction

Students are presented with the concepts of abstraction, modularization and "object interaction", using an implementation of a digital clock display (project clock-display, chapter 3). The project consists of two classes: (1) the `NumberDisplay` class that represents

a two-digit number display incrementing by one and rolling over to zero when it reaches a given limit; (2) the `ClockDisplay` class that contains two `NumberDisplay` object fields, one for the hours and one for the minutes.
Students face various difficulties when the fields of a class are not of a primitive but of an object type (Xinogalos et al., 2006b):
Subcategory 2.2 – object instantiation:

- students are not sure where and how they should instantiate the objects that the fields will refer to, as well as
- how to manipulate this type of field

Subcategory 2.5 – method calling:

- the fact that they have to use dot notation for calling methods for a field, which is an object itself, seems to confuse them
- in a class where both internal and external method calls should be used, some students use in both cases an external method call.

In this lesson it is necessary to use object diagrams in order to help students form a conceptual model of an object that "includes" other objects. As a first activity, students study the implementation of the two classes used for the display of the digital clock and: fill in tables regarding the fields, constructors and methods of the classes; draw the object diagram at the moment that the a digital clock is created; write down the line-numbers in the source code of the `ClockDisplay` class where we have an internal and external method call (providing the name of the object too in the later case).
Next, students implement their first class from scratch. The class includes primitive type fields, two constructors, accessor and mutator methods. The definition of object type fields is avoided for the moment.

4.3.5 Lesson 5: the main method

The goal of this lesson is the presentation of the main method and execution without using the visualization and direct manipulation features of BlueJ. This topic is not adequately covered in the textbook of BlueJ and the instructor must prepare notes with the following content: instance vs. class/static methods, the syntax and role of the main method, byte code, execution of a Java application, Java Virtual Machine. An example of a class containing a static method is presented and the environment of BlueJ is used in order to make clear the difference between instance and static methods: students right-click on the class containing the static method and realize that they can invoke the static method, without creating an instance of the class first. Students implement, with guidance, a main method for a project they have already worked with, for example the ticket-machine project. They write code for accomplishing the same result they had previously accomplished by interacting with the environment of BlueJ. The difficulties that arise are many and some of them are related, as we have mentioned in section 4.3.3, to the way the features of BlueJ were used in the previous lesson. The professional programming environment of JCreator is presented to students. Students are guided through the process of creating a new project, adding existing java files of a BlueJ project, adding a new class defining a main method using the auto completion feature, navigating through the classes of the project and the elements of each class using their tree representation, compiling, debugging and executing the project with JCreator. BlueJ is still used for presenting new concepts with the use of projects, as well as for exploring projects interactively. However, students are free to choose the environment that suits better to their needs and preferences when carrying out their assignments.

The difficulties that arise are many and some of them are related, as we have mentioned in section 4.3.3, to the way the features of BlueJ were used in the previous lesson. However, several difficulties which were attributed to the way the BlueJ environment was used in the first version of the course were not recorded in the following versions of the course. For example, "forgetting to declare the type of the variable that keeps a reference to the object being instantiated" was recorded only in the first version of the course (Xinogalos et al., 2006b; 2007). The most important difficulties that instructors must take into account and try to face are (Xinogalos et al., 2006b; 2007; 2009):

Subcategory 2.1, 2.2 – constructors, object instantiation:

- Some students confuse the definition of a constructor with its invocation, and use formal parameters instead of arguments when calling the constructor.
- Some students use as arguments in the invocation of a constructor the fields that are going to be updated.
- The type of object variables is missing.

Subcategory 2.3, 2.5 – "set" methods (mutators), method calling:

- The name of the field being updated is used as argument in "set" methods.

Category 1 – typical difficulties & Subcategory 2.5 – method calling:

- Missing arguments in method calls.
- Missing ( ) in methods without arguments.
- Calling a non-void method as void.
- A method is called without an instance.

Subcategory 2.4, 2.6 – "get" methods (accessors), access modifiers:

- Private fields are accessed directly outside their class instead of using a "get" method.

Special didactical situations must be devised by the instructor in order to help students face their difficulties. During the evolution of the course we found out that the following ones help:

- Students are provided with a presentation which utilizes animation in order to present processes that are either done automatically and "silently" by the BlueJ system - such as the declaration of an object variable during object instantiation - , or are overlooked – such as using the value returned by a non-void method. Screenshots of the dialog boxes that appear during the interaction of the user with the system are presented together with explanations of the processes that take place automatically and their form using Java syntax.
- Examples and assignments that are based on already known projects are used. Students are asked to write a main method for accomplishing the same result accomplished in previous lessons by interacting with the system of BlueJ.
- A program containing common errors is presented. Students are asked to track down the errors and then compile the program in order to check their answers. The corresponding error messages, which are not always comprehended by students, are presented and explained, so as to help students in utilizing error messages for tracking down and correcting the errors and not "blindly" changing the source code and waiting for the errors to disappear as if by magic.

4.3.6 Lesson 6: grouping objects in collections (ArrayList)

The use of collections for grouping objects is very common in object oriented applications, and even small-scale programs developed by undergraduate students. One of the most popular Java collections is the ArrayList collection, which represents a flexible-sized collection. The advantages of ArrayList collections are many and researchers state that it should be introduced first and emphasized over Arrays because it is *a "better structure for representing contiguous lists, both conceptually and in terms of implementation*" (Jacobson & Thornton, 2004) and *"it gives students better abstractions that are more general and will serve them in years to come"* (Ventura et al., 2004). So, the 6th lesson is devoted to the popular flexible size collection of ArrayList and the 7th lesson to the fixed size collection of array.

For the presentation of ArrayList collections a simple electronic notebook project is used (project notebook, chapter 4). Object diagrams are used for supporting students in understanding the structure of an ArrayList. Students perform various functions – add objects, remove objects, iterate the collection and print its objects' info - using the GUI of BlueJ, while they inspect the state of the ArrayList object using BlueJ's inspect function. Manipulating an ArrayList is not easy for students. Although students seem to comprehend the concept of object collections, they find it difficult to use flexible size collections for grouping objects (*Subcategory 2.7 – object collections*) (Xinogalos et al. 2006b, Xinogalos et al., 2008b):

- Students face difficulties in defining methods that return an ArrayList object and then calling it from main(): (i) other return types are used instead of ArrayList; (ii) the return statement is missing; (iii) the method is called from main as a void method.
- Some students do not use the built-in add method for adding objects to an ArrayList or use it incorrectly. For example, add is called for each field of the object being stored to the ArrayList separately and not for the object as an entity.
- Students face difficulties in iterating and retrieving the objects stored in an ArrayList: (i) a while loop is used but objects are not retrieved; (ii) the ArrayList is not iterated; (iii) the retrieved object is not assigned to a variable; (iv) students find it more difficult to use an iterator for iterating an ArrayList instead of an index and the built-in get method.
- Students access directly the private fields of the retrieved objects, sometimes even without an instance.
- Several students can not manipulate an ArrayList at all.

During the four years of teaching the course we have tested various activities for supporting students in dealing with their difficulties. The evaluation of the course led us to the following conclusions:

A first activity should focus on comprehending the structure of an ArrayList. As Kölling and Rosenberg (2001) state in one of their well-known guidelines for teaching object orientation with Java "*visualising class structure is crucial for students to develop an understanding of the important concepts*" (guideline 7, pp. 35). In correspondence to this statement, we believe that visualizing an ArrayList object structure is of great importance for students to comprehend the concept of ArrayList. Object diagrams seem to help students. Also, the visualization abilities of BlueJ seem to help some students, but these visualizations are not as effective for collections of objects (like ArrayLists) as for standalone objects, since they consist of object inspection windows that are not connected in any way. However, the students should not just "read" object diagrams. As Bergin (2000) states in one

of his pedagogical patterns "*Students can learn to read programs earlier than they can learn to write them. But, they should not be permitted to be overly passive in their reading*" (pattern "fill in the blanks"). So, we believe that students must not just "read" object diagrams but 'write' them too. In the context of their first activity students can be given a problem specification and the corresponding code (including a main method) and asked to draw in paper the object diagram. Students can also be asked to simulate basic ArrayList operations - such as iterating and processing their objects, adding new ones, removing objects – making the necessary changes to the object diagram and answering carefully designed multiple choice and open type questions. The correspondence of object diagrams with the visualizations provided by BlueJ should be presented and students should be encouraged to use them.
The next activity can be an exercise requiring filling in blanks. As Bergin (2000) states in his pedagogical pattern under the name "fill in the blanks": "*Students can often learn a complex topic by building several small parts of a larger artifact*". This pedagogical pattern has been adopted by Kölling and Rosenberg (2001) too as a guideline under the name "Don't start with a blank screen" (guideline 2). However, in our case, we believe that the "blanks" should not represent whole methods but specific error prone elements in an excerpt of code. A paper with the problem specification and the source code with blanks can be given to students in order to fill it in. When interviewed after an activity like this, students stated that the activity helped them "*track the points that cause them difficulty and make specific questions*", "*focus on issues that cause them great difficulty*" and "*manage to write some source code that otherwise could not be accomplished*" (Xinogalos et al., 2008b).
Next, students can implement programs from scratch.

4.3.7 Lesson 7: grouping objects in collections (ArrayList vs. Array)

This lesson is devoted to array collections and their comparison with ArrayList collections. In order to present arrays and their differences with ArrayLists we have implemented the notebook project of the previous lesson using arrays. This way, students comprehend better the similarities and differences of the two structures. Students are assigned a project that is implemented using both ArrayLists and arrays.

4.3.8 Lesson 8: using class libraries

In this lesson students are introduced to reading documentation and using library classes in general, as well as specific library classes in particular. This is accomplished in the context of exploring and improving a primitive implementation of an Eliza-like dialog program based on text used to provide technical support to customers of a software company (tech-support project, chapter 5). Students learn to read class documentation and are shown how various classes are used for improving the technical support system: the `String` class is used for improving the processing of user's input (ignoring letters' case, removing spaces and so on in order to process users' requests and respond); the `Random` class is used for adding random behavior in the system's responses; the `HashMap` class is used for associating keywords present in users' questions with related responses; the `HashSet` class is used for tokenizing users' input to a set of words. BlueJ's ability to generate the interface of a class (in the editor window) is presented and students are encouraged to use it for exploring the classes of the projects incorporated in BlueJ. Also, the way that javadoc and basic key symbols, present in all BlueJ's projects, are briefly presented. However, due to time

limitations students, although encouraged, are not asked to write class documentation.The first lab activity is about locating the `String` class in Java' standard class library, study its documentation and track down specific information: define the role of specific methods; search for methods that carry out specific tasks; recognize the information provided by the signature of methods, such as their return type and parameters. Finally, students use the methods of the class for implementing specific tasks that represent fundamental functions on strings. Next, students develop projects using class libraries. For example, a simple phone book is implemented utilizing the `HashMap` class.
Students comprehend easily the structure of Java's standard class library, the concept of packages, the way the documentation is read and used. The only obstacles are the language and the terminology used for describing methods. Some times students guess the role of a method from its name – after all students realize that using meaningful identifier names is important!

4.3.9 Lesson 9: designing classes

Presenting principles of good class design or/and recognizing bad class design is not an easy task. Just presenting theoretically the relevant concepts will not have a great impact on students' knowledge on designing classes. It must be clarified that an application that performs the intended task is not necessarily well-designed. Problems come to surface when the application has to be extended. An extension that would require trivial effort in a well-designed application might require extended changes in a badly-designed application. The best way to present this to students is to use an application with badly-designed classes that from the point of users works perfectly. Trying to make small extensions will bring to surface the underlying problems. An excellent project for this purpose is the world-of-zuul project (chapter 7) of BlueJ's textbook. This project is an interactive, text-based adventure game, which is highly extendable. The most interesting extension for students is providing a GUI for the game, a topic that is not covered in the course. Various extensions for the game are considered that give the chance to present clearly several concepts regarding class design: code duplication, responsibility-driven design, coupling, cohesion and refactoring. Students implement at the lab some of the extensions discussed in the lecture for the world-of-zuul game. Unfortunately, it is difficult for students to apply all the principles of good class design presented to them, since this means that a project of a considerable size must be implemented. Taking into account the time limitations of the course this is not easy to be accomplished. However, students should definitely be assigned a project that involves designing the classes on their own utilizing UML class diagrams.

4.3.10 Lesson 10: improving structure with inheritance

Inheritance is one of the most fundamental OOP concepts and is presented from the first lesson with the use of objectKarel. In the 10th lesson inheritance is revisited more formally using Java for implementing it. The 4th year of teaching the course we were pleasantly surprised to see how easy students comprehended the concept of inheritance. The project used for presenting the concepts related to inheritance is a database of CDs and DVDs (dome project, chapter 8). The project consists of three classes: CD, DVD and Database containing two ArrayList fields for grouping CDs and DVDs. In its first version the project does not use inheritance. Students easily realize the existence of duplicate code in all three classes. When asked how the project can be improved students propose the use of inheritance, which was clearly presented in objectKarel. The way that inheritance is implemented in Java is presented and a new version of the project that uses inheritance is presented and discussed. Polymorphism is also introduced with the definition of a print method in both subclasses, and the superclass for printing the values each class's fields. When students execute the program they are confronted with a problem: just the values of each class's fields are printed and not the ones inherited. This problem is faced in the next lesson.

Using objectKarel for introducing students to the fundamental OOP concepts provides great help to students. Some of the difficulties recorded in the previous years were not recorded in the 4th year of teaching the course, while others were reduced. However, the most common difficulties that instructors must have in mind, in order to deal with them, are (Xinogalos et al., 2006b):

Subcategory 2.1, 2.8 – constructors, inheritance:

- In the constructor of a subclass students do not invoke the constructor of the superclass (Truong & Bancroft, 2004) and as a consequence they do not use parameters and/or assign values to the attributes/fields inherited from the superclass.

Subcategory 2.8 – inheritance:

- In cases where multilevel inheritance is implemented, students - when asked to define the messages that an object of a subclass responds to – go up only one level at the class hierarchy.
- Some students face difficulties with subtyping. We observed that when students are confronted with a statement that declares a variable and stores a reference to an object, most of them recall the rules of subtyping and give correct answers to relevant questions. On the other hand, when students are confronted with the declaration of a variable and asked what types of objects can be referenced by this variable, several students do not think about subtyping and mention only the type of the class.
- Some students fail to realize the way that multiple inheritance is implemented in Java and believe that each concrete class can extend directly more than one class.

An activity that helps students comprehend what happens when the constructor of a subclass is executed is using the debugger and executing the project presented in the lecture step by step. This helps student understand: how the constructor of the subclass invokes the constructor of the superclass; how are the inherited fields initialized; that they have to provide in the subclass constructor invocation arguments for the superclass constructor too. This activity also prepares students for the introduction of some concepts introduced at the next lesson: static and dynamic type, dynamic method lookup.

4.3.11 Lesson 11: polymorphism and overriding

Having as a starting point the problem with the print method in the project of the previous lesson and the observations made during the step-by-step execution activity described above, the concepts of static/dynamic type and dynamic method lookup are introduced. It is clarified that the static type is used during compilation and the dynamic type during execution for dynamic method lookup. Students having in mind the concept of overriding presented at the second lesson with objectKarel comprehend without difficulty that the problem is solved by calling in the print method of the subclasses the overridden print method of the superclass. What is different in comparison with objectKarel is the syntax for

calling an overridden method in subclasses. With the help of objectKarel polymorphism and overriding are more easily comprehended by novices. The difficulties recorded in the first version of the course were significantly reduced:
Subcategory 2.8 – inheritance:

- In a "set" method of a subclass that overrides a "set" method of a superclass with the purpose of assigning values to all fields (including those inherited), students omit the call to the overridden "set" method of the superclass and just assign values to the fields of the subclass.
- Students include in a subclass method a call to the overridden method of the superclass, but they do not use the corresponding parameters in the overriding method.
- Some students can not differentiate between polymorphism and overriding.

4.3.12 Lesson 12: abstract classes and interfaces

Abstract classes and interfaces are presented using a classic predator-pray simulation (foxes-and-rabbits, chapter 10). The initial version of the project does not take advantage of inheritance. The project consists of several classes, but conversation focuses on three classes: the `Fox` class used to represent foxes; the `Rabbit` class used to represent rabbits; and the `Simulator` class which controls the simulation. This project is used not just for presenting the new concepts, but for reinforcing the already taught inheritance concepts and good class design principles as well. Students are guided through the process of creating an `Animal` superclass extended by the subclasses `Fox` and `Rabbit`; using one collection for grouping both kinds of the simulation's actors (foxes and rabbits) instead of two; substituting the `hunt` method of foxes and the `run` method of rabbits with a polymorphic `act` method implementing the basic behavior of each actor in the corresponding subclass; presenting the need to add an abstract `act` method to the `Animal` superclass in order for the project to compile (`act` is called for the objects-actors grouped in a collection and retrieved in a variable with static type `Animal`); an `Actor` interface is added so as to make possible the usage of other kinds of actors besides animals.
The evaluation of the course has shown that students do not find it difficult to implement abstract classes and interfaces, but instead to understand their true meaning and when they should declare a class as concrete, abstract or interface. Next, we present some misconceptions that were recorded in the first course (Xinogalos et al., 2006b):

- Some students have the misconception that they can create objects not only from concrete classes, but from abstract classes and interfaces too.
- Some students believe that a class can implement just one interface.
- Some students believe that it is not necessary for a concrete class to implement an abstract method declared in its abstract superclass.
- Some students believe that an abstract class declares only abstract methods, while others believe that both abstract classes and interfaces declare only abstract methods.

5. Conclusions

The long-term evaluation and reformation of the "Object Oriented Design and Programming" course presented in this chapter has established some guidelines that can be utilized by researchers and instructors for designing and teaching an effective course. These guidelines do not refer, as usually, to specific aspects of the course. The guidelines presented cover all the aspects of the course: teaching approaches utilized; sequence of concepts and organization of lessons; usage of the well-designed projects accompanying BlueJ and its textbook; programming environments used, their role in achieving the goals of the course and potential pitfalls; potential difficulties and misconceptions; didactical interventions for dealing with recorded difficulties.

Besides the specific guidelines for designing and teaching an effective OO Design and Programming course, the four-year evaluation and reformation of the course has also drawn some more general conclusions regarding course design and effective teaching of demanding subjects:

- *Continuous evaluation of teachings is necessary in order to reach valid conclusions and make improvements*. Although, the teaching approach adopted in the first version of the course was not an empirical one, it was our belief that it should definitely be evaluated by recording students' achievements and studying their conceptions. The decision to take on a long-term evaluation of the course proved to be right. This evaluation gave us invaluable insights into students' difficulties and helped us reform the course with increasingly positive results the last four years.
- *More than one tool is needed in order to support demanding cognitive areas, such as programming*. The usage of multiple tools for supporting the teaching of cognitively demanding subjects must not be avoided. In the OOP course described the use of three distinct but complementary programming environments helped in achieving better results without causing any cognitive overload.

With the belief that continuous evaluation of teachings is necessary in order to reach valid conclusions and make improvements we intend to continue the long-term evaluation of the course. The results of this never-ending evaluation along with the results of studies that are made available to the teaching community, the gathered experience and the new technology enhanced tools that come to surface will support us in developing even more appropriate educational material (i.e. examples, activities, assignments) and move to reformations for improving the teaching of OO Design and Programming. Our main goal for improving the course focuses on devising new material for supporting students in deeply comprehending the principles of good class design and the techniques for improving an application's structure and designing truly OO applications.

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Educational Effect of Externalization of Know-how Information for Care Planning Processes

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1. Introduction

Since April 2000, with the establishment of the Long-Term Care Insurance System in Japan, duty-of-care planning has been imposed. It is aimed at improving the quality of long-term care services. However, since there are many simplified and stereotyped plans, it has become apparent that the genuine care needs of clients are not being satisfied. The main factor involves care managers' lack of experience. To solve the problems stemming from such insufficient experience, we must establish a method of care manager training.
There are four important processes in care management: screening the person requiring care, assessment, making a care plan, and carrying out care plan, management. Care planning is a process that perceives care needs precisely from the result of care assessment, and includes plans from basic care guidelines to concrete care service. This process is the most important for improvement in the quality of care service. In order to improve the quality of care service, know-how information externalization, sharing, and transfer for grasping a care client's true care needs are important elements. We aim at development of an educational support system oriented to knowledge management, sharing, and transfer in care management. This system supports the process that perceives a care client's assessment result in care planning. As a method, we considered how to a make beginner notice the difference in a skillful person. Making the difference noticeable is one method of externalizing know-how information. Although there have been studies emphasizing the difference between a skillful person and a beginner in the field of care (Benner, 2001), (Herbig, 2001), there is no study on making a beginner strongly notice the difference. In this paper, we report that the know-how information sharing support system (KISS) has been developed, and the effectiveness of know-how information externalization has been confirmed from the result of trial at care service site.

2. Method of know-how information externalization, sharing, and transfer

We consider that externalization, sharing, and transfer of know-how information are performed through repeating of observing, imitating, comparing and practice. In care planning, these observation, imitation and comparison are performed more efficiently by using a computer that shows a skillful person’s care plan in various forms.

2.1 Definition of know-how information

Know-how information is tacit knowledge. It is said that there are two kinds of human knowledge: explicit knowledge, which is knowledge expressed verbally; and tacit knowledge, which is knowledge expressed non-verbally (Polanyi, 1966). A lot of knowledge is tacit knowledge and this is considered to be a very important element in group behavior (Nonaka & Takeuchi, 1995).

In recent years in the field of business administration, much attention has been paid to the role knowledge management plays in company strategy. There are a lot of studies about method to externalize, share (Desouza, 2003), (Choudrie,2005), and transfer (Leonard & Swap, 2005) tacit knowledge. Know-how information has mainly been studied as part of knowledge management. Recently, research on knowledge management has also been conducted in the medical treatment and nursing fields (Welsh & Lyons, 2001), (Abidi et al., 2005). Many studies have focused on applying ICT (Information and Communications Technology) to record, accumulate and share a skillful person's know-how information. These are the systems that a skillful person in externalizing know-how information by himself.

Tacit knowledge in care management is knowledge that depends strongly on a context or situation, and is based on advanced cognitive power, judgment, insight, and powers of observation. In this study, we are concerned with information that involves perception of care needs from the result of care assessment. The targets of perception are excavation of care needs and prediction of a serial change of a care client with a grasp of the care client's global image. Here, we define know-how information as information that assists the understanding of a client's daily life. Such know-how information includes heuristic information, cases experienced in the past, sequences for perceiving assessment results, and how to determine a viewpoint. Concretely, know-how information grasps relevance among assessment items, especially information that shows the strength of that relevance. That is, it is the information that is needed in order to make advanced recognition and judgment.

2.2 KOMI Radar Chart and KOMI Chart

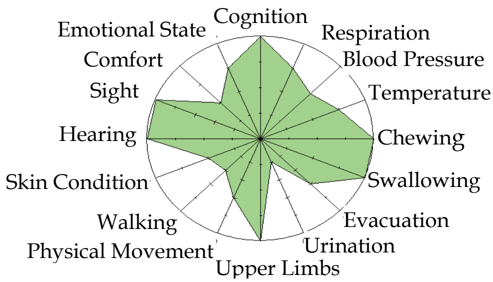
KOMI(Kanai Original Modern Instrument) is a graphical recoding sheet (Kanai, 2002). As shown in Figure 1, the result of having carried out assessment of the care client is expressed on the circular chart of the Radar Chart and KOMI Chart.

(a) KOMI Radar Chart

The KOMI Radar Chart is designed to record physical information about the client. It enables cares to understand at a glance the client’s physical condition at that point in time, using 16 checkpoints. Each checkpoint has a scale to reflect the level of that particular condition so that caregivers can perceive the client’s current situation. Such a normal state is shown close to the perimeter of a circle.

(b) KOMI Chart

The KOMI Chart is designed to help judge the cognitive and behavioral aspects of client. The KOMI Chart consists of 15 heading, each of which includes 5 checkpoints, making 77 cognitive checkpoints, and 78 behavioral checkpoints. The result of the checks are marked using three different shading patterns for cognitive aspect, and five shading patterns for the behavioral aspect. The shading patterns are: "Can be understood or performed by client", "Cannot be understood or performed by client", Unknown (Needs observation)", "Carried out with specialist's support", "Carried out with family member's support". Thus, the KOMI Chart makes a client's global image easy to grasp by visualizing the result of assessment. The result of care assessment is standardized by carrying out assessment of the care client using the KOMI Chart. That is, since it is visualized by expressing the result of assessment on a chart and a result can be given to anyone, standardization is further promoted. For example, in a KOMI radar chart, a physical condition can be condensed and transmitted into the information of a "form." With the KOMI Chart, both the missing abilities and operative abilities of a client can be condensed and transmitted into the information of a "color" and a "position." Thus, since the ambiguity of judgment by language can be eliminated by transposing the information of a care client's assessment result into the information on a "form", "color", and "position", it can judge anyone and transmitting becomes easy. Thereby, the sharing as a result of assessment becomes easy. In this meaning, the KOMI Chart can be considered as media for a kind of information sharing.



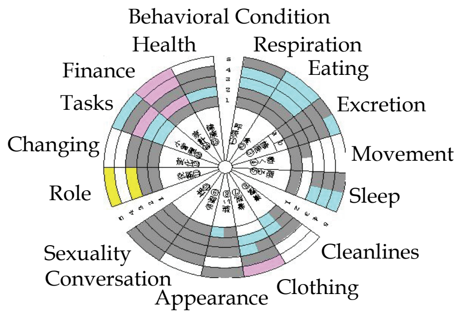


Fig. 1. KOMI Radar Chart & KOMI Chart

2.3 Difference between a skillful person and a beginner

We visited a hospital, welfare facilities, a home nursing station, a home care support center, a university, a nursing school, etc. which are performing care plan decisions using the KOMI Chart, and perceive and investigated the needs and the present condition regarding computer support in care management to the administrator, the educational person in charge, the practicing caregivers, and the educator. The following has been confirmed from the result.

(a) The process that perceives a care client's assessment result in the care plan creation by the KOMI Chart is the most important, and is difficult work for a beginner.

(b) The difference between a skillful person and beginner appears clearly in this perceived document.

(c) The difference mainly appears in the difference in viewpoint, and the difference in the view of the KOMI Chart.

2.3.1 Difference in a viewpoint

A viewpoint affects performance assessment. A skillful person understands and explains a phenomenon with the terminological (concept) related structure of explaining the item and phenomenon of assessment. On the other hand, a beginner understands and explains only from a concept. That is, a skillful person is looking at structure well, but a beginner is fixated on the evaluation for every item.

2.3.2 Difference in the view of the KOMI Chart

A skillful person looks at the whole KOMI Chart first. Next, black or white ("Can be understood or performed by client", "Cannot be understood or performed by client") balance is seen. Then, cognitive aspect and behavior aspect are seen. That is, it sees details (where a cell is smaller) from the whole (where the cell of a chart is larger). After all, the skillful person has a certain unique pattern, and sees and goes along with it. On the contrary, a beginner is considered to have the tendency to observe each item as a result of assessment too strongly, and cannot see the whole.

2.4 Externalizing and sharing of know-how information

We thought that know-how information could be externalized by paying attention to the difference between a skillful person and a beginner. The method of know-how information externalization, sharing, and transfer, which emphasized the difference between a skillful person and a beginner in the perceiving of a document about the assessment result, is described. A skillful person's documents are a mix of general knowledge, which refers to explicit knowledge such as theories and rules, and specific knowledge, which refers to tacit knowledge based on experiences such as original viewpoints, original patterned knowledge, and conceptualization. The externalization of know-how information involves separating specific and general knowledge. The method for separating general and specific knowledge involves creating differences between a beginner's and a skillful person's documents using repetitions that involve items such as operations, classifying the document for every viewpoint change using a concept-base, visualizing, and presenting the results. Furthermore, our method uses the KOMI Chart, which represents the origins of a document. That is, both qualitative data (the document) and quantitative data (the KOMI Chart) are shown, and differences are highlighted by combining both data sets. We believe that these differences trigger separation. This is stated in detail below.

(a) A user refers to the statistical values of an original idea or the KOMI Chart and then changes the viewpoints.

(b) Based on these viewpoint changes, the user moves vertically and horizontally in the hierarchy of a concept-base and calculates the degree of similarity each time.

(c) The system then classifies the document from the calculation results.

(d) Next, the system visualizes the classification results in a two-dimensional document space displayed on computer.

(d) By clicking on the document number based on its classification, the KOMI Chart that originates the document is shown.

(e) Finally, the user records, accumulates, and names what has been noticed.

By seeing many documents with a high degree of similarity, the difference between oneself and others can be seen and know-how information can be accumulated. These differences separate the specific and general knowledge used as the basis of documents. This separated specific knowledge is considered know-how information. This separation process, which is considered the method of externalizing know-how information, is shown in Figure 2.

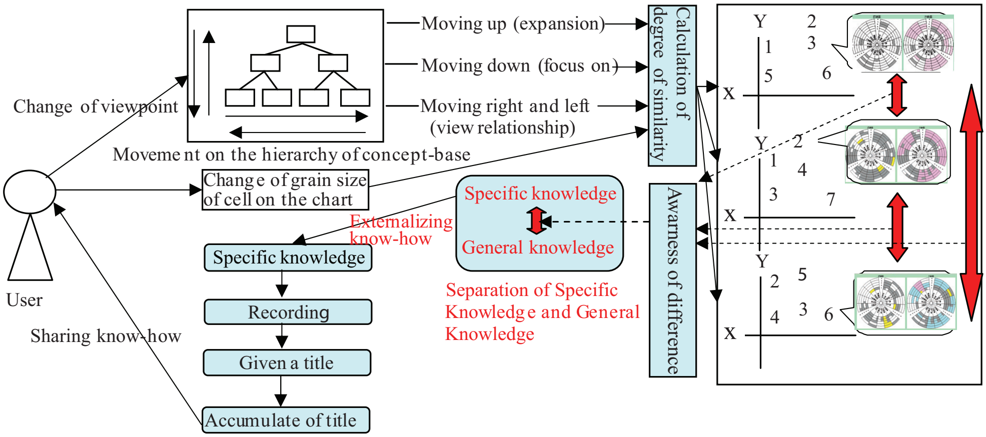


Fig. 2. Model for externalizing and sharing the know-how information

3. Development of Know-how Information Sharing System

After compiling and examining the system's needs from the nurses and care-workers of the hospitals, welfare facilities, home-visit nursing care stations, and in-home care support centers, the following three points were determined to constitute the basic development policy.

(a) A computer is not relied on for advanced decision-making like Intelligent Tutoring System (ITS), but a support system is positioned for decision-making on care management, externalization, and sharing know-how.

(b) The system does not stop at the research stage, but system development is performed for actual utilization.

(c) Concerning system specifications and function, the needs of the facility are fully investigated, analyzed, and determined. How much it has responded to the needs of the facility is crucial, as well as system evaluation.

Furthermore, in order not to apply too much burden to a user so that it may be used in the care facility, it tries to attain the purpose by the simplest possible function.

3.1 System Architecture

KISS is constituted by the module and interface using a database as shown in Figure 3.

The user makes a new care plan using our "Care-designer" software. The system extracts documents from the database of the "Care-designer", analyzes them with morphological analysis software, and extracts keywords from the analysis results. The system calculates the distance between an skillful person's documents and the beginner's new documents, chooses the three cases that most resemble the new case, and determines the coordinates of the new case by the distances and coordinates of the three cases. The system performs such calculation whenever a viewpoint is changed. The system displays calculation results on two dimensions. When users click on the number of documents on a display, the system displays a chart that originates the document. In a text file, users can describe freely what they have noticed. Furthermore, a user can search and refer to a document that other users noticed. User's operation history is recorded. The circumstances and thinking process noticed by users can be traced by analyzing this history.

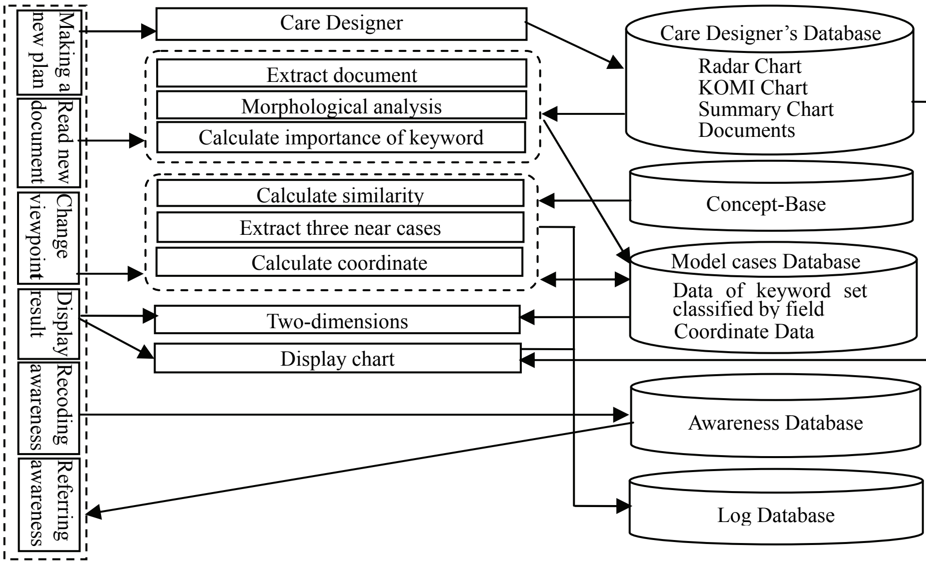


Fig. 3. System configuration

3.2 Modules

The main modules that constitute KISS are explained. The modules which constitute KISS are care planning, extraction of a keyword, calculation of the degree of similar between documents, coordinates calculation of a new case, a care designer database, a concept database, a model case database, a awareness database, a log database. Here, the main modules are explained.

3.2.1 Model cases

We collected about 1,500 cases from hospitals, welfare facilities, home nursing stations, home care support centers, etc. Two nursing and care experts verified whether an example was suitable as a model. 106 cases were selected from the result as a model case. As shown in Table 1, the cases of the 106 models were classified into four types: an acute term, term escaped from an acute term, convalescence, and stabilized term. The conditions of a model case were classified by color for clear and immediate comprehension. If a new case is applied to four states, then the effect is expected to simplify the comparison of model cases.

No.	Condition	Color	Number
1	Acute term	Gray	8
2	Term escaped from an acute term	Red	37
3	Convalescence	Green	53
4	Stabilized term	Blue	8

Table 1. Color mapping of a client's condition

3.2.2 Concept-base for the nursing and caring fields

A concept-base is a knowledge base that expresses concepts with its own and other conceptual sets. In this study, we constructed a specialized concept base for the nursing and caring fields. It has a tree structure with six levels and is constructed by a thesaurus. Viewpoints are changed by moving up and down its levels.

(1) Extracting concepts:

The concept-base contains about 6,300 terms. Since priority was given to use in the field of care, it extracted from the assessment item of the KOMI Chart, the model example of a care plan, the textbook relevant to the KOMI Chart, etc.

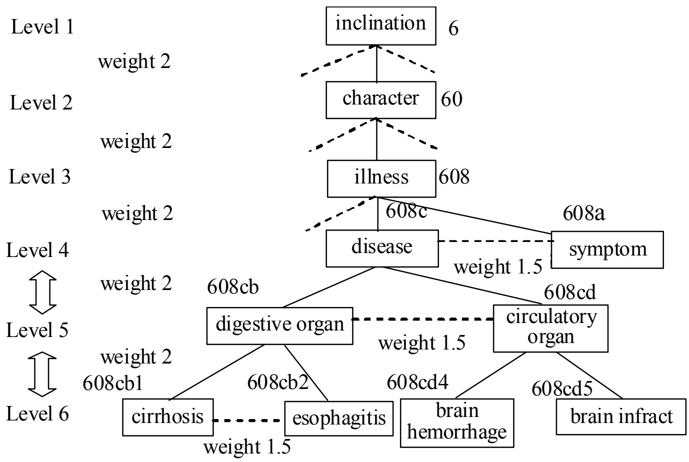


Fig. 4. Hierarchic structure of concept-base and encoding

(2) Coding of a concept

It becomes unnecessary to build the tree structure of a concept base on a computer by coding of a concept. Extracted keywords were encoded based on a Japanese language thesaurus. Keywords that did not exist in the thesaurus, such as disease names, were encoded in our own system. The code is used to identify the concept base's position on the hierarchy. Digit length denotes the level on the hierarchy. For example, as shown in Figure 4, the "disposition" of a level 1 is a concept and a horizontal number "6" is a code. Whenever a level falls, the number of beams of a code increases one by one with "60" of "character" from "6." If the number of the digit is the same, it will become the concept of the same level. That is, whatever figure of the branch of the tree structure of a concept base and a code is the same correspond.

3.3 Support function for externalization

To perform externalization of know-how information, the following support functions are considered.

3.3.1 Calculation of Degrees of Similarity and Visualization

We considered how to make a beginner notice the difference by visualizing and showing the degree of similarity between the documents with which the skillful person perceived the result of assessment.

(a) Calculation of Degrees of Similarity between Documents

Although methods such as a thesaurus and a vector space model are proposed for the method of calculating the degree of similarity between documents, we define the degree of similarity between documents as follows, in order to calculate the degree of similarity by change of a flexible viewpoint. The system extracts keywords from each document. The distance between keywords is determined by the nearness of the concept between keywords. We consider sibling relationships (adjacent keywords on the same level) in the thesaurus to be nearer than child-parent relationships (hierarchical relationships). Moreover, a class considers it as a thing with a nearer deeper thing also by equal sibling relationship. The distance between documents is measured by the distance between a keyword set. It visualizes by mapping the distance relation between documents to two-dimensions.

(1) Similarities between keywords

The distance between keywords is defined as the sum of the weight of the branch of the node that reaches other keywords from one keyword. The weight of the branch of the node of a parent-child relationship in the tree is set to 2, and the sibling relationship is set to 1.5. For example, as shown in Figure 5, since the three figures are identical if the code of cirrhosis and disease is seen, it returns to level 4 and the weight of each level is totaled; the distance is 2 + 2 = 4. Therefore, the distance between keywords changes when the viewpoint changes.

The distance between keywords a and b in viewpoint L is expressed as $d(a,b \mid L)$.

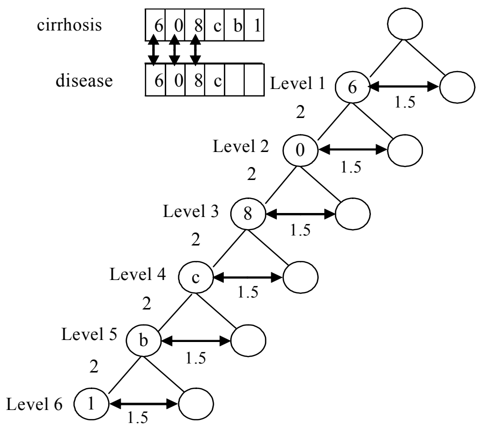


Fig. 5. Weighting between keyword and same class and between classes

(2) Similarities between Documents

The distance between documents is determined by the distance between keyword sets. The keyword sets are extracted from the document. Let the viewpoint on the concept-base be L . Let the keyword set be A, B . The distance between $^{\forall} a \in A$ and set B is defined by

$$D_w(a, B \mid L) = \min_{b \in B}\{d(a, b) \mid L)\} \tag{1}$$

The distance $D(A \to B \mid L)$ from keyword set A to keyword set B in viewpoint L is defined by

$$D(A \to B \mid L) = \frac{1}{|A|}\sum_{a \in A} D_w(a, B \mid L) \tag{2}$$

where symbol $|A|$ stands for the elements of set A .

The distance $D(A, B \mid L)$ between keyword sets A and B in viewpoint L is defined by

$$D(A, B \mid L) = D(B, A \mid L) = \max\left\{d(A \to B \mid L), D(B \to A \mid L)\right\} \tag{3}$$

(b) Mapping the Documents into Two-dimensions

Even if the distance between keyword sets (document) is obtained as a numeric value, it is difficult to intuitively see differences between many documents. We considered mapping each document as a point on the display of a personal computer. In practice, we tried to map documents on a plane (a two-dimensional space) using Kruskal's method, which is specifically aimed at multidimensional scaling. The similarity between documents can be grasped intuitively from this function, and the structure of set of document can be seen. The result of having mapped on the two-dimensions degree of similarity between the documents of 106 examples of a model is shown in Figure 6. The number beside a dot is a document number. The state of 106 examples is expressed as four colors.

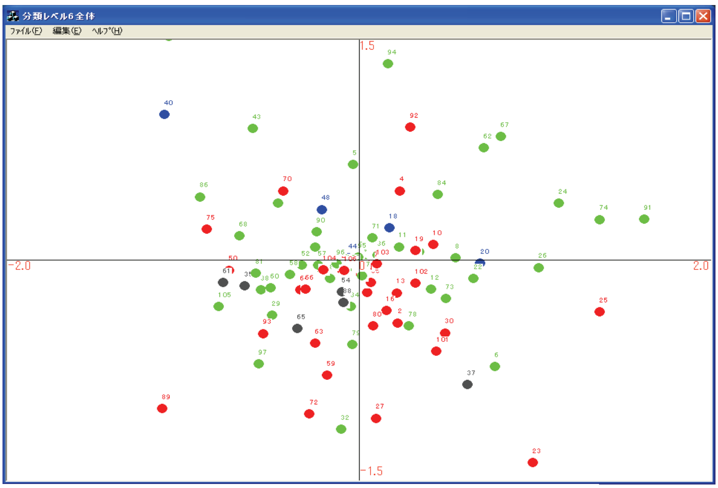


Fig. 6. Mapping documents of cases into two-dimensions

3.3.2 Referring to the original data of a perceiving document

All are shown as a result of assessment, such as the KOMI Radar Chart, which became the origin of a perceiving document, the KOMI Chart, and also basic information, to the question of why the far and near differences arose in the distance between perceiving documents. A user can find the factor and reason for the difference between a skillful person's perceiving documents by this function. Moreover, the factor and reason for the difference become awareness.

3.3.3 Changing Viewpoints

Changing viewpoints refers to expanding and narrowing viewpoints to recognize degrees of relevance. Whenever a viewpoint is changed, the distance between documents is calculated, and the difference is made noticeable by visualizing the results. This function supports the externalization of differences from the viewpoints of skillful persons and beginners. We achieved this function by moving the level of the concept-base. A skillful person recognizes a phenomenon structurally. To recognize a phenomenon structurally like a skillful person, training that repeats abstraction and embodiment is important. This training is performed by moving change of a user's viewpoint on the hierarchy of a concept base. For example, a care client's illness is "liver cirrhosis" When a concept is enlarged, it is regarded as the illness of a "digestive organ." Specifically, whenever a viewpoint is changed, the distance between documents is calculated, the result is visualized, and the difference is made to be perceived. Externalization of the difference in the viewpoint of a skillful person and a beginner is supported by this function. Figure 7 shows the results of changing viewpoints. After changing to level 6 from the top of Figure 7, the result is that the next change is with levels 5 and 4. When numbers 40, 67, and 70 are looked at, the distance is changed by changing a viewpoint, and the display position also changes.

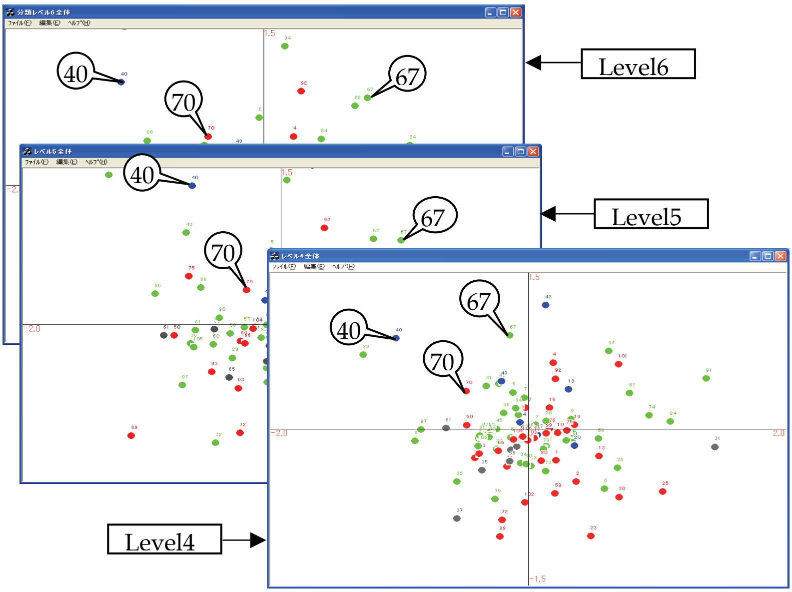


Fig. 7. Two-dimensional display of the model example by changing viewpoint

3.3.4 Experience of care planning

Externalization, sharing, and transfer of know-how information are difficult only by seeing or hearing it. When a user actually experiences care planning, noticing the difference from a skillful person is promoted. The care plan creation tool "Care Designer" which we developed, was built into this system, and this function is achieved.

3.3.5 Mapping the Documents of a New Plan into Two-dimensions

The documents of skillful person were previously mapped into two-dimension space by Kruskal's method. The new documents of beginner are mapped into the same space. We expected this function to highlight the effect that promoted awareness of the differences between beginners and skillful person.

3.3.6 Mapping several users' perceiving documents on two-dimension

Several nurses or care-workers assess one patient or client, and each draws up a care plan and can discuss care plan together. The similarity of several nurses' or care-worker's documents can be simultaneously displayed on two dimensions. Noticing a difference is promoted by carrying out comparison examination of this result. This function not only shows the difference in the viewpoint by the coworker of a place of work, or the difference in an occupational description, but sharing of information is achieved. Furthermore, the "Ba(field)" which is the context shared by the coworker of the field of work that mutually carries out an interaction is offered. The result of having mapped the new case at the same plane as model cases is shown in Figure 8. Yellow stars are new cases. On this screen, four persons' documents are in different position. In order to explore why they differ, the KOMI Chart is seen and compared here.

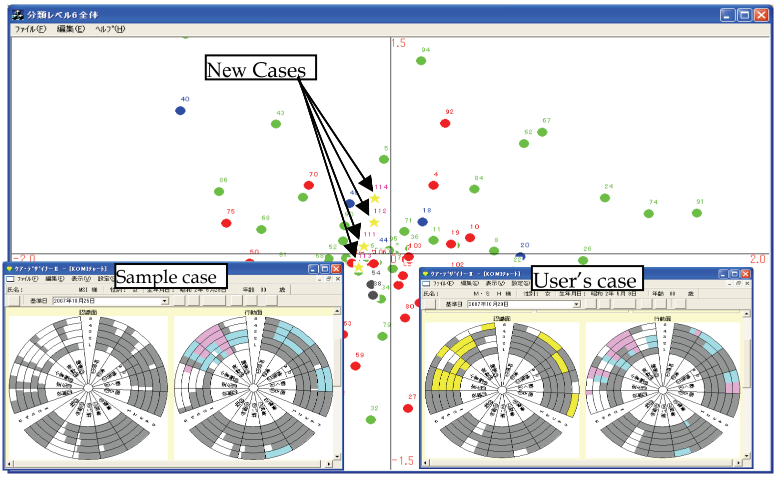


Fig. 8. Mapping into two-dimensions added several users' new cases and displaying chart

3.3.7 Writing what has been noticed

By writing what has been noticed, a user can externalize and be conscious of know-how information. When writing out diligently what has been noticed, its time and file name are saved to a single directory. Search becomes possible by this function.

3.3.8 Referring to other's awareness documents

It is expected by referring to other's awareness documents that a new awareness is inspired. Moreover, although the awareness document is a user's subjective item, a certain similarity can be found by referring to many similar awareness documents. Thereby, its awareness partakes of objectivity. We think that sharing and transfer are attained from these phenomena. If they are the same department, since the same aspect of affairs is encountered in many cases, efficiently similar awareness can be looked for. Search is possible in a keyword and a user name. The result is shown in Figure 9. If you see awareness document, it understands where the user's viewpoint and concern are.

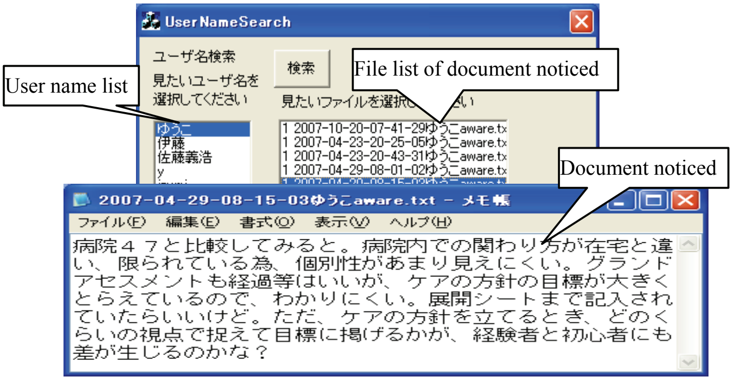


Fig. 9. Search results of document by user name

4. Evaluation

One target of this study is developing a system for actual use in nursing and caring situations. To evaluate the system's effectiveness, how requests of the facility are reflected is important. Therefore, we conducted a system evaluation in two steps. That is, they are evaluation by a skillful person, and evaluation by trial in the care facility.

4.1 Evaluation by skilful person

We are planning evaluation of the system in the care facility. In order to explore the possibility of effectively using the system in the facility, a preliminary experiment by a skillful person was conducted.

We conducted an evaluation by eight nurses and two caregivers to ensure that our system provides educational support before using it in a hospital. Three of the ten are teachers at a university and a school of nursing. The following comments were obtained in interviews with these experts.

(a) The results of mapping these documents into two-dimensions are appropriate.

(b) If what the beginner has noticed is written faithfully, know-how information can be extracted.

(c) Sharing of know-how information creates new awareness in users.
(d) Although documents are usually compiled from assessment results, in this system, improving assessment results has an educational effect on the classification results of the document.
From these expert comments, we concluded that this system can provide educational support in initial education.

4.2 Experiment Design

After the results of evaluation by skillful person, we have been continuously conducting this experiment for one year in nursing and care facilities to evaluate our system. The effectiveness of the know-how information externalization using KISS is evaluated.

4.2.1 Outline

The outline of the experiment is as follows.
(a) There are five users (one nurse, two care workers, one care worker, one care giver).
(b) The place of use is an in-home care support center.
(c) The period of use is from April, 2007 to December, 2007.
(d) The apparatus use is a notebook computer.

4.2.2 Method of evaluation

The concrete qualitative evaluation method employed interviews. Moreover, users' operation logs and records of observations are also analyzed.
Although trial of KISS in the facility should consider various ways, it was tried in the following three ways.
(a) By looking at the KOMI Chart etc., user does comparison examination why the case was mapped into that particular position on two-dimensions.
(b) A user draws up his new care plan and does a comparison examination with a model case.
(c) Two or more care practice persons do assessment of the same care client, a care plan is drawn up and a comparison examination is carried out with a model case and each other's care plan.

4.3 Results of trial

We are analyzing the result of having actually used this system now. Therefore, a part of the result is shown below.

4.3.1 Documents of awareness

The documents of awareness are classified into three types. The typical documents are shown in Table 2.
(a) The difference in environment that offers care service
Awareness about how to a care client to be concerned is conspicuous.
(b) The difference arising from those who offer service
Awareness by the difference between an experienced person, a beginner, an occupational description, etc. is recorded.
(c) Difference of aim to care

They have noticed the difference between the basic plans drawn from the assessment result. Thus, there are tendency that user's viewpoint moves to "Basic plan" from "Organization."

4.3.2 Users' operation logged data

A part of log of operation of KISS is shown below.
(a) Case that users referred to
All the members are referring to the example in which care service was received at home. It turns out that they are interested in the client of the same care environment as themselves. Moreover, the difference was looked at by the example referred to by occupational descriptions, such as a nurse and a care worker.

Difference	Contents
Organization	Care plan is incorporated in which direction of home care harnessed a client's individuality (for example, hobby etc.) more than the hospital.
Person	When making a care plan, differences appear between experienced persons and beginners in how fine viewpoint targets are held up.
Basic plan	Unless awareness of viewpoints in which care is denoted creatively, healthily, and firmly organizing everything in a person's daily life, care direction is not seen.

Table 2. Contents to notice

(b) Chart that users looked at
The difference has not appeared in the number of times of reference about the important basic information, the KOMI Radar Chart, the KOMI Chart, and grand assessment. It can be estimate that they have the knowledge what information important for care planning is, since this organization is holding the study meeting.
(c) Changing viewpoint
The number of times a viewpoint changes varies greatly with people and sample cases.
The difference was 1 to 12 times. Changing viewpoint has a tendency with more change of the item to perceive than up and down movement.
(d) New case
When adding the cases in which two or more persons did assessment of the same client and made a care plan, 11 cases were newly made and they were compared with the model cases. We have confirmed that mapping of this new case is appropriate (Eto, 2006).
(e) Mapping several users' new cases into two-dimensions
The comment that it involved the result of a display of two or more examples, and "having become like mini-study meeting" was able to be obtained from users. It was checked that KISS played the role of setting up the information sharing a "Ba(field)" (Eto, 2007).

4.3.3 Interview of users

We interviewed about the following items.
(a) Know-how information can be externalized.
(b) Know-how information externalization itself brought about educational effects.

(c) Is there any educational effect by use of KISS?
A part of the interview of a trial person is shown in Table 3.
The answer that it became the "trigger" of externalization of awareness or know-how information by use of KISS regarding externalization of know-how information has been obtained. This result is in agreement with the aim of development of KISS that externalization of know-how information is supported by promoting awareness. We think that know-how information was able to externalize from these answers "Know-how information is contained" and "know-how information is in a document". It is thought that it depends on the power of an organization etc. strongly further, and know-how information of such an answer from a user is effective in individual knowledge, capability, and KISS supporting know-how information externalization.
(b) Know-how information externalization itself brought about educational effects.
The educational effects of this system are shown in Figure 10.

Question	answer
Could know-how information be expressed using this system?	Since I can compare with other's care plans, it became the trigger to express what I think. Since it was comparable with the care plan of other care facilities by using this system, I have noticed that difference. This system became that trigger. I had seen and noticed other persons' care plans.
Do you think that know-how information is included in its document recorded notice?	Know-how information is contained. Know-how information is in the document recorded notice.

Table 3. Know-how information externalization

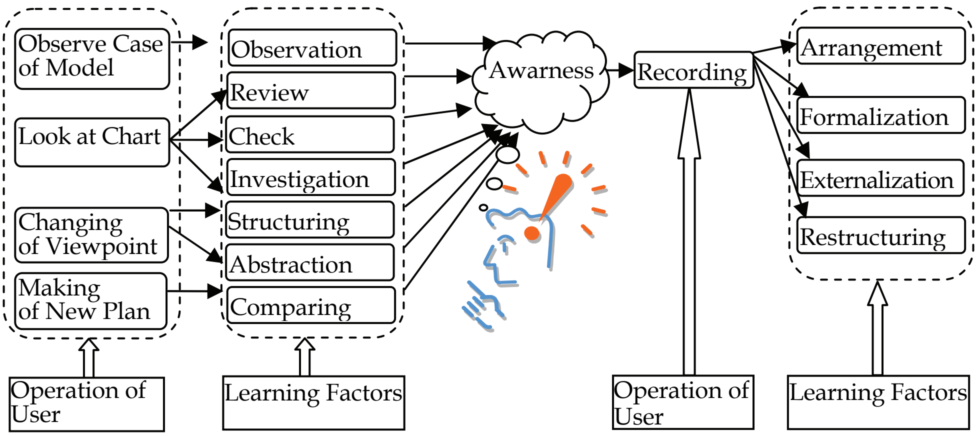


Fig. 10. Process and educational effect of externalizing know-how information

(1) The educational effect of noticing the difference from a skillful person
Using this system, user looks at a skillful person's model cases, changes a viewpoint, or also draws up a care plan and compares his plan with a skillful person's plan. In such a process of a series of operations, they come to notice by doing work like the item shown in Figure 10. We considered that an educational effect arose in this process. A part of answer to the interview to this effect is shown in Table 4.

Observation: They noticed the tendency of the method of observation, the difference in a viewpoint, or his viewpoint. Furthermore, the answer of "powers of observation having improved" and "it having been useful to observe deeply" was obtained. It is thought that it was useful for improvement in powers of observation to see the example of a skillful person, a coworker, etc. by use of KISS.

Review: Their weak points and strong points are reviewed by comparison with a skillful person, such as "returning to foundations is important", "you have to increase the viewpoint that prepares a life", and "continuing the view over a life." Furthermore, the action that improves its posture to a care client is also seen. From these results, imitation of KISS and a comparative function are considered to work effectively.

Check: By seeing information, such as the KOMI Chart that is other plan and its basis, it is checking that their viewpoint is not wrong. By seeing the example of a skillful person or a coworker using KISS, that it can check in this way will lead to confidence, and it will result in fulfillment.

Investigation: They investigate the assessment result about the care client of a coworker and one person, and it is acting based on the result.

Structuring: The answer, such as "which the relevance of the KOMI Radar Chart and the KOMI Chart came to understand to some extent", and "a cognitive aspect a behavioral aspect, and the physical condition not being considered separately", was obtained. From this answer, the relevance between the assessment items, which we defined as know-how information, is considered that it was able to acquire significant information.

Abstraction: The embodiment and abstraction by change of a viewpoint are performed, and the answer that KISS was useful was able to be obtained. "Change of a viewpoint" which is the function of KISS is considered to have been effective.

Comparing: They are comparing broadly from an assessment item with " seen paying attention to the potential abilities" to the behavioral aspect or the whole assessment result, and the result is interpreted for itself. It can be confirmed that imitation that is the fundamental method of KISS, and comparison are ensured from this result.

(2) Educational effect by recording awareness
As shown in Figure 10, a user can acquire an educational effect by recording by passing through processes, such as arranging, formalizing, externalizing and reconstructing one's awareness. A part of answer of the interview to this effect is shown in Table 5.

Arrangement: They have noticed the importance of writing "it was able to arrange", "by writing having shown the difference between me and other users clearly", etc.

Formalization: The posture that will be summarized and written briefly is a factor important for transfer and sharing of information.

Item	Answer
Observation	I thought that there were some tendencies in the method of observation. I thought that I also had a tendency. I could cultivate the power of observation. I found the habit of my viewpoint.
Review	I thought that it was important that get back to basics since it was found that I also have a biased tendency to conduce the result. I tried to speak to pull out the action of the care client who did not know until I saw other persons' care plan etc.
Check	Since the interpretation of results of assessment was the same as coworker, I confirmed that a client's condition could be grasped well. It has checked that the item with a first priority resembled my view closely, and I felt easy when its view was right. I have checked that the natural thing was not completed I checked that there were those who are writing finely, and those who are writing roughly.
Investigation	I compared the result together with the coworker. The spot became like a study meeting. We discussed to carry out such care services from now on. The chart is not created correctly and thought that it was a thing with many examples judged by force.
Structuring	I found some relevance between KOMI Radar Chart and KOMI Chart. I could grasp that recognition condition, a behavior condition, and the physical condition cannot be considered separately, Healthy body follows healthy recognition, and it is useless even if which is missing. It checked that the grand assessment written by I and a skillful person had been in agreement.
Abstraction	I could see finely, could see concretely, and can expand a viewpoint now. A difference with a specialist is felt. Those who can abstract are skillful persons.
Comparison	I compared paying attention to the potential abilities. I compared how grand assessment was drawn from the result of assessment. By comparing, showed objectively that I did not understand the care client.

Table 4. The educational effect in the process that noticed the difference

Externalization: The answer of "a certain grade was able to express", "what was considered having been externalized", etc. was obtained. The effectiveness of KISS was checked from this result.
Restructuring: "While writing it, I thought about various matters over again." From such an answer, it is shown that KISS is effective in reconstruction of an "idea."

Item	Answer
Arrangement	By writing, the difference of self and other persons became clearer. What I considered has been checked.
Formalization	I wrote what had been convinced. It tried to write briefly. It was going to summarize on the point.
Externalization	To some extent, what I noticed has been expressed. I wrote as I felt or considered.
Restructuring	While writing it, I thought about various matters over again. I can see a client's daily life while I will write it, by doing such work that goes out I remembered that I forgot it, or there was such a matter.

Table 5. Educational effect of recording

(c) Is there any educational effect by use of KISS
The answer to the educational effect of KISS is shown in Table 6.

Question	Answer
Is there any educational effect by using this system?	I could be aware of the bias of my view. I have noticed the difference of how to be concerned with a client. Comparing with others' care plan conduces to a good effect. It is effective that the degree of similarity of a document is shown visually. Since my weak point was found, there is an educational effect. Since I have noticed what is insufficient for self, I think that it is good for education. Having gotten to know the condition of the client which I do not know benefitted me
Is this system useful to personnel training?	This system is the tool that can carry out comparison examination on the assumption that the KOMI Chart is drawn. Since the difference from others document can be visually shown when teaching, this system is useful to user with to some extent fundamental knowledge as self-study. This system is applicable to reconfirmation and reeducation. It can be used for sharing of each other's viewpoint.

Table 6. Educational effect of KISS

(1) Is there any educational effect by using this system?
Comparison became easy by visualization at the answer to the educational effect of KISS, and there were some that have noticed the difference between others and a viewpoint.
(2) Is this system useful to personnel training?
It became a tool when teaching, since comparison becomes easy also by visualization at the answer about personal training, or that it is useful for self-study etc.

4.4 Discussion
We can discuss the result of trial of the system as follows from.

4.4.1 Documents of awareness
They have noticed the difference between the care of a hospital and in-home care whether to think the individuality of the care client is important. This is a view from the home support side, and is considered to be the know-how information from the place of work. In "a people difference", it can be said to be the know-how information about the difference in the method of observation, or how to catch a target. By the "basic plan", the condition of the care client is perceived, it is the scene developed to the statement of principles of care, and know-how information is surely written in clearly as awareness.

4.4.2 Users' operation logged data
Recording of operation of KISS shows that users fully understood the installed function and used it effectively. That the difference in an occupational description was looked at by the example referred to expresses the difference in the viewpoint by an occupational description.

4.4.3 Interview
(a) Is know-how information externalized?
All members have commented that the awareness arises by comparing with other persons' care plan by using KISS and the know-how information is included in the documents of awareness. This result coincides with the contents of the documents of awareness. As such, we considered that externalization of know-how information is possible by effective practical use of KISS.
(b) The educational effect of noticing the difference from a skillful person
An answer, such as "which the relevance of the KOMI Radar Chart and the KOMI Chart came to understand to extent", and "a cognitive aspect, an behavior aspect, and the physical condition not being considered separately", was obtained for structuring. From this answer, we considered that the relevance between the assessment items, which we defined as know-how information, was able to acquire significant information. Therefore, the educational effect of KISS was confirmed.
(c) The educational effect by recording awareness
The answer of "it was able to arrange", "it writing and awareness having become clear more", etc. was able to be obtained for arrangement. Moreover, the answer with the idea "various things were thought over, writing", "different the more, the more it writes" was able to be obtained for reconstruction. It is thought that the educational effect by recording was acquired from this result.
Thus, a user's capability not only improved according to the educational effect of externalization of know-how information, but it has checked having grown up also as an organization by sharing of know-how information. The important factor that brought about such an effect can consider to be hat comparison with a skillful person's care plan can be performed easily by visualizing and showing the degree of similarity between the documents that perceived the result of assessment.
(d) Is there any educational effect by use of KISS
It was confirmed that it is useful for the function of visualization of KISS comparing others' plan. An effect is expectable by using KISS for personal training from this result.

5. Conclusion and future works

As part of development of an educational support system oriented to knowledge management, sharing, and transfer in care management, we have developed KISS in the care planning process. A one-year trial was conducted in a care facility for evaluation of the system. Through these results, we confirmed that this system is useful for externalizing know-how information, and bringing about an educational support effect. From these results, it was suggested that KISS is a method of support by computer use in care management education. As future works, we will evaluate the effectiveness of the system in hospitals and nursing colleges. Improvement in individual ability and the activation of the organization will be evaluated through practical use.

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