An architecture of an ICT based system for constructivist based learning in higher education

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Abstract:

The development of web based learning environment for constructivist based learning in higher education is presented in the paper. It was based on the ADDIE model. The main orientation of the authors of the system was to take into account recent findings of pedagogical research and availability of new technologies in order to create efficient and effective learning support for the students. Active forms of learning, collaboration and appropriate feedback for independent learners are main characteristics of our learning system, which is student centred and changes radically many former practices in higher education.

1 Introduction

In the last decade higher education in Slovenia and in many other European countries experience great changes. The percentage of generations of young citizens between 19 and 23 enrolled into higher education study programs reached nearly 80%. On the other hand, the amount of money for higher education in the state budget and consequently number of pedagogical staff and all other resources have not followed the growth of number of students and the efficiency and quality of education has been endangered.

In most of higher education institutions responsible people came to the conclusion that the use of Information and Communication Technologies (ICT) in teaching and learning, usually called e-learning, can provide at least part of the solution to these problems. E-learning is defined for our purpose here as the use of any of the new technologies or applications in the service of learning or learner support. It is important because e-learning can make a significant difference to how learners learn, how quickly they master a skill, how easy it is to study; and, equally important, how much they enjoy learning [1]. Such a complex set of technologies will make cultural, intellectual, social and practical impact on the experience of learning.

There is also a financial impact. Networks and access to online materials offer an alternative to place-based education, which reduces the requirement for expensive buildings, and the costs of delivery of distance learning materials. However, learners still need people support, so the expected financial gains are usually overwhelmed by the investment costs of a new system and the cost of learning how to do it. Therefore Laurilard claims that it is not possible...
to build the case for e-learning on cost reduction arguments. It is more reasonable to argue for investment to improve value than to save costs.

The second catalyst for the interest in e-learning appears to be centered around concern that local higher education institutions might not be able to continue its monopoly on the delivery of education [2]. One area of potential competition is alleged to come from international institutions of higher education.

Most activities in e-learning are in the development of courses and their resources and only some institutions have recognized that successful e-learning takes place within a complex system, composed of many inter-related parts.

ICT and e-learning itself cannot solve all the problems mentioned above. New approaches to learning incorporate and integrate the strengths of face-to-face and online learning in a synergistic manner to create a unique learning experience congruent with the context and intended educational purpose [3]. These approaches are called blended learning. Blended learning combines multiple delivery media. The original use of the phrase “blended learning” was often associated with linking traditional classroom activities to e-learning activities. However, the term has evolved to encompass a much richer set of learning dimensions: blending online and offline learning, blending self-paced and collaborative learning, blending structured and unstructured learning, blending learning and practice [4]. Blended approaches to learning are not just more trendy technology driven ideas that will fade as fast as they come.

Up-to-date learning environments, based on the recent research findings, question conventional practices and the belief in the lecture as an effective approach to engage students in critical and creative thinking and learning. These designs illustrate how higher education can revisit and strengthen the fundamental values and practices that have been seriously compromised over the last half-century.

2 Methodology for developing learning system

In the framework of the SAKE (“Spletna arhitektura kot učna tehnologija za konstruktivistično e-učenje” in Slovene for “Web Architecture as Educational Technology for Constructivist E-Learning”) project we have developed architecture for ICT based system for constructivist based learning in higher education.

The most widely used methodology for developing new learning support systems is called Instructional Systems Design. This approach provides a step-by-step procedure for the evaluation of students' needs, the design and development of training materials, and the evaluation of the effectiveness of the training intervention.

A system is any set of components that work together to achieve a specified outcome or goal. There are many different ISD models, but almost all are based on the generic “ADDIE” model, which stands for Analysis, Design, Development, Implementation, and Evaluation.

During analysis, the designer develops a clear understanding of the “gaps” between the desired outcomes or behaviours, and the audience's existing knowledge and skills. The design phase documents specific learning objectives, assessment instruments, exercises, and content. The actual creation of learning materials is completed in the development phase. During implementation, these materials are delivered or distributed to the student group. After delivery, the effectiveness of the training materials is evaluated. This phase consists of formative and summative evaluation. Formative evaluation is present in each stage of the ADDIE process. Summative evaluation consists of tests designed for criterion-related referenced items and providing opportunities for feedback from the users. Revisions of the system settings as well as of the learning materials are made as necessary.
3 Analysis

In the requirements gathering and analysis phase of the system development life cycle we investigated the following factors: students, teaching staff, learning content, institutional framework, and infrastructure.

Our target population are students in engineering and science programs in higher education. Learning goals in majority of courses in these programs are related to higher cognitive taxonomic levels, such as application, analysis, synthesis and creation of knowledge. For this reason only traditional ex-cathedra lectures and reading of textbook are not efficient enough although courses also include a laboratory work. Hence, students are supposed to be more actively involved in the learning process, which needs to be transformed into a knowledge creation process. The learning pyramid metaphor is often used to show how the efficiency of learning increases with active participation of students. In average, students after two weeks remember only 10% of what they have read, but they remember up to 90% of what they have done. This was also historically a reason to extend the education process in engineering and science to include also a laboratory work. Moreover, the mentioned aspects are rather good supported in constructivist learning theory and in the methodologies based on this learning theory.

Lecturers and teaching assistants are highly qualified for their activities in selected courses. Their role in e-learning environment is supposed to be different than in traditional lecturing. They are actively engaged in the design of learning system with virtual laboratories and in preparation of different types of learning materials, such as virtual textbooks and activities in virtual laboratories. Some of them are supposed to be engaged as tutors, who are going to moderate different activities for students, who will take place in learning management system and in virtual laboratories. They will have very important role in different assessment tasks, as they are crucial for efficient feedback in virtual learning environments.

Learning contents are specific for each particular course, but there are some common properties for all of them. Usually they are developed from teaching and learning materials used in traditional courses. Authors have to take into account previous knowledge of the students, expected learning outcomes, and ascertainment of pedagogical research about motivation and efficient learning methods. Active forms of learning, collaboration with peers, and construction of new knowledge on previous knowledge are most important.

4 Design

Within learning environment, supported by a learning management system, we applied blended learning approach, in order to retain the benefits of face-to-face teaching and class interaction ands well as to capture the benefits of virtual learning environment [5]. Innovative learning activities, based on constructivism [6][7], were applied in the computer science courses, which were designed as pilot courses as most of participants in the project have background in computer science.

Constructivism is a theory of learning, which claims that students construct knowledge rather than merely receive and store knowledge transmitted by the teacher. According to constructivist learning theory knowledge should be internalized by learners [8]. In different stages of learning process we use different active forms of pedagogical work in order to engage students to personalize the knowledge [9]. They can adjust the depth of their learning according to their needs and abilities due to open definition of tasks.

We also prepared possibilities to engage students with new assessment forms such as peer assessment. We try to answer how assessment of the active forms of learning can be applied
in higher education. It is evident that active forms of learning and assessment will influence the quality of learning in our learning environment. Educational assessment is the process of evaluation and documenting, usually in measurable terms, knowledge, skills, attitudes and beliefs. The skills and competences of assessment are highly desired in higher education [10][11].

Students need opportunities for formative assessment and for getting feedback to develop skills and concepts. As there are usually not enough opportunities to get them from staff, peer learning settings provide opportunities for additional feedback. Peer assessment is a process where students consider and specify the level, value or quality of a product or performance of other people in similar situation, usually student within a given class. It represents also an approach to train students how to provide valuable feedback and suggestions for performance improvement on one hand and also how to reflect on their own work on the other hand. Sluijsmans [12] identified many advantages of peer assessment. Some of the most relevant are that it can motivate students and encourage their active involvement in learning, encourages students to become more autonomous in learning, signals students that their experiences are valued and their judgements are respected, and make students think more deeply, see how others tackle problems, pick up points and learn to criticise constructively. Teachers often experience difficulty in evaluation students involved in collaborative activities. The problem lies not only in evaluating the level of learning produced by the process itself, but also in gauging the actual degree to which the individual has actively participated in and contributed to the shared work.

Another important aspect of efficient learning is social dimension of learning. Social constructivism emphasises how meanings and understandings grow out of social encounters. The emphasis is on the learner as an active creator of meanings. Teacher and peer learners enter into a dialogue with the learner, trying to understand the meaning of the material to be learned for each particular learner, and to help learner to refine his understanding.

Traditional educational environments are often characterized by a process whereby the teacher assigns a learning activity that is generally carried out autonomously by the student. However, this strips the learning process of a fair amount of its social dimension. So the idea of fostering collaborative learning strategies as a situation in which two or more people learn or attempt to learn something together, presents itself as a mean of strengthening this dimension by creating the conditions for individual cognitive development as a result of group interaction [13].

In the case of networked collaborative learning, these strategies are often implemented by assigning a group of students with the task of collaboratively discovering the solution to a given problem (collaborative problem solving) or collaborative developing a written text based on a given argument (co-writing). The mentioned activities include different communication and collaboration tools, which are characterized by a variety of unique and powerful information-sharing and collaboration features that offer key advantages, such as allowing learners to be actively involved in their own knowledge construction, as well as improving co-writing processes and facilitating their monitoring.

5 Development

It is a special challenge to implement all these concepts in the ICT supported learning environment. Most of currently available ICT supported learning environments are only a collection of more or less unconnected traditional learning materials, some of them originally created and many of them just digitalised textbooks and other learning materials. Students are supposed to read the texts, which are in some cases enriched with illustrations or with some animations and videos. But most of them are based on traditional teaching approach with
initial explanation and with some exercises in different forms afterwards. In some cases different multimedia motivational elements are integrated. Therefore we decided to define first an architecture that will permit co-operation of various tools and environments. This represents an innovative approach with a constructivist learning theory as a starting point.

Figure 1 shows the architecture of the learning environment developed in the framework of the SAKE project. It is based on the active learning approach. Students are active in problem based learning activities. It is extremely important to define appropriate problems, which are not too simple to avoid students to be bored and not too pretentious to prevent students from giving up. Vygotsky defined this concept as the zone of proximal development, which is the difference between what a student can do without help and what she can do with help. Vygotsky stated that a student follows an example and gradually develops the ability to do certain tasks without help or assistance. The role of education is to provide students with problems, which are in their zone of proximal development and in this way encouraging and advancing their individual learning.

In our architecture, problems are defined in standard learning management system – LMS (e.g. Moodle). After getting familiar with the problem, students are directed into a virtual laboratory, where they can find basic “research infrastructure” with many tools needed to solve the problem. They can also consult tutor, who supervises activities in virtual lab, and can give different type of advice and recommendations.

Learning achievements of self-directed learner depends on learner’s self regulated processes. Different categories of Web-based tools (e.g., collaborative and communication tools, content creation and delivery tools, assessment tools, administrative tools) that are part of learning management system, can be used to support different self-regulated learning processes (e.g., goal setting, self-monitoring, use of task strategies, self-evaluating, time planning and management, help-seeking) [14]. Nevertheless, this support is better if the course is facilitated. In (e-) learning environments tutors are supposed to facilitate planned activities and “take care” of students.

Tutor’s main tasks are to:

- create a syllabus that lays out the schedule, requirements and activities of the whole course,
- create code of behaviour within the course,
• announce learning goals and expectations,
• follow learners’ work and monitor their progress,
• help learners to progress jointly on the right way,
• stimulate a communication among course participants,
• actively participate, promote and lead the interactive discussions,
• provide answers to questions, feedback and recommendations on course activities,
• evaluate and analyze learners’ work.

Usually the course begins in a classroom, where at the beginning, learners are introduced to their teacher (e.g. instructor, tutor) and other learners in the classroom. Face-to-face classroom sessions take place at appointed times.

Schedules for the course should be made on a weekly basis. The schedule determines events (e.g. real-time meetings, videoconferences, chat sessions), readings (e.g. learning contents that learners must read or view) and activities (e.g. laboratory work, assignments, tests, intermediate products for a multi-week project). The activities should have deadlines, although learners can complete activities according to their own schedule [15]. This degree of synchronism is important as a motivation and gives students feeling of social inclusion and participation in a group.

An important functionality in our system is an assessment. We implemented facilities that can support both aspects of assessment, formative assessment, which is used to give immediate feedback to students and can be used to direct them in further learning activities, as well as summative assessment at the end of learning activities to measure the achievement of learning goals and to certify the final result of learning [16].

Because we wanted to allow students to complete activities according to their own schedule, we cannot provide a continuous presence of tutor. On the other hand students are supposed to do many activities by themselves, and hence a feedback in the form of formative assessment of their activities is crucial. Formative as well as summative assessment can be automated and implemented as an expert system that is part of a special functionality of virtual laboratory or it can be provided by means of “human tutors” – with a possible delay in this case. Obviously, the results of formative assessment are presented to students in the virtual lab, while results of summative assessment need to be sent to LMS.

We mentioned the importance of social aspect of learning and its importance in constructivist learning approach. In our architecture at least part of activities are designed in such a way that they stimulate peer learning. “Peer learning” is a form of collaborative learning that enhances the value of student-student interaction and results in various advantageous learning outcomes. To materialize the benefits of peer learning, tutor must provide “intellectual scaffolding”. Learning environment needs to support collaborative activities by means of communication support and by means of resource sharing. For this reason we extended usual forums infrastructure in LMS by inclusion of fashionable social networks such as Twitter, Facebook, etc.

6 Implementation

In the first phase of implementation we mainly focus on Computer Science students and we implemented virtual labs for courses in Programming and in Computer networking [17].

The integration of learning system with learning materials into other courses at the University of Ljubljana, Faculty of Computer Science and Informatics and its evaluation are planned for the next semester, beginning in October.
7 Conclusions

We have identified the learning problem, the goals and objectives, the students’ needs, existing knowledge, and other relevant characteristics about students and teaching staff during analysis. Analysis also considered the main requirements for the learning environment and other infrastructure needed to implement the selected courses. In the design phase we defined the architecture of the system and outlined the main elements of learning activities and contents for the selected courses, based on the specified learning objectives and goals.

The actual creation (production) of the content and learning materials was carried out in the development phase and was finished at the end of this academic year.

We expect that actual implementation of the courses will start at the beginning of next academic year in autumn 2010 and that evaluation of the learning system and learning materials, that is foreseen for the following months, will bring us a lot of important information for the further development of the SAKE learning system and will help us to improve the system and learning contents and will contribute to better quality and efficiency of learning.

References:


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