Smart e-learning systems in tertiary education

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***Abstract*— The problem of laboratories in tertiary education, especially in polytechnic universities, is particularly acute. el-Chem is an application deployed to assist students in the Aristotle University of Thessaloniki, Chemistry Department [1]. After study [2] have emerged some weaknesses in the application el - Chem. In the new study proposed to amend the application by using multi-agent system. The use of intelligent agents will be a tool not only for students but also for teachers. Its importance for teaching staff will be two-fold, since it frees them from bureaucratic procedures and also provides for professor and student self-assessments.**

***Index Terms*— e-learning, multi-agent systems, formative assessment.**

I. INTRODUCTION

Tertiary education in Greece is characterized by many peculiarities. One of the most important is that students are able to enroll in the next year of studies, regardless of how many courses they have managed to complete successfully. The second peculiarity is that the term of studies is not fixed. In accordance with the most recent law on new enrollments, the years of study correspond to n+2 years (where n is the standard years of study at any faculty). The term of studies is 2n+2 for old students, which leads to the phenomenon of so called "eternal students". Thus, it is concluded that Greek students can attend the final semester of their studies even if they have not already passed their first semester courses. Bearing in mind that attendance of certain theory-based courses is not compulsory at Greek universities, many students focus on laboratory courses; as a result they fail to pass the theory-based courses for their regular teaching semester. A large number of students who had to move from their fixed residence to another city for the sake of their studies, return back home upon successful completion of their laboratory courses. Being far away from University, these students are obliged to prepare themselves for exams. It is a fact that distance and place of residence reinforces inequalities among students. In his study, Hamnett [3] shows that distance constitutes a determining factor that reinforces inequalities among students. Similarly, Peterson [4] focuses not only on distance, but also on the differentiation of students' residence. The same results are described in Rivkin's study [5].

In tertiary education, and especially in natural sciences, one further laboratory-related problem needs also to be tackled.

Hofstein [6] makes particular reference to the importance of laboratories for the consolidation of theoretical concepts, particularly of chemistry concepts. In the present study conducted at the Aristotle University of Thessaloniki (Department of Chemistry) revealed many alarming findings:

- First semester students have better knowledge of water chemistry compared to students who have completed of 8 semesters;
- Students who have completed the study program 8 semesters, although that they have attended the laboratory classes and they have successfully examined in them face difficulties in water chemistry.

The studies of Hofstein [6] and Rivkin [5] confirm that natural science education laboratories, especially chemistry laboratories, are key to the successful learning of chemical phenomena.

In the context of aiding students, a presentation-based learning system was developed for the Physics-Chemistry and Environment laboratory course. This application, apart from the theory-based part, also includes audiovisual materials thoroughly describing the experiments related to the water analysis and measurement of physicochemical parameters.

The target of the new application is to assist students attending the Physics-Chemistry course, as well as the graduates of the Department of Chemistry at the Aristotle University of Thessaloniki. This application is composed of the following parts:

- The theory-based part which describes the basic principles of the subject matter for a certain laboratory.
- A video showing all steps of the experiment.
- Multiple-choice test questions to assess the learner's comprehension of the particular subject matter.
- Project exercises aiming at improving the learners' grades.

The scope of the new system will begins when students are enrolled at the Department of Chemistry. Passwords are automatically issued will allowing students to sign in the application. Once logged in, students will may access and study the theory-based part, and then watch the experiment video.

Students will may only proceed to the assessment questions once they have accessed both the theory-based part and the video. These questions, four in total, are randomly will selected out of 10 questions from the database. Each question is followed by 4 suggested answers; only one is true. Therefore, provided that they have accessed the theory-based part and video, learners are then able to answer the multiple-choice questions. The difficulty level of these questions is varied; there are two low level (easy) questions, one medium level question and one high level (difficult) question. The score for each learner being assessed is calculated by the system, from zero to ten. The ranking of questions per level is shown in the Table 1.

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Table 1: Ranking questions per level.

Level	Question	Answers
First level (easy)	Water hardness is due to:	A. Dissolution of CO_2 in rainwater. B. Rock dissolution in surface water. C. Rock dissolution in underground water. D. All the above.
Second level (medium)	Permanent hardness is due to:	A. Sulphates. B. Chlorides. C. Nitrates. D. All the above.
Third level (difficult)	Which of the following statements – relating to determination of hardness by complexometric titration of a water sample using EDTA – are true:	A. pH of sample is buffered at 10. B. pH of sample is buffered at 8. C. pH of sample is buffered using HCl. D. pH of sample is buffered using NH_3.

If the score will be over 50 units, this means that learners have passed successfully the said laboratory course; otherwise they have to repeat the process from start.

Over the last three years, the education landscape has changed a lot, moving rapidly towards US standards. The explosive growth of e-Universities is typical (almost all universities worldwide offer many different courses on general-purpose). el-Chem will be modified on that philosophy to help learners acquire better general knowledge on issues relating to water analysis.

Learner-application interaction is at the core of distance learning. Of course, attendance alone is not enough for learners to experience active learning, contrary to the mental participation which is particularly more significant than the student's simple physical participation in a learning environment. As suggested by Mayer [7], interactivity-based applications are the best way to ensure the use of mental processes to develop cognitive activities. It is a fact that a basic level of interaction could not be sufficient for the implementation of new knowledge learning, without activating the learner's emotions and mental processes. According to Liu's study [8], clicking a button or activating an options menu should not be considered as sufficient interaction. The explosive growth of web technologies contributes to the integration of animation multimedia technologies and other multimedia material, easily and reliably, in web-based environments enabling distance learning.

Another problem of web technologies and sending a large volume of information is that web applications transmit and process a huge volume of information. It is very difficult to process this information without any help, therefore smart applications are used to facilitate our work. The multi-agent system is such a system; it enables artificial intelligence, learning and runs tirelessly. For this reason, it is used in learning systems.

II. MULTI-AGENT SYSTEMS

Multi-agent Systems in Distance Learning Systems.

The process of determining the architecture of a Multi-Agent System which is able to support the formative assessment in learning management systems consists of the following main processes:

- Requirements specification
- Analysis and design process based on the Gaia methodology [9].

The stages of such a system are briefly described below:

Specification requirements

The first step of determining a multi-agent system architecture is to prepare the specifications. The main requirements of such a system have been adopted from the studies of Hadji [10] and Perrenoud [11], the practical experience of the research team of Otsuka and Rocha [12], Ferreira, Otsuka and Rocha [13], in computing e-courses as well as from the work of Thorpe [14], Hopper [15], Nelson [16], Cerny [17] and Gomez [18] regarding the assessment of learning in distance education.

The requirements of the el-Chem system have two main parameters regarding the formation of the assessment process. These parameters are instructors and learners. Thus, the requirements to support the needs of instructors are as follows:

- Instructors should receive on a continuous basis relevant and reliable information regarding the participation of learners in every suggested activity throughout the learning process.
- Instructors should receive information about learners' participation in all activities suggested, in order to monitor participation in educational processes and identify their participation.
- Mechanisms have been set up in order to assist the analysis and interpretation of the abovesaid information just-in-time, with coherence and impartiality.
- Instructors should be supported regarding the activities assessment through the pre-analysis of learners' participation based on criteria determined in the activities plan. To provide detailed feedback on a continuous basis regarding this assessment.
- Flexibility should prevail and assessment criteria should be specified for each activity.

The system requirements on the part of learners are as follows:

- To receive on a continuous basis monitoring and learning reports for their profiles, which should contain feedback on every participation and for every suggested action. These reports shall be available throughout their course and shall help learners be aware of the difficulties throughout their developmental process.
- To also send feedback thus updating the profile of other learners in order to create a reliable learning profile of the whole team, which could potentially lead to collaborative learning improvements.

The next step is to specify the roles of system agents, i.e. the behaviors that should be implemented by agents to support the abovesaid requirements.

III. Analysis and Design of a Multi-Agent System.

There are a lot of methodologies which can will be used to describe the roles of agents in el-Chem. The methodology developed by Wooldridge, Jennings and Kinny [7] is simple and efficient and provides sufficient support for the specifications of behavior factors (roles model), the definitions of inter-role protocols (interaction model), the definition factors of the agent types (agent model), as well as the specification of communication among different agent types (acquaintance model).

At the analysis stage, the roles model and interaction model should be defined. The roles model determines a set of agent behaviors, necessary to support the requirements presented in the previous section. The model of roles defines a set of behaviors of agents who need it to support the requirements presented in the standard requirements for multi-agent systems in distance education systems.

At the design stage, the agent model and the acquaintance model should be defined. The agent model determines the agent types necessary for the application and could be considered as a set of agent roles. To optimize system performance, these roles were grouped to minimize the number of agent types. This process resulted in an agent model consisting of three agent types (Figure 1):

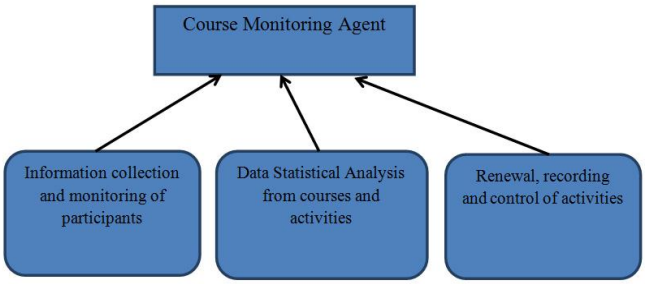

Figure 1a) Course monitoring agent model with cardinality (1 … n).

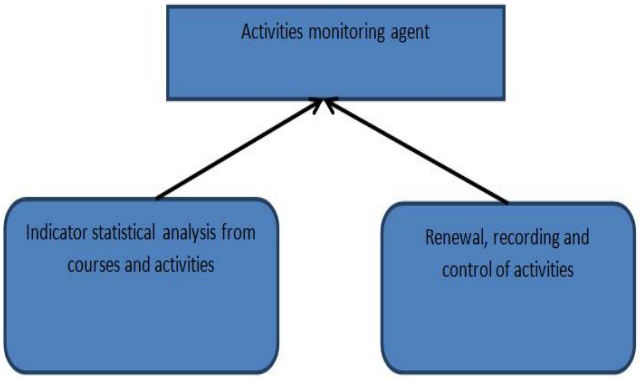

Figure 1b) Activities monitoring agent model with cardinality (, 0 or more).*

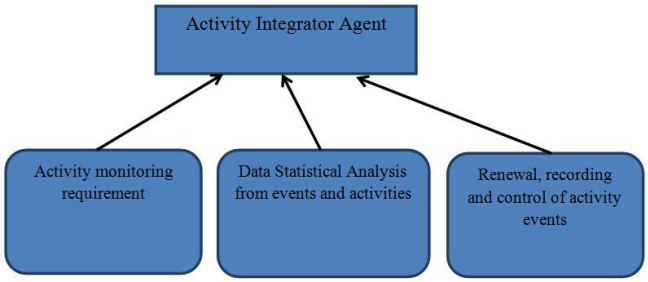

Figure 1c) Activities integrator agent model with cardinality (1, … , m).

Course monitoring agent:

This agent type is responsible for the continuous monitoring of learners' participation throughout the course (from watching the video, to studying the theory and taking the exams). This agent type has access to the database, and specifically to data describing the participation of learners in the course and in any activity suggested (e.g. access to the file of theory, watching the video, synchronous and asynchronous discussion with instructors and learners etc.). Indicators collected from the database are sent to the relevant agent monitoring the activity and handling each learner's activity analysis. This application uses one agent of this type who is responsible for the overall analysis of participation of the whole team of learners in each course and creates learning profiles. This system has one to n agents of this type, where n is the number of courses in the distance learning system.

Activities monitoring agent:

This agent type is responsible for the analysis of the learners' participation indicators in any activity developed in the distance learning system (such as discussion forums, chat, email). el-Chem may include one to n agents of this type, where n is the number of tools monitored in the distance learning system.

Integrator agent:

This agent type is responsible for the interconnection of el-Chem with instructors. This agent type receives events from the distance learning system and informs the el-Chem relevant agents. Every time an instructor is connected to the distance learning system, a distance learning agent is created (Integrator Agent) that remains live till the end of the instructor's connection.

The acquaintance model has been directly created by the agent model and shown in Figure 2. The communication connections among three different agent types are also shown.

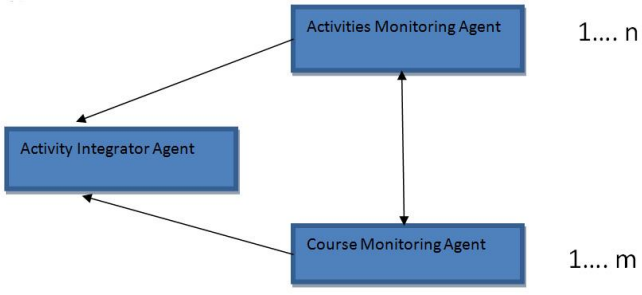

Figure 2: Acquaintance model directly created out of the agent model.

The objective of this model is to detect any difficulties in communication which could cause problems at run time [9].

A suggested architecture of el-Chem

The architecture of el-Chem has been created based on the agent types specified above. A suggested architecture which can be integrated in a distance learning system is shown in Figure 3. This system contains the n number of courses and n tools to be monitored. In view of the above, the system described should include n monitoring agents for courses and n monitoring agents for activities to support the distance learning system.

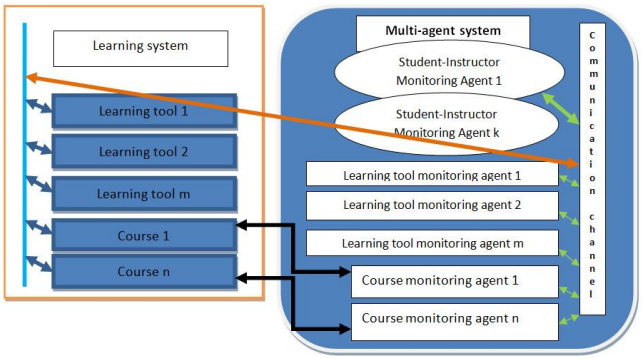

Figure 3: Suggested architecture of a distance learning system.

The suggested architecture seems that it may easily expand the distance learning system and support new tools and courses monitoring, which can be integrated in the distance learning system. This can be achieved by creating and adding a new activity monitoring agent handling the learners' participation analysis in the context of the new tool. The role of the agent in charge of course monitoring can be slightly modified to monitor and deal with the new tool. But, the changes to be made are not significant or extensive enough to change the predefined agent roles.

Definition of knowledge base

The roles of agents monitoring courses and those monitoring activities also include information analysis aiming at generating new knowledge. To this purpose, it is necessary to determine a new knowledge base to better coordinate the agents. A knowledge base has been defined for each activity monitoring agent to enable the analysis of learners' participation in activities being developed. Knowledge representation has been made through frames and production rules. This process has been developed by the Protégé – 2000 & Algernon applications [19]. An initial set of rules has been determined in cooperation with the Department's teaching staff who, using various student knowledge assessment tests, drew conclusions regarding the students' knowledge and comprehension of subject matters. Formative assessment in distance learning is very important and, for this reason, particular attention has been paid.

When creating an activity (watching video, studying the theory etc.), the instructor will selects certain criteria to be taken into account when examining the rules to will be used for learners will attending a certain activity. The instructor may also specify certain reference indicators to be used as parameters in the rules during the implementation of the application, thus enabling some flexibility when using these rules.

Therefore, when the monitoring data is collected through a discussion forum, the agent monitoring the forum activities may produce new knowledge by taking into account the rules for that activity.

The knowledge base is at an early stage and it may will be improved using suggestions of learners, from the instructors' and the learners' perspective. To make this possible, i.e. to improve and expand the knowledge base, easily expandable models have been created not dependable on source code. One other point requiring particular attention is setting up new rules easily. For this reason an interface has been created which enables setting up new rules directly from the end instructors and learners for future projects.

Application-related issues

el-Chem, as a prototype, has been implemented and partially integrated in the distance learning system, which was created within the framework of the Physics-Chemistry and Environment laboratory course. It is a solution supporting formative assessment.

Technological research

During the implementation of the overall system, certain tools will be used, which are designed in a way that can enable the quick creation of an el-Chem system, as well as of a knowledge base and deduction systems. Obviously, the JADE tool is one of many promising tools for the creation of el-Chem systems, while Protégé- 2000 was used for the knowledge base and the Algernon tool for the decision-making system.

IV. Integration of el-Chem in the distance learning system.

The integration of the prototype el-Chem in the distance learning system be done aimed at monitoring easily and impartially the participation of learners in various tools of the distance learning system. The tools included directly in el-Chem are the discussion forum and monitoring of certain sections. This decision was made because it was considered that both tools will be important for formative assessment. These tools, i.e. the discussion forum and monitoring of certain sections, are asynchronous and allow for the learners' deeper engagement during participation, resulting in more efficient and consistent contribution to learning. The asynchronous feature also contributes to the instructor monitoring and regulating the learners' participation in the overall development of activities. This process is very detailed due to the huge volume of information to be analyzed. The discussion forum interface has been adjusted to allow selection of a message's relevance degree (no relevance, low relevance, medium relevance, high relevance). This enables recording participation and analyzing the assessment and learners' participation records.

The integration of the multi-agent system in the distance learning system is achieved through an integrator agent running on an applet at the user's browser handling communication with the server (server-side agents). The integrator agent is activated, when necessary, and is called through the distance learning program using Javascript code; through the applet, the integrator agent forwards any

necessary information. Once the integrator agent receives the data, it should transmit it to server-side agents (activities monitoring agent, courses monitoring agent) sending an ACL message using HTTP and Jade's HTTP MTP (Message Transport Protocol). When server-side agents receive the data, they process it according to pre-determined protocols and communication is performed for specific pieces of information that server-side agents need to know.

As shown above, the system is easily expandable to monitor new tools, since the system core is built in a way minimizing the need for changes. All agent classes needed for the new tools are ready and may be used directly without major changes. The system expansion to monitor a new tool is performed in 3 main stages:

- Establishment of a new method for course monitoring agent (to collect participation indicators needed for the new tool).
- Establishment of new methods for integrator agent (to receive applications for reports relating to the new tool which monitors and presents the analysis results).
- Establishment and application of a new activity monitoring agent and setting up a knowledge base of new factors for the analysis of learners' participation indicators in activities developed using the new tool.

To help our system develop and obtain intelligence, it should be able to develop in terms of education and the assessment should lead to system improvements. This assessment should be made by both instructors and learners. The process is known as formative assessment. It is briefly described in the next section.

Formative assessment

Formative assessment is integrated during the course (module) or the teaching intervention, aiming to control the course of students towards achieving their educational goals:

- Feedback on student progress.
- Feedback on achieving learning goals.
- Opportunities to correct miscomprehensions.
- Need to adapt teaching (fine-tuning).

Formative assessment employs any method which allows to draw, interpret and use evidence of each student's performance.

Scriven [20] introduced two assessment roles. He defined formative assessment as a type of assessment which, on one hand, evaluates the value of an educational program at the early application stages, and on the other hand, it ensures time for educational program managers to modify and improve it. Moreover, for an assessment to be described as formative, it is necessary to provide feedback on assessment data to program managers, in order to enable assessment of the educational level in terms of standards provided. Formative assessment is a guide of how an educational program may be improved so as to approach the necessary standards.

According to Crooks [21], the increasing formative assessment leads to the following results:

- Reactivating or consolidating prerequisite skills or knowledge before introducing new material
- Focusing on important aspects of the subject matter
- Encouraging active learning strategies
- Providing opportunities to students, exercising practical skills and ways of learning consolidation
- Announcement of results and corrective feedback
- Assisting students to monitor progress and develop self-assessment skills
- Guidance for further learning activities aiming at increasing performance
- Helping students to get the sense of fulfillment.

Formative assessment is essentially feedback [22] given to both instructors and students with an aim to ensure subject matter comprehension and skills development, leading to progress. For this reason, assessment is a part of teaching. When it comes to feedback between instructor and students, the parties should actively participate in the decisions regarding the next steps towards learning. A student knowing how to act is more probable to assume the responsibility of the effort required. The involvement of students in their assessment means that they should be aware of their learning goals. The communication to achieve these goals is not easy, but the reward of a successful effort is great, not only for the assessment, but also for self-regulated learning.

Through internal feedback, students may control their involvement in learning activities and goals, assessing their progress towards achieving the goals. Those who are more efficient in self-regulation produce better feedback or are better in using the feedback to achieve their goals [23]. Self-regulated students actively interpret external feedback coming, for example, from instructors and other students, relating to their internal targets. Although the study proves that students can learn to be more self-regulated [24, 25], it is not still clear in this literature how feedback can be enhanced (self-produced and external) to then enhance self-regulation.

Pintrich and Zusho [26] give the following definition for self-regulation: Self-regulated learning is an active constructive process based on which students set objectives for their learning and monitor, regulate and control their knowledge, motives and behavior, driven and restricted by their goals and the relevant distinctive features of the environment.

This definition acknowledges that self-regulation is not applied only to knowledge, but also to driving beliefs and obvious behavior. It also acknowledges that there are limits in student self-regulation. Formative assessment and feedback cover, in a wider context, the self-regulation of motives and behaviors, as well as of knowledge.

Practically, self-regulation is demonstrated in active control and the regulation of different kinds of learning processes, such as regulation and orientation of targets towards learning, as well as in the strategies used to achieve goals, resource management, the effort deployed, the reaction to external feedback and final products.

Another way to make our application more interesting and competitive is to self-regulate how our students interact with our application. Using intelligent agents offers a solution to this problem.

Self-regulated learning is one of the most important new objectives of education. This is due to the fact that today's society requires students that are able to learn in a self-regulated way during and after their education, but also

during their financially active life [27]. However, although self-regulated learning has been an important subject of educational research for several decades [28], it is still an important issue when it comes to educational efficiency. Recently, it was concluded that self-regulation includes three sectors of psychological operation: knowledge, meta-knowledge as well as motive / influence. Knowledge concerns cognitive processing and information strategies applied to target efficiency. For instance: attention, examination and processing. Meta-knowledge is a strategy providing control and knowledge regulation. Motive and influence include all driving beliefs relating to a target. For instance, self-efficiency, interest beliefs or emotional reactions [29]. Each one of those components is necessary, but not satisfactory on its own to achieve learning [23].

According to Schraw, Crippen, and Hartley [30] the role of meta-knowledge is the most important "because it allows people to control their current knowledge and skill levels, schedule and provide their limited learning resources with ultimate efficiency and assess the current situation of their learning". Little information is available to date about the role of instructors as a model or about their skills to provide feedback to both learners and self-regulated and meta-cognitive level. Several studies show that many instructors lack satisfactory knowledge to implement meta-knowledge [31, 32].

The new educational methods mentioned above, such as formative assessment, self-regulated learning, and finally the role of meta-knowledge play a significant role in our application maximizing its contribution for students. The disadvantage is that instructors have more chemistry knowledge (University professors) than pedagogical skills; they are also burdened with difficult research work which does not allow them to develop new educational methods and thoroughly assess the performance of each student (many in number). On those grounds, it is essential to use utilities intelligent enough to help instructors cope with the workload required for proper student assessment and the development of more reliable and efficient learning tools. Intelligent agents are such tools.

V. Conclusions

New technologies create a new culture relating to social networks, education, and e-learning in general, which employs a range of implementation methods. E-learning is often understood as a presentation of teaching material, and not as an interaction between application and student. The system described in this paper attaches greater importance to the interaction between student and application, than to simple presentation of teaching material. To achieve a maximum interaction among application-students and application-instructors, agent technologies were used. These technologies help both instructors and learners to tackle the complex problem of education.

Agent-based applications offer many application possibilities, enabling intelligence acquisition that assists the persons involved to better tackle complex exercises and scenarios to be implemented. Indeed, agents can be useful in many cases, including assessment. The application is designed in a way that feedback is provided to both students and instructors. Furthermore, it is possible to be informed about the results of the examination and the success of knowledge acquisition using the assessment results based on the application multiple-choice questions and the time allocated by students to various sections of the application when comprehending the teaching material. What is required is the possibility to improve the application, since the aim is formative assessment. To achieve formative assessment in an e-learning environment, intelligent agent technology is widely used. This technology allows us to provide both artificial intelligence in the application and all necessary information for instructors and learners, in order to achieve formative assessment. The goal is to improve and accelerate learning. It is a fact that: student self-assessment and quality information provided by the application to students on how they manage their education, increase student confidence and encourage them to reduce the gap between current and pursued performance. Instructors are freed from the bureaucratic burden of monitoring students, since this task is assumed by the application. The provision of reliable information allows teaching adaptability for better results. Thanks to the above, it is possible to include assessment, thus making it a significant part of teaching. Of course, the involvement of students in assessment should be on the basis that they are aware of their learning objectives. That is not as simple, however successful education is particularly rewarding and the possibility to offer self-regulated learning is even greater. Successful completion of this project (i.e. good learning performance) is very important for all persons involved. The more the system will be used, the more reliable the statistical data will be exported from the application. In the research which was realized [2] students of chemistry department utilize the utilities that are created on the web increasingly. The update of the application will be another tool that will contribute to optimize the educational process for both teachers and for students.

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