GEOMATICS E-LEARNING WITH EXOMATIC:

IMPLEMENTATION AND ASSESSMENT

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Abstract

The Geodetic Engineering Laboratory (TOPO) at the Swiss Federal Institute of Technology (EPFL) has introduced e-learning into its undergraduate topography course. The Centre for Research and Support of Training and its Technologies (CRAFT) has introduced the Moodle Learning Management System (LMS) to facilitate this. TOPO has developed and introduced online exercises as an alternative to its traditional classroom-based teaching methods. The motivation behind this is to move from teaching and learning in a traditional way to an interactive way; personalized exercises are completed by students on the Internet and are corrected automatically with online help facilities available. The project behind this concept, called ***Exomatic***, is aimed at encouraging the students to be more autonomous in their learning of, and training in, geomatics data processing and analysis.

Exomatic uses the scripting language PHP combined with a MySQL database. This allows for the integration of ***Exomatic*** in the Moodle LMS already used in TOPO courses. The main functions of ***Exomatic*** are the generation of Internet accessed exercises, the presentation of personalized data, a collection of answers in HTML form, automated corrections and hints for individual users. The system provides evaluations for students and statistical feedback for the professor on student performance and progress. The objective of ***Exomatic*** is to improve the autonomy of students and facilitate the preparation and correction of exercises for teachers and teaching assistants. The ultimate aim is for ***Exomatic*** to be a component in the LMS of the EPFL, with the ambition of sharing ***Exomatic*** as a standard Moodle module for use by the wider community. This paper will present the structure of ***Exomatic***, the implementation of interactive exercises and its integration in the LMS.

More than a hundred students have participated in the ***Exomatic*** project to prepare for their first exam. The evaluation of progress in the exercises shows a linear improvement from the students' first and latest attempts. An online questionnaire on the acceptance of ***Exomatic*** by the users has been presented to the students. This will precisely evaluate the progress made by the students, the way they use this service and their acceptance of this learning process. The results and analysis of this evaluation, along with a discussion of the project, are presented in this paper.

Keywords - Exomatic, E-learning projects and experiences, online exercise of topography, Internet-based technology in education, assessment, Geomatic, Moodle.

1 INTRODUCTION

The ***EPFL***, ***Ecole Polytechnique Federale de Lausanne***, in Switzerland, is a school of engineering and offers 13 complete study programs leading to Bachelor's, Master's and PhD's degrees in 6 faculties**.** The institute has introduced e-learning strategy with the Funding Program for Teaching and Learning (FIFO). This program supports projects which aim at developing educational resources and educational scenario experiments. In accordance with EPFL's guidelines (E-Learning Strategy [1]), the educational projects are on an equal footing as the other educational developments. Only the best proposals are selected and financed by the FIFO fund and Geomatic e-learning with ***Exomatic*** is one of them.

Geomatic refer to an engineering sector that is more and more present in our daily activities. Oxford dictionary defines this field as "The mathematics of the Earth; the science of the collection, analysis, and interpretation of data, especially instrumental data, relating to the Earth's surface" [2]. Since 80% of the political decisions concern our life space, and that all actors on the environment stage can face the acquisition or the use of spatial data, a coherent teaching in geomatics must be offered. Geomatic engineering is composed of three main disciplines (Figure 1): Geographical Information Systems (G.I.S.), Photo and remote sensing, and finally Geodesy and Surveying. Our teaching staff is specialized on the latest domain and work especially on geodata acquisition, satellites based positioning (G.P.S.) and land surveying.

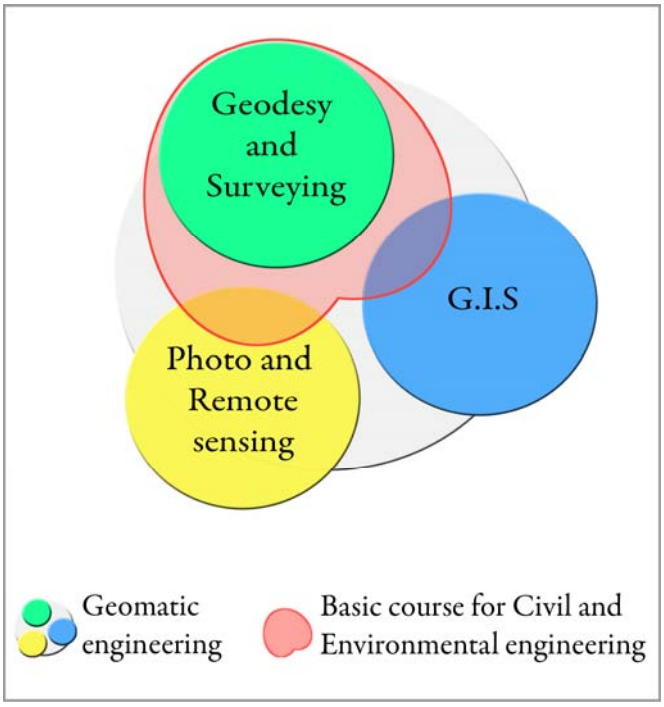

Fig.1: Positioning of the basic course in geomatics within the main domains of geomatic engineering.

The Geodetic Engineering Laboratory (TOPO) is a research unit and is traditionally involved in the teaching of topography, geodesy and navigation technology. These disciplines comprise a large part of mathematics (linear algebra, geometry, and statistics), computer science, and the optics and mechanics needed for the knowledge of the surveying instruments. Nowadays education, learning technologies take a useful role in education. They are becoming an unnoticeable part of pedagogical interventions [3]. TOPO has introduced learning technologies melting into a beam of educational tools, integrated within many other pedagogical activities that the teacher orchestrates for the course.

2 GEOMATIC COURSE AT EPFL TOWARDS E-TEACHING

2.1 Presentation of the course

The basic course in geomatic is followed by the first-year class of students from Civil and Environmental Engineering sections. The program launched a curriculum that provides an introduction in GIS, the fundamentals of geodesy, the principles of geomatics and the surveying techniques.

As shown in figure 2, the number of students has been growing for the last years. Moreover, the recent fusion, for this course, of both sections of civil and environmental engineering tripled the number of students who attend the basic curriculum of our course, about 180 persons this semester. The vertical axis represent the number of students and the horizontal one represents the different sessions. The fusion between the two sections occurred in 2004 and the total number of students upward since the last three years.

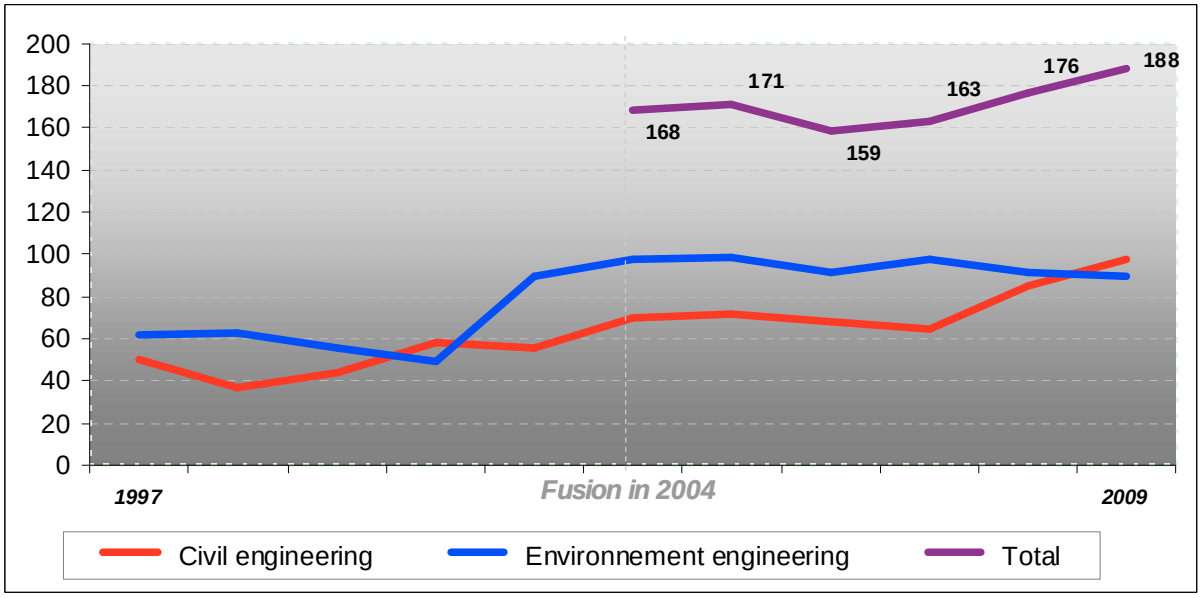

Fig.2: Number of students taking part to the basic course in geomatic since 1997.

The traditional teaching in this branch requires a significant time investment and small-size classes for good students comprehension, the use of the new technologies was obvious in our case to start the development of a comprehensive course for all the participants. This will reduce the teaching staff mobilization and give the skills to the students for a better independent learning.

The structure of the courses is divided in two parts as shown in the Figure 3. Firstly the traditional teaching with the lecture and exercise in face to face hours followed by the exam. Secondly the e-teaching part with the Web-based Learning Management System (L.M.S) to facilitate access to learning content and resources, and the ***Exomatic***.

The courses balance between face to face lectures followed by individual exercises. This domain comprises a large part of mathematics calculus (linear algebra, geometry), and the need for the knowledge of the surveying instruments, this is the reason why the students practice lots of them during the semester. These types of exercises help the learners to autonomously master the concepts seen during the lecture. This also satisfies our pedagogical demands by preventing the simple copy of results as well as the passive wait of the correct version. All the teaching staff is present during those exercises to assist and answer the problems encountered by the students, but it's clearly impossible to assist all of them. Moreover the comprehension of the calculus is based on the repetition, and we can't spend more long time in face to face courses and focus on each student personally.

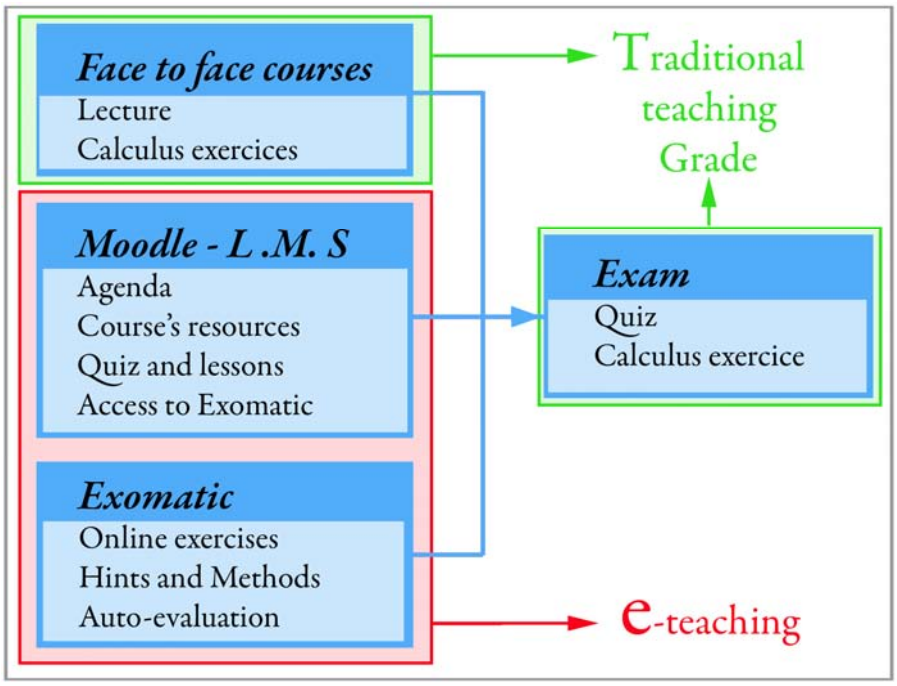

Fig.3: Structure of the course.

The few hours of contact, and the important part of the exercises on the comprehension of the courses was the principal motivation for the lab to think about integrating online exercises and assessment on the curriculum of the Geomatic courses.

2.2 Motivation for e-learning development in geomatic

The best proposals for e-learning are supported by EPFL through the Funding Program FIFO, its aim to encouraging the development of resources for training and testing of learning scenarios. Our proposal has been submitted by the teaching staff in 2008 for two years of realization. Three principal reasons have triggered this project.

- The development of innovative resources for teaching the fundamentals in geomatic engineering.
- The improvement of e-learning tools with a focus on calculus exercises and the spare of man power during the teaching correction work.
- The increase of student's autonomy in learning geomatic and its exercises

The development phase of ***Exomatic*** is performed by the same people as the teaching staff. This close connection between the teaching and the implementation of web-based learning technology is a great advantage because of the availability of real teaching condition. The students are involved in the evaluation of the early ***Exomatic*** version, which is fruitful for the development team.

One of the first steps of the e-learning deployment at the EPFL is the choice of a web-based learning management system (LMS). The Centre for Research and Support of Training and its Technologies (CRAFT) has proposed the Moodle LMS [4] as a common environment for most teaching resources at the EPFL. In 2009, more than 350 active courses are hosted on. Due to the

growing use of Moodle at the EPFL, it was necessary to integrate the development of ***Exomatic*** within Moodle and to benefit from the functionality of the LMS.

The introduction of e-learning in geomatic is above all based-on personalized exercises. Traditional lessons remain, although the focus is now on non-formal learning via different online resources provided by the LMS. With this approach, real faces can be associated with this virtual world that is not necessarily attractive at first glance. This concept of e-learning is also better accepted when it is supported by a direct contact with the teaching staff [5]. For a student, the insertion of online educative resources in such a context is reassuring. It simultaneously offers the teacher an opportunity to elaborate interactive and gratifying courses.

Teachers and teaching assistants use essentially the LMS interface to deliver content of the courses to students and assess learning using quizzes and lessons. These solutions were accepted by the students with a large participation as shown in figure 4 and the results of the course evaluation as demonstrated the high level of approval (see section 4).

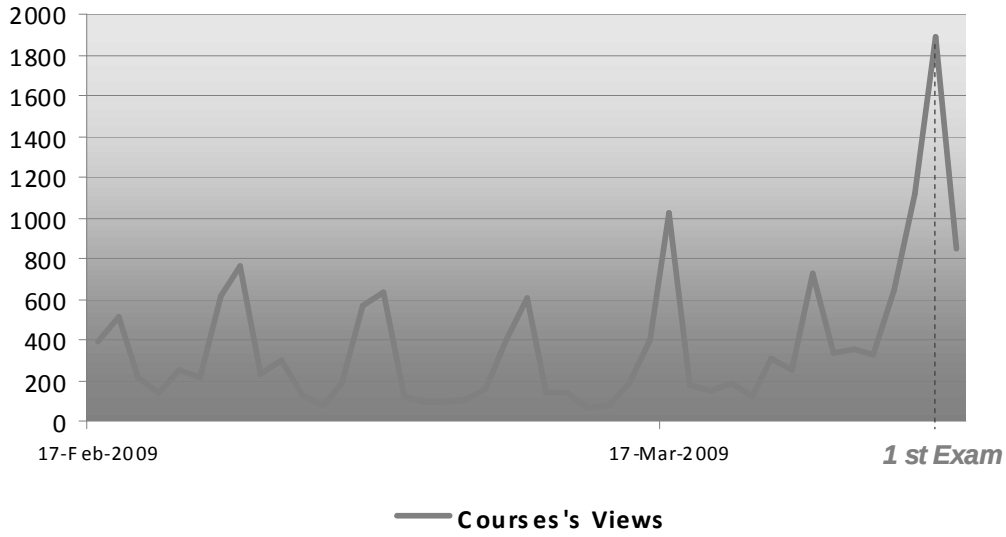

Fig.4: Number of connections to the geomatic LMS during the semester.

Each rise represent the number of students connected on the LMS after the weekly ex-cathedra course. What is notable is the higher peak reaching about 2000 logins, which shows the affluence of the students on the online resources courses during the self-training for the test. This schema demonstrates that the “LMS technologies” closely coupled to the content of lectures are efficient and remarkably accepted by the majority of students and the teaching staff to.

A forum was introduced, to bring a collaborative tool between students and teaching staff and facilitate the communication between the main actors of the courses. Moodle offered a large possibility of managing resources and activities. However, our field of exercises is based on specific calculus and computation, the different possibility of Moodle concerning mathematical question wasn’t efficient in our particular case.

After a brief state of the art on web-based exercises in geomatic, the teaching staff decided to develop and implement online specific exercises. Different reasons have encouraged this choice. Firstly, the cost and the complexity of other software solutions and the required interfaces with the LMS was the principal argument. Secondly we wanted a personalized application to bring the actual geomatic course’s library exercises on dynamic web pages.

3 DEVELOPMENT AND IMPLEMENTATION OF EXOMATIC

3.1 Overview

The project behind this concept, called ***Exomatic***, is aimed at encouraging the students to be more autonomous in their learning of, and training in, geomatics exercises. The motivation behind this is to move from teaching and learning in a traditional way to an interactive way; personalized exercises are completed by students on the Internet and are corrected automatically with online help facilities available. In concrete terms, ***Exomatic*** provides a pedagogical material to solve exercises via a user-friendly interface that stimulates the students' involvement and allows them to prepare exercises before the exam.

Each student has a personal and direct access to the online exercises (Figure 5) via the Moodle interface. This screen capture presents the first page displaying the exercise to the students.

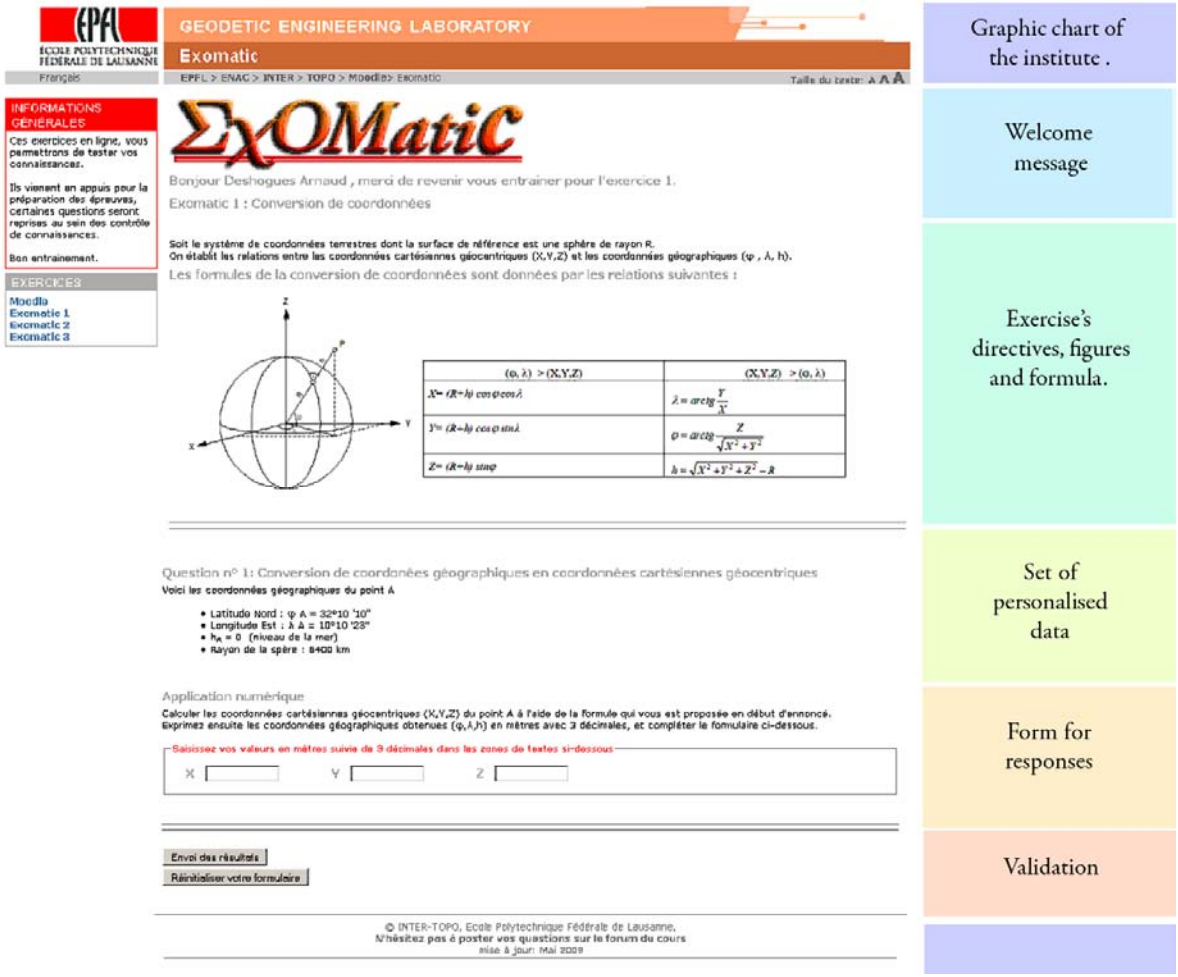

Fig.5: Screen capture of an online ***Exomatic*** exercise.

The access to the web-based exercise is secured by a control service which provides a unique login method to the different web pages of the EPFL. The access to the LMS is based on this unique identifier of the student which simplifies the management of ***Exomatic***. To perform the visual effects we've used the EPFL graphic standard and the different cascading style sheets proposed by the institute. Attractive illustrations and the fact of addressing the students by their first name create a catchy environment that is publicly visible via any web browser. Those particularities should facilitate the acceptance of our program by the users.

3.2 Conceptual scheme of Exomatic

The following section describes the global concept of ***Exomatic*** with links and process between the client (student), the database and the server.

1. Once connected on the web pages, the student is able to read the reminder of the goal of the exercise and its related instructions. One can see their own session data on the basis of their name (identifier), automatically the program save this information on a student's profile.

2. The data of the exercise are generated by a random function that provides and personalizes the numeric values to each student. All the data set is directly transmitted and displayed to the user interface with the possibility to control at the end of the exercise the validity and the correctness of the student's answers.

3. Once the process and the calculus are solved, the student transfers responses into a html form.

4. These responses are integrated on the student's database via the server.

5. In case of bad numerical values or faults from the student, the program performs a warning and proposes to restart the exercises keeping student' initial values on the different forms.

6. The automation of the exercise correction is given by the comparison of the student' values with the correct responses stored into the exercise database. The evaluation of the results is done by taking into account a certain level of tolerance. Three classes of evaluation are proposed: (i) accurate, (ii) with a small precision error and (iii) out of tolerance (large error) depending on the results sent by the student, its evaluation and the predefined level of tolerance.
The results and the feedback are automatically presented and a simple click on an icon allows the user to access on hints and advices for a better comprehension of the error committed.

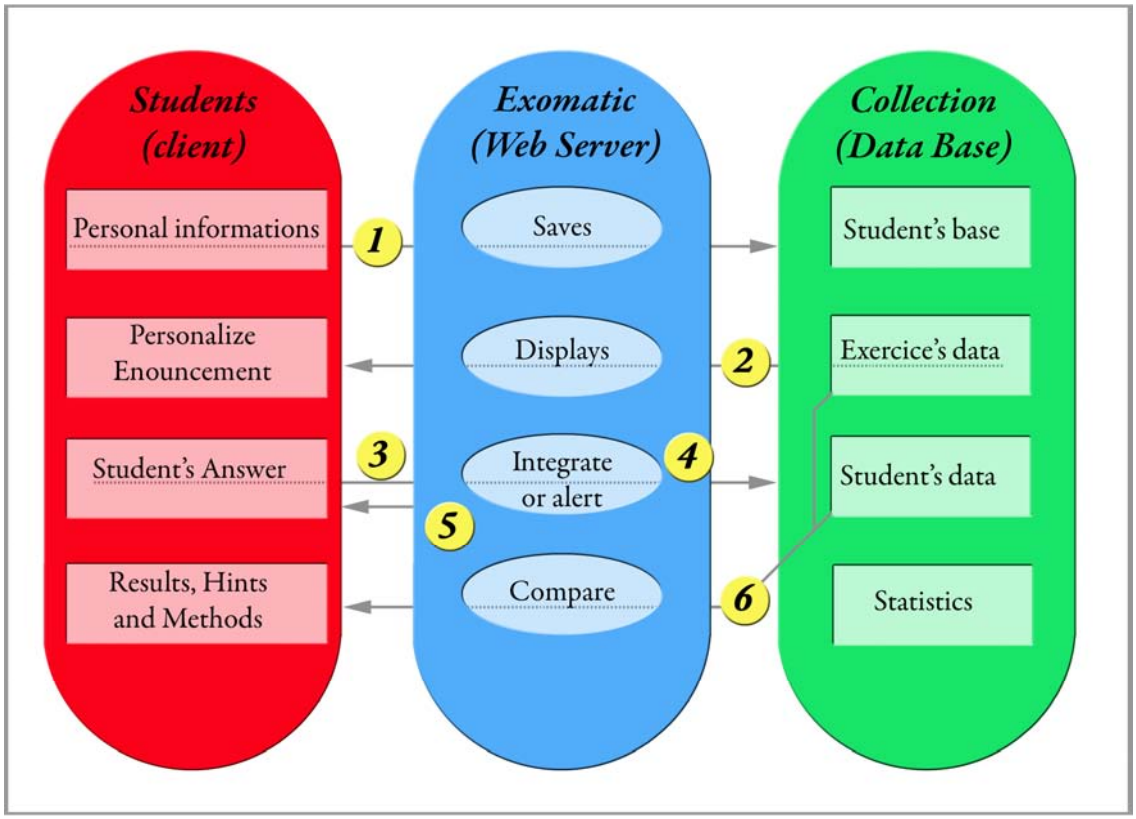

Fig.6: Semantic structure of ***Exomatic***

Conceived as a cross-platform application, ***Exomatic*** automates the production and marking of individualized exercises. It is a collection of interactive procedures between the students and the database as shown in the Figure 6.

For a better communication around these online exercises, let's note that, during the writing of their practice the students can add comments on the dedicated forum where the different users and actors can participate.

The main functions of ***Exomatic*** are the generation of Internet accessed exercises, the presentation of personalized data, and a collection of answers in HTML form, automated corrections and hints for individual users. The system provides evaluations for students and statistical feedback for the teacher on student performance and progress.

The ***Exomatic*** side for teachers proposes a set of management tools for the elaboration of exercises and other more specific functions for statistical analysis of the exercises (success rate) and later the possible assessment of the students. This specific management page allows the teaching staff to access to the exercise statistics and identifies the typical difficulties of students. With this information we can point on some part of exercises and explain for longer the calculus process during the next lecture.

3.3 Informatics' design

To maintain the ability to integrate our project ***Exomatic*** as Moodle module, we have logically oriented our solution on PHP script language using MySQL database management. We have installed the package called WAMP [6], computer acronym designating four components. WampServer is a Windows web development environment allowing us to create a web application dedicated to online learning geomatics exercise with Apache, PHP and the MySQL database. It also comes with PHPMyAdmin [7] use actually to create and manage our databases for monitoring and evaluation exercises.

Our web pages are hosted by the university's server for better performance. For the moment we are disconnected from the LMS, just a link on the Moodle courses make the relation between these two online learning interfaces. If the first trial is accepted by the students, we will go further into this project to integrate it on the institute LMS.

The development with these softwares, facilitate the generalization for the community of geomatic courses around the institutes. The aim is to construct, bring and exchange bookstore's exercises with the others partner (see section 5).

3.4 First trials during the semester

Since the beginning of the semester we have introduced the LMS courses with a rapid acceptance and participation of the two third part of the class. Students were motivated by the availability of the quizzes and online resources throughout the semester after each course. The Moodle interface was already familiar for the students because of its previous utilisation in the other courses of the institute.

Our project ***Exomatic***, whose development began during the semester, has introduced two online exercises just before the first evaluation test. This was the first trial of the project. The motivation behind the introduction of these online resources before the exam was to stimulate student's autonomy and to help them in their learning to achieve and understand the geomatic course and the different calculus process. After two months of development the first version of ***Exomatic*** was making available and integrated into the geomatic course. This step constitutes the second path of our cyclic development. As you can see in Figure 7 it starts with the informatics'design, the modelling and the production of basic algorithms to propose online exercises to students. Then the implementation on the curriculum of the courses and the evaluation by the students. The assessment has been performed by the CRAFT who provides a range of information on the acceptance of the technology, and also the positive or negative aspects of the program.

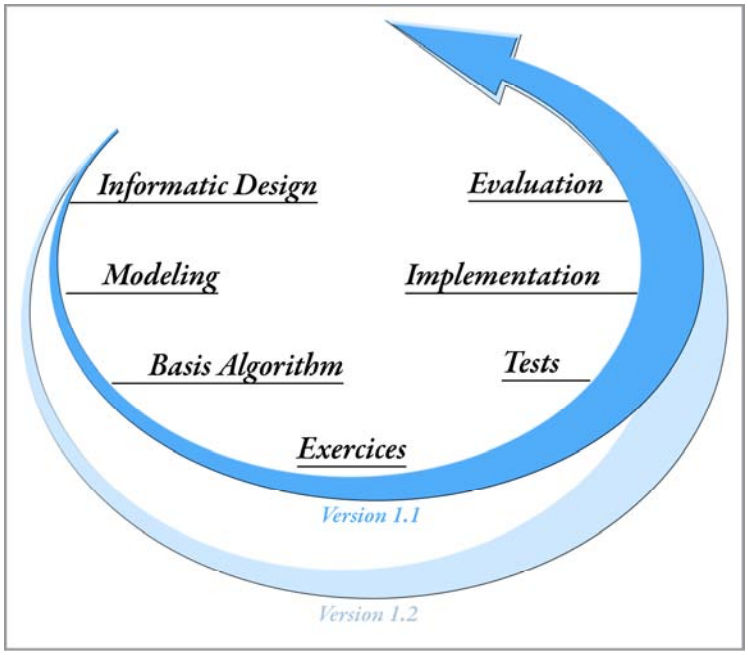

Fig.7: The semantic structure of ***Exomatic***

The students are naturally involved in the evaluation of the first ***Exomatic*** version, to adapt the utility and the quality of these online exercises for the next version.

All these online resources were not mandatory, but strongly encouraged by the teaching staff in preparation for the exam who logically takes in the same type of questions and calculus.

An on-line survey form was elaborated in collaboration with the CRAFT and proposed to the students after their first exam, to evaluate user's positions on this new system course and its necessity.

4 ASSESSMENT OF THE NEW SYSTEM COURSE

One of the objectives of the CRAFT is to evaluate courses at the teachers' request [8]. The CRAFT has a long experience in assessing the pedagogical methods in the institute and offers to willing teachers questionnaires specifically related to their course to:

- enhance the commitment and performance of teachers,
- provide elements of discretion in appointments, promotions and allocation of resources,
- detect problems in the quality of education and remedy.

In collaboration with them an anonym online form was proposed to the students by e-mail. More than the two third part of the class have filled the questionnaire out and individually evaluated the course in general, the online resources and finally the ***Exomatic***.

After a careful processing of the students' answers, the CRAFT has assessed the content of the course and its resources and gave advice to our teaching staff. This feedback is really important for the improvement of the course's efficiency and its relevance.

This methodical analysis provides useful data information for the enhancement of the pedagogy on the geomatic course, and has a direct impact on the development of the ***Exomatic*** project. This section will present the different criterion and the results of the pedagogical evaluation.

4.1 Evaluation mode and Criterion

The curriculum of the course, the LMS's resources and the ***Exomatic*** were evaluated by the students. The compilation of responses and the final assessment was performed by the CRAFT. This evaluation was done just after the first exam during the spring semester 2009. This mid-term evaluation is adequate because students are deeply involved in the exercises and in the preparation for the first exam. 95 students answered a series of questions and brought commentaries about the weaknesses and strengths of this teaching method and the content of the course in general. The questionnaire is organised in three sections:

- Lecture on the face to face contact
- LMS course and its resources
- ***Exomatic*** online exercises

A total of 26 questions based on these three main topics were proposed to the students, which have to give an appreciation about their agreement: totally agree, agree, no response, disagree, and totally disagree. More than 65% of the students have answered to this form, what is representative. The next section will present the results corresponding to the LMS and on-line exercises developed in this paper.

4.2 Analysis of the results

With regard to the detailed evaluation via the questionnaire given to the students, the block of questions can be divided into two parts: a first part concerning the perception of the online resources and a second one concerning the global acceptance of them in the curriculum of the course.

The Figure 8 shows graphically the grades of responses for the two different learning activities introduced during the course: first the Moodle management system and the quizzes, and then our project ***Exomatic***.

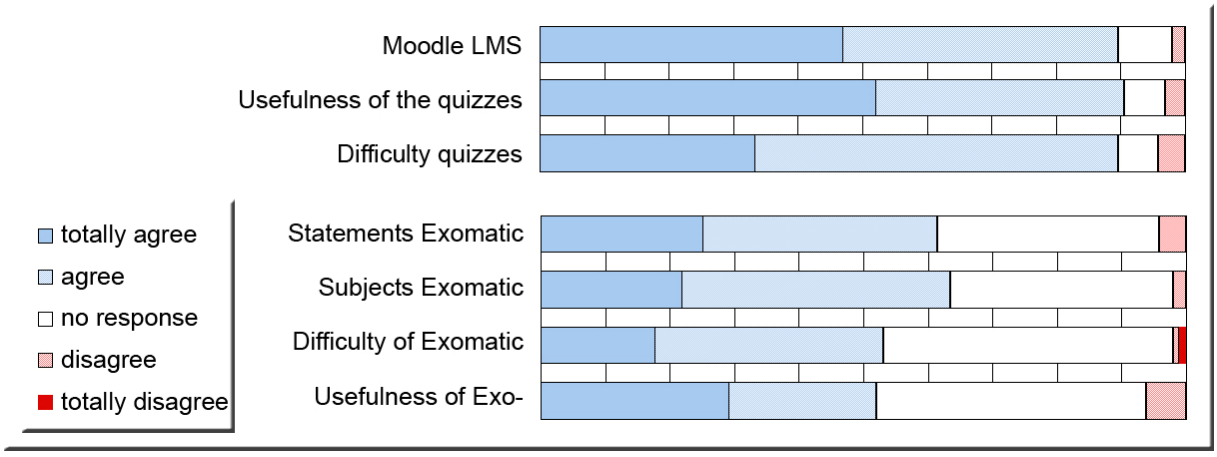

Fig.8: Online learning and training resources appreciation

First of all we can notice a relative uniformity of the students' answers. The online course via Moodle is well evaluated with more than 80% of favourable opinions. However, this global analysis seems reassuring and reflects a positive acceptation from the students, for whom this computer-based approach represents no major difficulty. The result for the acceptance of the learning management system is very encouraging for the teaching staff who proposed a set of quizzes and resources after each face to face lecture.

The second part of the graphic, related to the ***Exomatic***, shows a large percentage of no response. This means that some students have not used the online exercises because they were introduced late and shortly before the first exam. Only motivated students have used them for their personal training before the exam. However the ***Exomatic*** is well accepted by this group of students with a

few percentages of disagreement. During their first year at the EPFL, students are more accustomed to classical exercises in the basic sciences such as maths and physics. This positive sign of acceptance of ***Exomatic*** is very promising for future development of e-learning tools, especially for the exercises of calculus.

Finally the students give a general appreciation on the set of ***Exomatic***, and the LMS activities graded on a scale from 1 (very poor) to 6 (excellent). The assessment of ***Exomatic*** is quite good with an average of 4.6, and the appreciation of the Moodle‘s activities is better with an average of 5.1.

The second block of questions presented in Figure 9 concerns the global acceptance of the online resources. 80% of the students are mainly agree with the new teaching methodology proposed during the semester although the automated correction is weakly decried by 5 % of the surveyed This means that the feedback provided to the users during the online exercise has to be more illustrated in order to understand the reason of a false response or a bad result of calculus. Among the other criterions, one can observe that the coherence between the different course’s resources (lecture’s notes, exercises, quizzes, power point…) offered to the students is much appreciated.

Fig.9: Global acceptance of the online resources

Student’s observations are predominantly positive but it is probably due to the variety and the combination of different activities: face to face lectures and exercises, handouts, quiz and ***Exomatic***. All these resources are well perceived by the students and moreover their usefulness. There are some weaknesses too, regarding the tedious calculations exercises and the lack of clarity of certain statements (quiz). These remarks are interesting because they suppose more investment in the preparation of online resources. This confirms the necessity of improving online exercises with more interactive tools for the training of the users and the enhancement of knowledge.

This good acceptance of these new learning technologies for the geomatic course, encourage us to carry on the development of ***Exomatic*** while evolving it with the expectations of the users (students) and the e-learning strategy at the EPFL.

The feedback from the CRAFT presents a technical analysis based on the teaching methodology used during this course. The courses in geomatics have been regularly evaluated by the CRAFT which provides useful pedagogical advice. All these recommendations are also necessary for the evolution of the course and offer constructive criticism on the actual teaching technologies. The CRAFT has appreciated the variety of methods and resources made available for the students to learn this discipline and the clarity of the course and materials. Beyond this finding, the CRAFT propose some specific improvement for the geomatic courses.

Firstly, they recommend us to check the various feedbacks generated by the learning resource like ***Exomatic*** and quizzes to perform them for a better learning interface. Secondly, by integrating the different part of the course and establish a complete scenario, they propose us to improve the link between the course content, the exercises and the quizzes.

On the whole, the assessment of students combined to the interpretation of the CRAFT remains positive for the teaching staff with recommendation and pertinent remarks to adapt the geomatic course. The balance is good teaching with useful educational investment.

4.3 Viewpoint of the teaching staff

The use of Moodle and the establishment of ***Exomatic*** have allowed an efficient organization of the course of geomatics for an attendance of more than 160 students. A balance between lectures and exercises generates a direct link between the theory and applied calculus. The time gain for answering the questions and marking the exercises is noticeable, and allows managing such a teaching with one teacher aided by most of the time one or several teaching assistants.

However, a good start of these automated exercises still requires contacts during the lectures. This allows the teachers to ensure that the autonomous work following the contact hours will happen in good conditions. The teaching staff has invested large efforts in the preparation of resources and online exercises. After a first semester experimenting this new concept of teaching, the staff can be confident that the time spent in the preparation is well adapted to the requirements of the course.

The use of a LMS is quite a new way for the management of resources' course and for the communication with students. Moodle enables the record of many parameters which could be very useful for the monitoring of learning processes. Avoiding falling into misuse of statistics, Moodle provides information about attendance and the use of certain resources. This type of information is mainly used for the detection of gaps in knowledge: e.g. if most of the students choose a bad answer in a quiz, the teacher can identify a specific topic which needs clarifications. Each quiz and each ***Exomatic*** are based on a self evaluation system which provides a mark at the end of the session. Therefore this information is available for both the student and the teacher, which allows the verification of students' progress. However the teaching staff has to inform the students on the type of parameters monitored by Moodle in order to protect privacy of users.

Finally some statistics shows that more than 150 users have access to the geomatic course during the current semester for a total of 40 000 logins with a 2000 login pick just before both exams. The introduction of e-learning in the geomatic courses was well accepted and very promising for the development of new online exercises.

5 PERSPECTIVES

5.1 Full implementation of Exomatic

The second phase of the project consist in the full implementation of ***Exomatic*** within the geomatic course. After the first trial and assessment of this new learning system we are able to propose an improved version of ***Exomatic*** that will be introduced before the next semester. One of the goals of the next version is the adaptation of online exercises with a new set of tools for calculus. This semester ***Exomatic*** was introduced late and only few students took this opportunity for a better preparation for the test. The introduction of online exercises after the face-to-face session will allow the students to better understand the concept developed during the lecture.

This next step of development will reduce the time between the distribution of a new homework and its correction. Until now students received a new exercise and the correction is available only one week after. Bringing partial solution within the ***Exomatic*** process will be a source of motivation because students are able to monitor their progress in quasi real-time.

For the teaching staff, the full implementation of ***Exomatic*** will allow a better monitoring and detection of the gaps of knowledge which will induced a targeted teaching according to these feedbacks: e.g. explanation of specific misunderstood algorithms during the next lecture.

5.2 Dissemination of Exomatic

An important perspective for the project is to join and exchange resources with the world of geomatic education. This could be possible with a cooperative system (e.g. Moodle) which allows sharing common resources in a standard format: e.g. a common library of exercises specialized in geomatics. One of the important things is to propose a robust interface to share our program with other interested teaching staff. One of the opportunities in the world of geomatics is the research activity of the working group “education” of the International Federation of Surveyors (FIG). The next world convention will be held in 2010 in Sidney and a track of sessions will be organized for the presentation of research in e-learning.

The release of the ***Exomatic*** code under a General Public License (GPL) license is a way of publishing this web-based training and, if possible, to federate the interests in such an approach. The use of convenient tools and targeted objectives on the exercises has proven to be a sustainable solution for implementing online exercises. This program will have to take into account the directives of the Moodle product in terms of development with the final goal of a full integration into LMS (resources and activities).

5.3 Integration into the LMS

First of all, the integration of ***Exomatic*** as a full component of the Moodle program at the EPFL is an important step for our project because we want to share this resource with the user community, especially with the others courses specialized on calculus. This platform allows contextualising and highlighting the different learning developments of the institute [9] .Secondly the ambition of sharing ***Exomatic*** as a standard Moodle module with a wider community.

A multi media interface designed for smart phones and PDA will be probably developed in order to take into account the trend of the mobile Internet. This has probably a deep impact on the way to access to information (news, TV channels, services…) and also to teaching resources. This potential extension of e-learning should be considered carefully: the main goal is a global improvement of the learning process and not only an easy access to resources.

The development of ***Exomatic*** will take into account a series of remarks and propositions made by the students. These essential elements will have for a positive impact on the evolution and the enhancement of the next stage of development of the ***Exomatic***.

6 CONCLUSION

The originality of our project is that the development is not separated from the teaching part but stakeholders (teachers and students) and developers are moving step by step towards the formal implementation of a web interface offering to the students an effective solution for training exercises according to their needs. This close collaboration has proven that the level of acceptance is better when the design of the program can evolve within the context of teaching.

Future steps of development with the inclusion of smart help and new tools like dynamic calculus and graphic interface will increase the autonomy of students. They will be capable to generate their own data for each exercise and to understand the relationship between the calculus and its graphical context.

It should not be forgotten that ***Exomatic*** is a complement to the face-to-face course. It is absolutely not envisaged to develop a global concept of web-based learning, only a better integration between the course content and the online exercises is planned.

The introduction of the LMS and online training is well accepted by the students. The assessment of the course has provided a series of remarks which will be useful for the next step of the development. The other fact is that the students are quickly autonomous when carrying out their exercises. It is a positive sign for this pedagogical approach which is a promising path that has to be followed and enhanced.

7 AKNOWLEDGEMENTS

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