Improving Learning Processes and Evaluation in Laboratory Classes for Engineering Courses using Online Learning techniques supported by Moodle

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Abstract: - Based in the results of a proposal developed in an innovative research for improving classes preparation, teacher support and evaluation for laboratory classes in engineering courses, this paper applies the previous validated methodology, using the world known platform for online learning, Moodle. The presented system allows that the Teacher-Student interaction and the Teacher support be improved by using Information Technology and Internet Communication. This proposal is a hybrid solution: part online and part presential. This way, is possible to enlarge the learning efficiency of a basic discipline of an engineering course curriculum. Additionally is applied an evaluation methodology equally hybrid, part online and part presential, that ensures the student certification, generating a parameter for measuring learning, difficulties and the quality of learning process. This system was tried out for engineering students and some results are presented in this paper. Finally, this system was implemented in Moodle for using with a real discipline of the engineering course curriculum.

Key-Words: - Online and Distance Learning, Internet Learning, Quality Assurance on Distance Learning, Evaluation, Laboratory Disciplines Learning.

1 Introduction

Huge transformations have been occurred in the last decades in the education area in the last 20 years, mainly in the relation school-teacher-student, involving new pedagogical techniques. In the human relationship aspects, if we compare the nowadays classrooms reality with the same reality of 40 years ago, it is easy to realize that deep changes have occurred, mainly due to the society transformation and the strong influence of the communication media over the already mentioned three main actors of the education: school-teacher-student.

In the learning support tools aspects, it is unmistakable the fact that the computer is the powerful introduced element, mainly in the last two decades. Nowadays, it is impossible to imagine the teacher not using the computer in all the parts of his job, as in the classes preparation, classes presentation and also in the evaluation tests. By the student side, the computer is a very important tool, as a support for research and learning. And finally, it would be unnecessary mentioning, the use of the computer by the schools in administrative tasks and in management of the students academic life [1].

Considering the power of the tools: computer, information technology and connectivity, it is possible to see that their potential of application is still not explored enough in the traditional education.

Nowadays, it has been often discussed the distance learning and its potential for multiplying the available educational resources [2].

On the other hand, in the basic education that is developed up to the college, it is not possible to eliminate the predomination of the present teacher, that is conducting the student in his first steps, in the hard task of finding the basic knowledge that will permit him to receive and retain the huge amount of technological information that is generated daily.

It is possible to realize that there are two different situations nowadays: the traditional learning processes of the basic education and the new techniques of distance learning frequently used for complementary, additional and informative courses. However, in practical laboratory classes it is shown that the traditional techniques used in most universities are not revealed, presenting some difficulties and limitations. To deal with the mentioned issues, this research is now proposing a solution.

As the main actor in the presential school is the teacher, if it would be possible to optimize his acting, multiplying his presence and support, it would improve learning efficiency, using teacher potential for other activities of teaching art.

Online learning is a learning method that has as the main feature, the physical separation between teacher and student. The learning iteration in online learning can be done by several ways, as video, TV, Internet and other kind of communication media. On the other hand, in the presential learning, the teacher-student iteration happens in a classroom, with the physical presence of both of them. Online learning has the objective of increasing the access possibilities to the knowledge, reducing the limitations of the presential learning.

Traditionally, in the laboratory learning, it is possible to find, three educational approaches:
- Simulation: the students actually do not go to the laboratory. Softwares are used for circuits and processes simulation. Of course, that solution do not replies the experience got by the students in a real laboratory.
- Weblab: sensors are installed in the laboratory and the measured variables are sent to the Internet to be remotely accessed by the students. In the same way, the students actually do not go to a real laboratory.

This article presents a proposal for the development of laboratory classes in Engineering Courses. That system could be applied with small changes in other knowledge areas. [3], [4], [5], [6], [7], [8], [9].

2. Justifiyng

There are no doubts, that is possible to increase the teacher acting using IT and online learning. As a result of this, the teacher potential and experience can be redirected for more noble activities in the art of teaching. One of critical points detected in online learning is how to deal with the students heterogeneity. The students assimilation is done in different ways, many times demanding specific techniques, directed to an heterogeneous public.

Traditional techniques used in most universities are not so efficient for deal with the mentioned points and neither for the delivering of theoretical concepts.

Other important point is to find a method for measuring the difficulties of each student during the online learning process and this way, acting correctively in the learning process.

This article are thus proposing a solution for those mentioned problems [10], [11], [12].

Aiming at knowing the reality practiced in Laboratory Disciplines in the main Engineering Schools, a field research was done, consulting 29 teachers of Digital Systems in Electrical and Computing Engineering, from 16 brazilian important universities. For that schools, it was applied a research about methods and processes used in Digital Systems Laboratories. Table 1 describes the consulted universe in the field research.

Table 1 - Consulted universe in the field research

Description		**Qty.**
Universities	Total	16
	Government	7
	Privates / Fundations	9
Received forms		32
Teachers		29
Laboratorie Groups		140
Students		670

The following results were found in that research:

- Hosting didactic subjects in Internet is already a reality;
- the student group structure for the experience execution is held, enabling dependency from some students over others;
- some professors do not apply a specific test for laboratory courses, mainly due to lack of time to do it;
- 50% of the professors that replied the research, make a theoretical presentation before the practical experiments in the laboratory, for the students background;
- that mentioned presentation is made additionally to the theoretical class of the discipline and takes from 10 minutes up to 1 hour, expending a significant part of the laboratory class and many times it is revealed insufficient;
- likewise, 50% of the professors that replied the research, consider important to apply a preliminary test before the experiment, with the objective of

students knowledge equalizing and certification of acquirement for the practical activities execution;
- after asking the professors that replied the research, about who actually applies the preliminary test, it is possible to see that only 20% of that sample effectively do it and the rest of them do not apply it due to lack of time;
- similarly, only 50% of the professors that replied the research demand written reports for the experiments executed by the students; this way, for the rest of the professors, the follow-up of the real learning of the students is restricted to the tests, which in certain cases can present limited results;
- it is also mentioned the high frequency of doubt settlement requests by the students to the professor and this fact can conduct to conclude the need for an intensive follow-up process by the professor.

Further, in [13] it is explained that students found so much difficulty in experimental disciplines, mainly if it involves many theoretical concepts. One of the main problem is the reduced time to received the theoretical background and doing the complete experience.

As a result of this, in [13] is proposed that the students must know the theoretical concepts and the experimental procedures before going to the laboratory, otherwise the student learning efficiency is not satisfactory in the experimental disciplines.

3. Proposal

3.1 Characteristics of the proposed system

The proposed system in this article, once implemented, permits to the users, the following resources: [3], [14]:
- Preparation and theoretical basement for the student in the experiment execution;
- continuous interactivity to the teacher, online and presential;
- continuous interactivity to the university;
- teachers can take notice of all the learning process steps;
- evaluation of contents and spent time in each student task.

3.2 Computer interaction

The disciplines content are become available to the student, through the online learning platform Moodle, that permits the students may interact to the discipline teacher and the school. Through Moodle, is possible to the student:
- Accessing to the discipline program;
- registering in the discipline;
- seeing the discipline support and theoretical background bibliography.
- downloading and accessing the content, the project guide, the necessary calculations and basic texts for doing the experiences;
- interacting with the discipline teacher, clarifying doubts and receiving;
- doing the experience;
- sending the experiment report to the teacher;
- receiving professor comments and the respective grades;
- presenting doubts and difficulties to the professor, receiving from him, explanations and guidance about the necessary studies for knowledge complementation, in order of reaching total skill of the subject of the experiment.
- scheduling dates and rooms for the experiments.

Through Moodle, is possible to the teacher:
- Delivering to the students, general information about the discipline, general rules and standards;
- registering the bibliography, discipline contents and experiment guides;
- verifying scheduled data, time and rooms for the registered students in the discipline experiments;
- verifying the process course for the registered students in the discipline experiments;
- receiving the tests and reports from the students;
- registering the students grades in the system.

3.3 Preparation for the experiments

The teacher starts the process of the present experiment, asking the students to register in Moodle and in respective discipline. The student accesses the discipline in Moodle, acquaint himself with the discipline program and finding the present experiment to be done. He must read the basic recommended bibliography for the theoretical basis necessary for the execution of the experiment. Further, the student must do all the projects and calculations necessary for this preparation. When the student is sure that he is able to execute the experiment, he must do the online qualifying test and sending it to the teacher. This test is time-controlled, time-measured, personal, and under supervision in the university inside a room with video camera monitoring and recording. In order to do the qualifying test, the students must keep in touch with the laboratory monitor who, by using his password, will enable the beginning of the test in a microcomputer located in a specific room. Should the student is not considered able to go ahead, by the teacher, the professor will propose, by email, new readings to the student and he is going to do a new test, aiming at the certification. This process will be repeated until the student is qualified. When it occurs, the student will receive the permission for doing the experiment, being enabled to schedule that step under a pre-defined deadline [3].

3.4 Execution of the experimental part

After scheduling the experiment, the students can be distributed in different groups in each experiment. This fact can avoid the dependency that some students have over others. In the scheduled date and time, the students will be present at the reserved room for the execution of the experiment. With the requested equipment and components, the students will start the experiments, using the guide available in Moodle. This guide is interactive, containing questions about the respective experiment stage, also measuring the time spent on each one. Following the specific instructions of the guide, the students will take photos of the requested steps of the experiment, attaching the respective photos to the experiment data report. After finishing the measuring and answering the presented questions, the students shall make available the experiment report to the professor, by Moodle. The professor will evaluate the students report considering aspects like data consistence, answers to the questions presented during the experiment and also computing the expended time to the execution of the experiment. After that, the students must do the final certification test, with questions that will involve aspects related to the executed experiment. This test is also done under supervision and time-controlled, time-measured and must be done also at the university. The procedures will be the same as those used in the initial qualifying test. The test, after concluded, will be available to the professor that will emit the respective evaluation. The results will be informed to the students by Moodle. As the next step, the students must fill a preformatted report, detailing their doubts and difficulties in all of the concluded process. The professor will analyze the emitted report and considering the student's accomplishment during the experiment and in the final test, he can, at his discretion, present to the students, guidance about the necessary studies for complementing their knowledge in the unclear points, and also propose the re-execution of the experiment in another date and time defined in the item: Evaluation and approval procedure. Should the professor consider the reasons given by the student not justified, he will not be approved in the present experiment [3].

3.5 Evaluation and approval procedure

The traditional evaluation and approval criteria in learning, regardless of the type of course, level or academic stage, assign grades to the activities executed by the students, among a scale from 0 to 10, corresponding to 0 to 100%. The threshold grades change in each school and might be, most of the times, 50 or 70%. It means that if the student is approved with the grade 70%, it is accepted that he does not know at least 30% of the delivered content charged in tests and works. More serious than this, would be the case of the 50% approval criterion, where it is accepted that the student knows only a half of the taught subject in the respective course. How is it possible to accept that the professional that leaves the university does not have the expected knowledge that the own university curricula establish as important to the formation of that same professional ? It is possible to wonder if the blanks detected by the evaluation process along the several available courses will not be felt in the accomplishment of those professionals graduated from the schools that use threshold grades of 50% or even 70%.On the other hand, with the traditional learning and evaluation methods, it becomes extremely hard to change the parameters described above. The question is how to permit the approval of only the students that know 100% or approximately 100% of the taught topics during the course ? Once the students are not totally homogeneous in their basic knowledge level and they present variable learning curves, a learning system that proposes taking the totality of a class to an almost excellence level, must obligatorily treat each student in a different way, using interactive processes and frequent evaluations 18.

The evaluation method, grades and approval criterion, presented in this system integrated with IT, which is proposed for the Digital System Laboratories, only permits the student to reach the next step or be approved in the discipline, if he indeed knows the course delivered contents deeply.

Two types of grades are defined: the grade that the student obtains in each stage and his accumulated grade. The student always goes into the process of each experiment with an initial accumulated grade equal to 10. As the student passes through the several stages of the experiment process, he can lose points if he does not reach some defined objectives for each evaluation test and for the experimental part of the experiment. Missing the test and experiment and not reaching targets and deadlines will also make the student lose points.

In the qualifying stage, the student must get the necessary knowledge for doing the experimental part of the experiment. This will be evaluated by the qualifying test, that can hold or reduce the initial accumulated grade equal to 10. Should the student not obtain the maximum performance (qualifying test grade equal to 10), he will have his accumulated grade reduced to a value less than 10, according to a previously defined rule.

This way, the student will not be allowed to the experimental part. He must contact the professor and under his supervision, redo partially or integrally the research and the initial reading, preparing himself for a new evaluation test. Every time the student comes to the initial stage, once his qualifying test grade is less than 10, his accumulated grade will be reduced.

The professor will follow the student's accomplishment and when his accumulated grade reaches a value less than or equal to 5, it shows that the student is not evolving in the learning process. Thenceforth, the professor must intercede, contacting the student personally to know which his difficulties are. The professor can at his discretion, reinsert or not, the student in the experiment process. Should the student not reinsert in the process, he will receive grade zero in this experiment. Being enabled, the student will schedule and execute the experiment.

The experimental stage will generate a grade, based on the consistence and correction of the report sent to the professor and also based on the time the student spent to do the experiment. This grade, being less than 10, will cause the reduction of the accumulated grade that the student obtained after the qualifying stage, according to a previously defined rule. After doing the experimental part, the students will do the final certification test that evaluate the obtained knowledge with the experimental part as well as their technical knowledge related to this experiment. The final test will generate the third grade of this process, based on the answer to the questions and on the time spent by the students to do the test. Similarly to the previous stage, this grade, if less than 10, will cause to reduce the accumulated grade that the student obtained in the experimental part, according to a previously defined rule. It will be considered approved, in the respective experiment, the student that obtains maximum accomplishment (grade equal to 10) in the experimental part and in the final test. The student that was not approved must present the professor a filled perform report, describing the doubts that he still has and after online and personal contacts with the professor, redo the process: experimental part and final test until he obtains in the last stage, the maximum accomplishment (grade equal to 10). Every time the student comes to the last stage, once his qualifying test grade is less than 10, his accumulated grade will be reduced, according to a previously defined rule. Similarly, the professor will follow the student's accomplishment and when his accumulated grade reaches a value less than or equal to 3, it shows that the student is not evolving in the learning process. Thenceforth, the professor must intercede, contacting the student personally to know which his difficulties are. Similarly, the professor can at his discretion, reinsert or not, the student in the experiment process. Should the student not be reinserted in the process, he will receive grade zero in this experiment. The final accumulated grade represents, in an inverted way, the difficulty level that the student showed to get the maximum accomplishment in the respective experiment and it is possible, with this parameter, to evaluate the entire learning process [3].

4. Tests and simulation of the proposed system

The proposed system was applied to 10 third series Electronic Engineering students of the Universidade Presbiteriana Mackenzie in São Paulo, Brazil. The students have done one complete experience according the criteria described in section 3 of this paper [3].

The main results detected in the simulation are:

- The habilitation test acts as a process input filter. It demanded that the students studied more, reducing the initial heterogeneity of the students;
- preparation for the experiences. Done in advance (in any place and in any time);
- in the second time that the students did the test, the results were always good;
- many activities occurred on evenings and on weekends (in any place and in any time);
- the email communications did well in all levels and have documented all the process of the simulation;
- the preformatted reports with photos of all process, have oriented the experiment execution and have documented in details the experimental part.

5. Implementation in Moodle plataform

The proposed system in this article was implemented for the discipline *Comunicações I* of the 6th level of Electronic Engineering at Universidade Presbiteriana Mackenzie. The discipline is composed by 10 experiences during the semester.

The theoretical and the experimental topics are available in Moodle Platform, customized for Universidade Presbiteriana Mackenzie.

Fig. 1 - Partial aspect of Moodle initial screen

Fig. 2 - Initial screen of *Comunicações I* course

Fig. 3 - Partial screen with the topics 7, 11 e 19 of *Comunicações I* course

Moodle is a free distribution software, used worldly in management and availability of learning material in online form [3].

The students and teachers, each one with their defined functions must be registered and doing the login for accessing the online media. In Fig. 1 is shown a partial aspect of Moodle initial screen, accessed thought Universidade Presbiteriana Mackenzie website: www.mackenzie.br or directly by link: http://ead.mackenzie.com.br/moodle/course/ view. php?id=885 [15].

After login, the teacher or the student can have access to all the available online courses of Universidade Presbiteriana Mackenzie in Moodle, and after that, is possible to find and access the course: *Comunicações I*, as the initial screen that is shown in Fig. 2 (in Portuguese). This screen presents the objectives of the discipline and describes the contents that will be studied in *Comunicações I.*

Comunicações I course is composed by 21 topics. The first topic is about general information. The next 20 topics are 10 about theoretical subjects and 10 about experimental subjects, each one by experience. Fig. 3, shows the partial screen with the topics 7, 11 e 19, as an example.

In each experience topic, the following learning contents are presented:

- Theoretical introduction referring the specific experience subject;
- revision exercises or research activities / projects referring the experience subject;
- experience procedure;
- exercises and tasks answers (it can be hidden by the teacher if necessary);
- evaluations (it can be hidden by the teacher if necessary).

The students can download the available files and after doing the tasks / exercises they can upload them for the teacher and he is advised every time a new work sent by students are available.

The teacher can interact with the students, through emails or forums. The teacher can also see students access reports (logs) in order to know if and when the students are doing their online jobs.

A grade system that can be applied manually or automatically by the teacher is available. That system can be applied for every activity, like exercises and evaluation.

6. Conclusions and future work

This article describes a proposed methodology for improving the learning efficiency in laboratory classes for basic disciplines in Engineering courses, using IT and Internet access, optimizing teacher acting and this way multiplying his presence and support to the students. Distance and Virtual learning are not new concepts. However this work proposes the application of the most efficient aspects of the distance and virtual learning to a basic laboratory discipline of the Engineering curriculum.

It is important to highlight that this application is not completely online or at distance, but, combine the necessary presential components where they are demanded.

Other aspect addressed by this proposal is the evaluation methodology, that only permits the students leave each level of the learning process when they actually demonstrate know all the contents delivered in that same level. This way, it is possible to certify the student and measuring the difficulties he have faced in the learning process through of an evaluation parameter [3].

Considering the related simulations and the results analysis presented in the section 4 of this article, is possible to conclude that the proposed system can addresses questions like:

- Time flexibility for the laboratory classes (that is considered an important point in the conventional laboratories, permitting the students can do the laboratory classes according their time availability);
- implementation of a standard for the reports of laboratories experiences, in an electronic form, with photos of the entire process, permitting a clear and precise documentation of the experience;
- experience preparation can be done in advance, at home or at the university on a student free time, becoming easier activities anticipation and preparation;
- knowledge equalization, before the experience execution, equalizing the results got by the experience and the respective learning process;
- consolidation the possibilities of learning activities in any time and any place [1].

Other aspect detected during the simulations described in the section 4 of this article is the about the difficulties that many students present in circuit mounting during the experiences. Those difficulties show other kind of trouble found in the traditional laboratory classes. Often, there is no enough time during the classes, for the students practicing and minimizing their difficulties with mountings.

It is possible also propose, with the hybrid system (presential - online) described in this article, to offer short-time video courses, about some subjects that the students find doubts and difficulties. Those courses could present orientation about every step of experiments mounting and also about the correct use of laboratory instruments.

The methodology related in this article was implemented in Moodle online learning platform, that is widely already used in many universities in the world, mainly in theoretical subjects learning. Is possible now, use all the potential of the tool Moodle for increasing the efficiency and the flexibility of the experimental disciplines. Certainly for the implementation of the described system it will be necessary a deep change in the forms for generating the pedagogical contents, by the teachers and it will be also necessary more technological investments by the universities [16].

The next steps of this research will be the application of this methodology to the students of the discipline *Comunicações I*, doing the necessary adaptation and measuring its advantages and verifying the difficulties found, for thenceforth acquired experience, applying the refined methodology in other disciplines.

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