METHODS OF ELECTRONIC EXAMINATION APPLIED TO STUDENTS OF ELECTRONICS

Comparison of Results with the Conventional (Paper-and-pencil) Method

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Abstract: Electronic examination is of great interest from both the educational and pedagogical points of view. Different methods have been applied during three examination periods at the Technological Educational Institute (T.E.I) of Athens for "Electronic Physics", which is one of the core modules of the Department of Electronics. For this purpose, an application named "e-examination" has been developed. The selection of the module was based on certain criteria concerning the applicability of the methods. Preliminary preparations have been made for the conversion of the available educational material into an appropriate form for the creation of question sets for the "e-examination". To avoid bias and ensure objectivity of the methods and therefore the reliability of the results extra caution was taken. Thereafter, the results of the electronic and the conventional examinations were statistically processed and compared. The comparison indicated that the performance of students electronically examined was, in some of the cases, better than that of students who were examined conventionally. The percentage of knowledge assimilation and the efficiency of the teaching process were also investigated.

1 INTRODUCTION

Today it is widely accepted that new technologies can radically alter the educational practices and enhance the learning procedures (Dede, 2000, Fox, 2002). Their incorporation in the academic practice is a key element of modern educational process (DeBord et al, 2004). On this concept, new technologies have been used in the frame of improving the quality and the efficiency of the provided education (Bigum, 1997, Howard et al, 2004). Today, user friendly applications are available to students, supporting the teaching process through the use of polymorphic educational material (Ali et al, 2004, Fox and Herrmann, 1997). A type of these applications is computerized testing systems used for evaluating students (Buchanan, 2002).

Usefulness of electronic evaluation is still under investigation (Bull et al, 2002). At the T.E.I. of Athens, an application named "e-examination" has been developed for the examination of students (Tsiakas et al, 2005). A number of case studies have indicated that it can be used in the academic environment of the T.E.I. The results have been quite encouraging for further research and investigation(Triantis et al, 2004, Tsiakas et al, 2005).

The capabilities of electronic evaluation methods, let educators go beyond the limits of multiple choice tests and make possible alternative assessments. This work presents a comparison among the implemented methods and the paper-and-pencil one. The purpose was to study their appropriateness, feasibility and effectiveness (Thomas, 2003) and to investigate how the examination process can become more productive and accurate.

In order to ensure that the results of the case studies would be realistic, reliable and comparative, it was essential to meet some basic requirements. Students that participated in the pilot program should be familiarised with new technologies, the nature of the evaluation method and the use of the

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"e-examination" application. Finally, they should have access to a series of self-evaluation tests for practicing and to polymorphic study material for studying (Tsiakas et al, 2005).

After conducting the examinations in the three periods, the results were stored in a database for statistical processing and indicated that students who were electronically examined, in some of the cases, performed better than those who were examined conventionally (Triantis et al, 2004). This led us to the conclusion that electronic examination can be used as an alternative method of evaluating students and can eventually improve the teaching process.

2 "E-EXAMINATION" APPLICATION

"E-examination" is a stand alone application developed at the T.E.I. of Athens. It is mainly a managing and editing tool which can help the teacher to build and deploy assessment tests in a suitable form so as to be displayed in a web browser. In this way, it is assured that each test is portable and cross-platform.

The tests can then be used either for examining students or for self-evaluation purposes. The examinee has to answer a series of questions through a user-friendly interface. "E-examination" tests support four categories of questions:

- True or false.
- Multiple choice.
- Questions that require short calculations. In this case, students must type their answer in the corresponding field.
- Problems or exercises that require multiple steps for their solution. These steps include questions which belong to the previous categories.

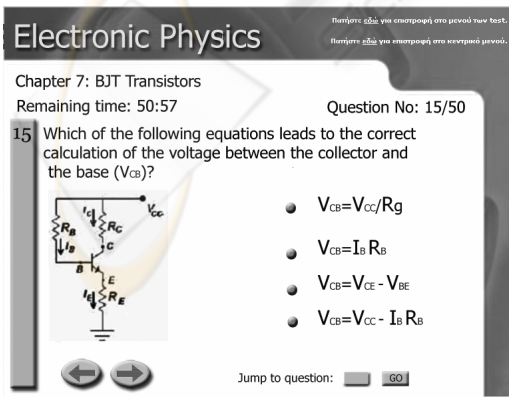

Figure 1: A multiple choice sample question of the electronic examination.

Figure 1 shows a sample screen of a multiple choice question. The user interface is divided into two areas. The wider one displays the question, the possible answers and the navigation panel. The other area, displays real time information such as the remaining time, the total number of questions included in the test, the current question number and the chapter it refers to.

3 REQUIREMENTS AND PREPARATION

"E-examination" was used for the evaluation of students who have been attending the module "Electronic Physics", with the following outline: Semiconductors, pn junctions and diode circuits, bipolar, field effect transistors and bias circuits. According to the current curriculum provided by the Department of Electronics of the T.E.I. of Athens, it is a core module and is taught during the first semester. The selection of the module was based on the following criteria:

- The teacher should be able to create sets of questions comprised of the four types supported by the application.
- Students from the specific department were more or less accustomed to new technologies and the use of computers.
- Their everyday contact with new technologies made them willing to try new examination methods.

Besides the scheduled module lectures and the companion book, polymorphic educational material should be available to every student. This material could be found on a web platform named "e-education" that contains web pages referring to taught modules. This platform acts supportively, operating as a digital library and a free, instant information provider. Students can access the web pages and download:

- Lecture notes.
- Theory questions answered or not.
- Problems and exercises with exemplary solutions or just hints.
- A series of questions of past examination periods with their solutions.
- Self-evaluation practice tests produced by the "e-examination" application.

Successive sessions were also organized in order to get the students accustomed to the "e-examination" user interface. They also took a

sample electronic test which was a simulation of the final one and had no effect on the final assessment.

The teacher should also prepare the subjects in which students would be electronically examined. The challenge was to fragmentise big problems and exercises into questions that could be edited and managed by "e-examination", covering at the same time a wide range of the module topics (Epstein et al, 2001).

Another issue was the equal distribution of students in two large groups at a time. One of the groups would be examined conventionally through the paper-and-pencil method and the other group would be examined electronically. During the semesters, students participated in three ordinary paper-and-pencil multiple choice tests. The score achieved in these tests had no effect on the students' final grade of the module. The score distribution was grouped into scales and students belonging to each of these scales were randomly and equally divided into the two groups mentioned above.

4 THE APPLIED METHODS

Four types of electronic examination took place in the last three semesters. Each semester, a different method was applied and the results were compared with those of the corresponding conventional method. The methods described in sections 4.2 and 4.4 were both applied during the third semester and on the same group of students. The final grade for the module in that semester was the average of the two examinations. In all cases the questions did not necessarily cover all of the module topics and their difficulty level varied. The examination topics for the methods implemented were of the same difficulty level, they covered the same range of module content and the available time was realistic and adequate. Every correct answer added certain points to the final result. The range of grades used for marking students was 0.0-10 and successful grades were considered those ranking higher than 5.0. The comparison was based on the following parameters:

- Percentage of students who passed the examination
- Percentage of students who received an excellent score (>7.5/10)
- Average score of students who succeeded
- Average score of students who participated

4.1 The Conventional (Paper-and-pencil) Method

The conventional method is the one currently used for the evaluation of students for most of the modules in the Department of Electronics. In particular, the teacher prepares four subjects which cover as many of the module topics as possible. The subjects consist of theory questions and problems and their difficulty level varies. Students are trying to cover all subjects as better as they can and the teacher evaluates their effort.

4.2 The "Classic" Method

In this case, all wrong answers along with any unanswered questions count for zero. The final score of the examination is the sum of the points given by correctly answered questions. In Table 1, the results of the two types of examination are presented.

Table 1: The results of the examination methods applied.

	e-examination	Conventional examination
Number of students	44	45
Succeeded (>5.0/10)	28	23
% Succeeded (>5.0/10)	64%	51%
% Excellent score (>7.5/10)	50%	43%
Average score of students who succeeded	6.6	6.4
Average score of students who participated	5.4	5.0

4.3 The Method of Negative Score

The difference of this method from the previous one is that whenever an examinee gives a wrong answer, certain points will be subtracted from the final result. If the examinee does not answer the question, no points will be subtracted. Likewise, students are discouraged from just guessing the answers. In Table 2, the results are presented along with those of the conventional method.

Table 2: The results of the examination methods applied.

	e-examination	Conventional examination
Number of students	49	48
Succeeded (>5.0/10)	19	24
% Succeeded (>5.0/10)	39%	50%
% Excellent score (>7.5/10)	26%	42%
Average score of students who succeeded	5.7	6.3
Average score of students who participated	4.4	5.3

4.4 The Method of Multiple Paths (First Variation)

In this method, as shown in Figure 2, there are multiple paths which lead to the completion of the test.

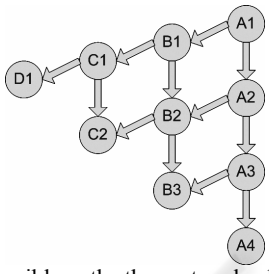

Figure 2: All possible paths the system leads the student to follow during the examination.

The test is divided into groups of questions of different difficulty level. Groups A1 - A4 contain basic questions through which teachers can investigate whether students are familiar with basic concepts of the module. Groups B1 - B3 are used to check whether students have adequately comprehended fundamental concepts. Groups C1 and C2 contain questions of medium difficulty and are used for helping teachers to verify if students have fully understood the main topics. Finally, group D1 is a collection of more sophisticated and specialized questions which investigate students' comprehension of various module topics and whether they have developed their judgment and analytical way of thinking. Accordingly, questions belonging to groups A1 - A4 have the minimum weight in the final score, while questions belonging to group D1 have the maximum weight.

In the beginning of the test, all students begin with A1 group. They can proceed to a group of questions belonging to the higher difficulty level if they have achieved the minimum score required. If not, the system automatically leads them to the next group of questions which belongs to the same difficulty level. This process is repeated until the end of the test. The final mark is the sum of all marks of the groups that have formed the path the student has followed. If the examinee cannot reach groups of high difficulty level it is obvious that the final mark will be low. In all cases, students have to answer four sets of questions. Table 3 presents the results of the current electronic and conventional examination.

Table 3: The results of the examination methods applied.

	e-examination	Conventional examination
Number of students	41	40
Succeeded (>5.0/10)	25	22
% Succeeded (>5.0/10)	61%	55%
% Excellent score (>7.5/10)	48%	41%
Average score of students who succeeded	6.5	6.3
Average score of students who participated	5.3	5.1

4.5 The Method of Multiple Paths (Second Variation)

This method is similar to the previous one. The difference is, as shown in Figure 3, that students will necessarily proceed to more difficult questions. There are only three possible routes which lead to the completion of the test.

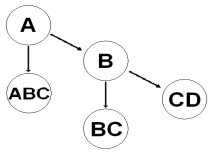

Figure 3: All possible paths the system leads the student to follow during the examination.

All students begin with the same set of questions. Once again the system decides which group of questions the examinee will confront depending on the achieved score of the current group. If the score is lower than the minimum required, the system leads the student to a final set of selected questions of mixed difficulty. This way, the examinee has the opportunity to answer questions which belong, at least, to C-level of difficulty. The final mark is the sum of all marks of the groups that have formed the path the student has followed. In

Table 4, the results of this variation of examination are presented.

Table 4: The results of the examination methods applied.

	e-examination	Conventional examination
Number of students	41	40
Succeeded (>5.0/10)	27	22
% Succeeded (>5.0/10)	66%	55%
% Excellent score (>7.5/10)	59%	41%
Average score of students who succeeded	6.7	6.3
Average score of students who participated	5.6	5.1

5 RESULTS

In all cases of electronic examination, except the one with the negative marking, students had a better overall performance compared to the conventional method and the scores achieved were also higher. This is summed up in Table 5 and is clearly shown in Figure 4.

Table 5: The overall results of the examination methods applied.

	e-examination	Conventional examination
Number of students	175	133
Succeeded (>5.0/10)	99	69
% Succeeded (>5.0/10)	57%	52%
% Excellent score (>7.5/10)	46%	42%
Average score of students who succeeded	6.4	6.3
Average score of students who participated	5.2	5.1

The difference in the performance is mainly due to the following factors:

- The electronic examinations contain more questions of all levels of difficulty which cover all of the module topics. In this way, students can find more questions that are easier for them to answer.
- Complex problems can be broken down into simpler ones. Thereby, students have the opportunity to answer some questions and score some points even if the complete solution is unknown to them. In the conventional method, only the final result is usually marked and students get no points for unsuccessful attempts.
- The above mentioned method of presenting complex problems works as a guide for students towards the final solution. It is also a good method for students to practice the way of thinking they have been taught throughout the semester for solving complex problems.

Some of the electronic examination methods that were implemented are rather strict. Such an example is the method of negative score. Students who took this exam did not achieve high scores and the percentage of success was low (Figures 4, 5 - case 4.3). This is due to students' hesitation to give an answer if they are not sure about it. Thereby, the factor "sheer luck" is eliminated. Additionally, there are no rewarding points for students that know how to solve a problem or exercise unless all calculations and the final result are correct since the system is unaware of how students think while taking the test. Thus, the answers must be accurate and correct.

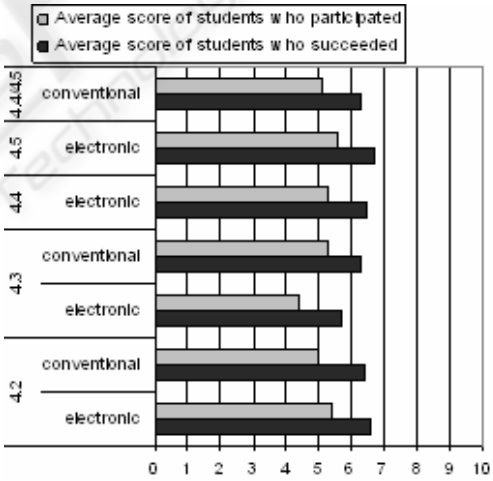

Figure 4: Average scores of students.

The implementation of the classic method shows an improvement of the results in relation with the conventional one (Figures 4, 5 - case 4.2). In both cases, the subjects were of equal difficulty and did not necessarily cover all topics of the module. The difference in the performance is mainly due to the fragmentation of complex questions and exercises.

The methods of multiple paths were applied in the same group of students. In both cases the students performed better than those who were examined conventionally. It is obvious that the first variation is stricter than the second one (Figures 4, 5 case 4.4, 4.5). If students fail to get the minimum

score in group A1, they are offered another opportunity as the system guides them to a group comprised of the same type of questions (A2). If students fail once again to achieve the minimum score required, they are "locked" in groups of low difficulty level and they will eventually fail to pass the exam. In order to succeed in the examination, even with a minimum score, a student must reach, at least, level C groups. If students cannot reach D1, they will never achieve a score greater than 7.5/10, a score that is considered "excellent".

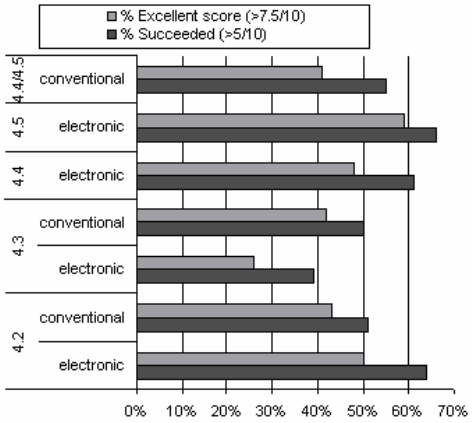

Figure 5: Percentages of success and excellence.

The second variation is less strict. If students fail to pass the first group of type A questions, they are directed by the system to a group which consists of A, B and C type of questions. Hence, even in this case there is a chance for an examinee to pass the test since they reach C-level questions. The results have shown that by implementing this method, students who could not pass the test when examined with the first variation but were close to achieving it, they managed to achieve the minimum score required when examined with the second variation. In addition, students who passed the examination, performed better and many of them managed to pass the limit of 7.5/10.

As far as the teachers are concerned, they can check if the questions they have prepared are fairly distributed in groups and properly assigned to the levels of difficulty. They can verify it by checking the results of groups of questions in relation with their difficulty level. For example, in Figure 6, this relation is shown for the first variation of the multiple path method (section 4.3). It is clear that this relation is linear for the percentage of failure of students concerning the difficulty level. In level D this percentage is higher than the percentage of level C and is almost four times higher than the percentage of level A. It is clearly indicated that groups A1-A4 include the easiest questions while group D1 includes the most difficult ones.

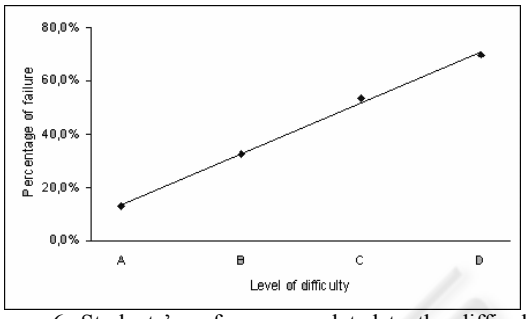

Figure 6: Students' performance related to the difficulty level of questions for case 4.3.

Statistical processing of the results can also help teachers locate topics of the module which students failed to comprehend and focus their tutoring on these subjects during the following semester. This is clearly shown in Figure 7, where we can see for each unit of the module, the corresponding percentage of failure related to the difficulty level of questions of the test.

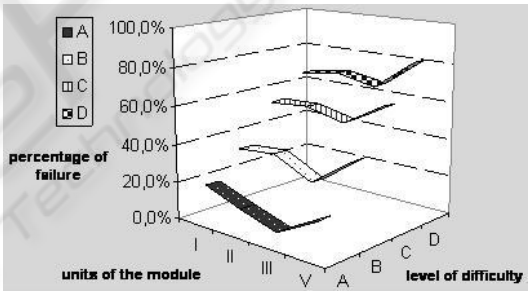

Figure 7: The relation between the percentage of failure, the units of the module and the difficulty level of questions.

6 CONCLUSIONS

For the first time in the T.E.I. of Athens, a coordinated and essential effort has been made in order to incorporate new technologies in the educational process. Electronic examinations have been implemented as a pilot program for a certain module. The results showed that students performed better. Our goal was not to find out which method is better, but to make sure that they are applicable, feasible and effective.

Results demonstrated that electronic examination methods can be as strict as teachers might wish (Bigum, 1997). There are methods like the one of negative score which makes it hard for students to pass. There are also methods which can really make weak students to pass the exams and consistent

students to perform even better (method of multiple paths – second variation). Teachers are those who will decide of which method they want to apply. The nature of the module and its topics is also a significant factor involved in this decision. Perhaps there will be an ideal examination which can be a combination of more than one method.

Unlike previous efforts which failed to stimulate the interest of the academic community in the institution, this time feedback from students and teachers is positive and encouraging. The module of informatics which is taught in the secondary level of education and the use of computers in everyday life creates a suitable background for students to adopt the newly introduced tools.

Conclusively, every innovation in the field of education attracts students' interest (Bloom and Hough, 2003). The reason is that students are encouraged to develop initiative and pursue knowledge, rather than merely react and absorb. The right pace has to be found for the achievement of the best possible results for education. Those results will require an intense focus on the substance of what the new technology can deliver, as much as on the process (Fox, 2002, Howard et al, 2004). We will still need libraries, seminars and tutorials, faculties, books, laboratories and residential environments. The role of new technologies is not to replace or even degrade the traditional forms of teaching, but to strengthen what already exists, and also extend our capacities (Bigum, 1997). This will result to the accomplishment of higher percentage of knowledge assimilation and better efficiency during the teaching process.

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