

Educational evaluation of Matlab simulation environment in teaching technological courses: The example of Digital Control Systems

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Abstract. *The computing environment Matlab is widely used internationally, in the modern Engineering Education with constant improvements and potential that reflects recent findings of modern scientific research. This paper presents the educational evaluation of the computer simulation environment Matlab, as it is used in the educational process of Higher Education in the sector of engineers/technologists and in the scientific field of Digital Control Systems. The evaluation methodology involves the learners and studies the following three main features: (a) the usability of the system, (b) the lesson plan and (c) the learners' assessment. The survey was conducted using structured anonymous questionnaires in the department of Automation in TEI of Piraeus during the academic year 2009-10. The first results highlight the importance of the educational use of the Matlab environment in the pedagogical context of teaching technological courses.*

Keywords. Matlab, Simulation, Evaluation, Technological courses.

1. Introduction

The transition to information society and knowledge is a challenge for education more than any other social sector. At the same time, the convergence of computing and communication technologies (ICT) in the educational process creates new opportunities and challenges for both learners and teachers. This convergence is accompanied by an increasing investment in material and human resources. Therefore, the issue of evaluation is of paramount importance [11].

On the other hand, the simulation as a technique of imitating one's system behavior from another system, occupies a prominent position within the framework of educational applications. The training simulation is defined as a model of a phenomenon or an activity, which users use and learn through interaction with simulation [1], [5]. There is a significant number of scientific publications that suggests new strategies for developing educational software, especially in simulation and the multimedia environment [3], [4], [7]. What is observed is that most evaluations focus on the concept of usability, which according to Nielsen, is the ease of learning from new users, high performance work done by experienced users, the sustainability of the capacity to use the system over time by the user, the small number of wrong handling, the easy way of resuscitation and the subjective satisfaction of users from contacting the system [8], [9]. However, it is quite a helpful factor in evaluating an educational system. On the contrary, the learning effectiveness of software is a key assessment factor. How to measure learning effectiveness is an important question that is implicitly connected to the methodological approach to investigate the effectiveness of the educational resources evaluated. For example, when we set as a criterion for educational evaluation the promotion of critical thinking by the software tested, its effectiveness is literally judged by whether it manages to meet this criterion [11]. In conclusion, the educational assessment reflects values attributed by the evaluator to applying information technology in the classroom. Of course a key objective is, if the evaluated educational software improves the educational process, but the factors are difficult to be

established clearly and objectively, as it is done in mathematics and applied sciences. From this fact, results the lack of assessment standards.

2. Theoretical Analysis

The educational software that will be assessed in conjunction with educational subject in which it is used (Automatic Control Systems), is a Computer Simulation Environment (of quantitative type), which is applied to the educational process in higher education in the sector of engineers/ technologists, in particular in the scientific field of automatic control. This software is Matlab v.7 and is widely and internationally used in the education of engineers in several sectors (Engineering Education). The evaluation concerns its use at the Digital Control laboratory based on the Educational Objectives (EO) set, and the training methodology used for laboratory teaching of Digital Control Module (5th semester) in the Automation Department of TEI of Piraeus (Table 1) [10], [12].

Table 1. Teaching Approach of Matlab in Digital Control Module

EO	Knowledge	Skills	Training Methodology
EO1- Application/use of mathematical tools of Automatic Control Systems (ACS)	Maths Knowledge (Basic and Applied Mathematics) Design & Analysis Skills CS	Problem-solving - Construction-Analysis Model ACS	-Verifying a model (simulation and interaction with the instructor) -Classical interactive simulation (individual use by students, homework)
EO2-linear systems modelling			
EO3-simulation of models of digital control systems			
EO4-use of graphical tool SIMULINK			
EO5-Design of Digital Controllers (PID)			
EO6-analysis of the systems in state space			

The compatibility of EO compared with the description of the course, concern the theoretical foundations of the subject rather than the

technical implementation of the ACS (hardware), ie the components, microprocessors, sensors, which constitute the "real" world of an ACS model. Matlab helps the realisation of the "reasonable" world of an ACS model. This relates to the theoretical design and implementation of the ACS model depicted in reality with the design of a software control system for digital automatic control. This implies the following educational activities in the computing environment Matlab: analysis, design and dynamic modelling [10].

3. Research Methodology

The research concerns the educational assessment of Matlab software from the perspective of trainees for use in the laboratory Digital Control Module. It was implemented with the use of a questionnaire, which is divided into two main parts: the training and technical part [10], [13]. In particular, the following issues were examined:

- Assessment of module, teachers and learners themselves,
- Evaluation of technical data of the simulator (using tools, multimedia, textbooks, teaching planning,etc.).

The survey was conducted at the end of the winter semester of the academic year 2009-10 to the students of the Laboratory of Digital Control of the Automation Department of TEI of Piraeus. The number of trainees who participated in the survey was 22 (out of 39 students, who were enrolled in the workshop for this semester). The process of completing a questionnaire (anonymously) was implemented. The processing of research results was made using a computer (MS Excel). In particular, the survey includes the following variables as shown in the following table (Table 2):

Table 2. Methodological Framework (Variable Research)

Independent variable	Dependent variable
1. Year of Study (B-2nd, C-3rd, D-4th, Advanced-Years: concern students who declared the module beyond the formal years of study, mainly because of the requirement to have succeeded in the modules required for attending Digital Control Module).	1.Course Assessment(4 sub-variables) 2. Teachers' Evaluation (4 sub-variables) 3. Trainees' Evaluation (three sub-variables) 4. Multimedia use 5. Trainees' tools 6.student User-friendliness (two sub-variables) 7. Didactic design (3 sub-variables) 8. Bug fixed in terms of student 9. Evaluation of trainees in simulator 10. Manuals & Help (3 sub-variables) 11.Infrastucture (3 sub-variables)

The dependent variables constitute the criteria relating to the oversight of the use of Matlab simulation environment in this educational process. The tutorial design, presentation, content, structure, dynamics and interactivity are monitored. The evaluation took three main factors into account: Instructional Objectives (tutorial design, course evaluation), the medium used (use of multimedia tools, assessment instrument, friendly user manuals and support, bug fixes, infrastructure) and learning outcomes (assessment of learners, teachers) [3], [4], [7]. The form of the questions included in the evaluation questionnaire to the corresponding scale is as follows (Fig.1):

Question	A lot	Pretty	Moderate	Fairly	Not at all
Analyzes and presents concepts in a simple and interesting way?					

Figure 1. Question Form with the rating scale

The processing and interpretation of responses will be based on the answers, which exceed (numerically and in percentage) for each classification (based on the rating scale) compared with all the answers. The purpose is the clear identification of the sample trend towards a characterization based on the rating scale and its appropriate interpretation. In case of equivalence to more than two classifications (ie a total of six responses there are two “a lot”, two “Pretty” and two “Fairly”) then it is designated as "No Response superiority" because the trend of the sample cannot be determined clearly. The methodology of the survey includes the following steps:

- general information for the purpose of research to trainees;
- completion of the questionnaire (duration 20-25 min) and
- leaving the venue of the survey.

This paper presents the main results of the survey and in particular those related to educational part of the evaluation.

4. Results

After the collection of survey data and their processing, the following information regarding the analysis of the sample to the independent variable is presented:

Independent Variable: Year of Study (B-2nd, C-3rd, D-4th, Advanced Years-AY) for the sample as a whole:

- B-2nd Year: 3 (13.6%)
- C-3rd Year: 7 (32%)
- D-4th Year: 3 (13.6%)
- AY: 9 (41%)

as shown in the following graph (Fig. 2). The normal academic year for the laboratory course is the third year of C-to E' & F' semester because it typically belongs to E' half. The AY concerns the semesters H' and over (I', J', etc.).

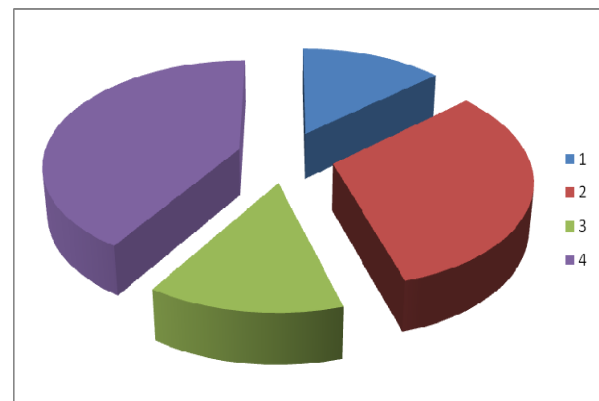


Figure 2. Schematic illustration of the survey sample on the academic year (1:B, 2:C, 3:D, 4:AY)

Below lie the options of the responses in the questionnaire and the corresponding frequencies for the independent variable in relation to the dependent variables and sub-variables of the survey questions regarding the educational part of the questionnaire:

Course Evaluation (Table 3): includes four questions relating to the educational evaluation of the course (content, material, etc.).

Table 3. Most frequent answers in the Assessment of the course (4 sub-variables) in relation to the academic year.

Question	Year of Study (22)			
	B (3)	C (7)	D (3)	AY (9)
The material covered with Matlab's help met the objectives of the course?	"Pretty" (2)	"Fairly" (4)	"Pretty" (2)	"Fairly" (7)
The educational material given helped to a better understanding of the subject?	"Pretty" (2)	"Fairly" (3)	There is no precedence answer	"Fairly" (4)
Using knowledge from other classes?	"Pretty" (2)	"Fairly" (4)	"Pretty" (3)	"Fairly" (4)
How is the level of difficulty of the course with the help of Matlab for the corresponding academic year?	"Moderate" (3)	"Moderate" (5)	"Moderate" (2)	"Moderate" (7)

Evaluation of Teachers (Table 4): includes 4 questions about the evaluation of teachers in the classroom by the students.

Table 4. Most frequent answers in Educational Evaluation (4 sub-variables) in relation to the academic year.

Question	Year of Study (22)			
	B (3)	C (7)	D (3)	AY (9)
How do you assess the organization and presentation of the material?	"Very good" (2)	"Good" (5)	"Good" (2)	"Good" (7)
Does it succeed in stimulating the interest in the subject?	"Pretty" (2)	"Fairly" (4)	There is no precedence Response	"Pretty" (5)
Analyzes and presents concepts in a simple and interesting way?	"Pretty" (2)	"Fairly" (4)	"Pretty" (2)	"Fairly" (5)
Encourages students to formulate	"Pretty" (2)	"Fairly" (4)	"Pretty" (2)	"a lot" (4) "Enough"

queries and questions to foster their critical thought?				(4)
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Student Assessment (Table 5): includes three questions about learners' self-assessment during teaching process.

Table 5. Most frequent answers in Student Assessment (3 sub-variables) depending on the academic year.

Question	Year of Study (22)			
	B (3)	C (7)	D (3)	AY (9)
Study systematically the subject matter?	There is precedence answer	"Fairly" (4)	There is precedence answer	"Moderate" (5)
Respond systematically to exercises / work?	There is precedence answer	"Fairly" (5)	"Pretty" (2)	"Fairly" (5)
I spend time weekly to study the course with the help of Matlab	"0-2 hours" (2)	"2-4 hours" (5)	"0-2 hours" (3)	"0-2 hours" (6)

Didactic Design (Table 6): refers to the instructional design in connection with the help of Matlab provided in the course of Digital Control (educational use, problem solving).

Table 6. Most frequent answers in Educational Planning (3 sub-variables) depending on the academic year.

Question	Year of Study (22)			
	B (3)	C (7)	D (3)	AY (9)
Rate Matlab in promoting problem solving (on the technical potential)	"Very good" (3)	"Good" (3) "Very good" (3)	"Very good" (2)	"Very good" (5)
educational activity at Matlab helps in understanding the subject (numerical control)	"a lot" (2)	"a lot" (3)	"a lot" (2)	"Fairly" (5)
How do you judge as a whole the educational process of Matlab use?	"Very good" (3)	"Good" (4)	"Very good" (2)	"Very good" (7)

Respectively, follow the answers to options on the major dependent variable and sub-variables of the survey questions regarding the technical part of the questionnaire:

Use of Multimedia (Table 7): concerns the evaluation of the educational use of multimedia environment Matlab (where available).

Table 7. Most frequent answers concerning the use of multimedia depending on the academic year.

Question	Year of Study (22)			
	B (3)	C (7)	D (3)	AY (9)
How do you judge the overall use of multimedia (text, image, sound, animation). Does it help you understand the lesson?	There is no precedence Response to	"Moderate" (4)	There is no precedence Response to	"Moderate" (4)

Trainees' tools (Table 8): Refers to the evaluation of the use of auxiliary tools simulator.

Table 8. Most frequent answers on the Trainees' tools about sex, year of study Knowledge of PC

Question	Year of Study (22)			
	B (3)	C (7)	D (3)	AY (9)
How do you assess the overall use of auxiliary tools (graphics, computers, a.) by the software. It helps you understand the lesson?	"Good" (2)	"Good" (6)	There is no precedence answer	"Good" (7)

Trainees' User-Friendliness: Refers to the evaluation of the interface (interface) & navigation provided by the simulator.

Table 9: Most frequent answers in the trainees' User-Friendliness (two sub-variables) depending on the academic year.

Question	Year of Study (22)			
	B (3)	C (7)	D (3)	AY (9)
How do you assess the overall illustration of the software interface. Is it easy	"a lot" (2)	"Fairly" (5)	There is no precedence answer	"Fairly" (6)

to use?				
How do you value the navigation aids?	"Very good" (2)	"Good" (4)	"Moderate" (2)	"Good" (6)

5. Discussion

The educational evaluation of a simulation environment has some special features (it does not have separate scenarios, assessment tools) in relation to an "independent" educational software. What should be noted is that Matlab is an integrated environment with significant technical capabilities and important educational opportunities, as long as teachers use them effectively through the correct teaching design. The purpose of the survey is to evaluate the software Matlab in teaching a technological course, regarding features such as digital control, a course that requires a range of prerequisite knowledge (mathematics, physics, control systems, etc.) and at the same time constitutes a specialized field of synthesis of many areas. From the presentation of the survey results as outlined, we draw the following conclusions:

- Trainees (regardless their academic year) are fully satisfied regarding the evaluation of educational material, the combined use of further knowledge and generally the course overall.
- Teachers' evaluation is in general satisfactory with one objection (by the students of the year attending the lesson and also older students) regarding the organization and presentation of the taught material, which means that a better design of the course is needed with the help of Matlab (examples, applications, etc.).
- The trainees' self-evaluation on average (regardless of the year of study) shows that students respond to the demands of the course. But there is a contradiction because regarding the last question on studying hours, except for the trainees who belong to the year of study (3rd Year of Studies – E', F' Semester), all the others respond with 0-2 hours suggesting that they don't prepare well.
- Those who have the responsibility of the course should, with an appropriate design (use of incentives, assignments etc.), increase students' study time and also, by increasing the hours of training in the form of free workshop, aiming to adequate training in this subject area, which constitutes a key training subject and helps students, especially the older ones, who may

abstain (for different reasons: labor, lack of knowledge) from the Faculty, to meet the requirements.

- The Teaching Design is valued by all learners positively and particularly the assistance provided by Matlab in problem solving, thus resulting in better understanding of complex modules of digital control. There is a distinct gap rising only among students who belong to the current year of study regarding the teaching design (lower overall assessment), which would help teachers further explore the causes and improve the educational use.

- Finally, the evaluation reflected the demands of teachers and manufacturers to improve the design of the use of multimedia tools and navigation means (by all students regardless their year of study) that helps learners to familiarize with the capabilities of Matlab, so as to be able to respond in a better way to the educational process.

6. Conclusions

In conclusion, Matlab can help a learner to develop:

- Synthetic thinking. That means creativity and building concepts and acquisition of skills (problem solving, modelling), which promote the design of appropriate educational activities by the instructor.

- Analytical thinking. The available tools help each student to analyze phenomena, complex or simple concepts offering a significant growth in the respective dimension of student thinking.

- Critical capacity. It can be achieved through all the properties of teaching design (discovery, integration, problem solving, modelling) that the Matlab environment can provide to the teacher and student. Also it trains the critical capability for the determination of what is to blame for the mistake (through suggestions from Matlab), through the facilitation process in cases of error.

What should finally be noted is that the computer simulation environments (Matlab) can be used effectively in the educational process, as long as the teacher designs the educational activities in an educational way, giving priority to the knowledge acquisition phase, to the maximum advantage of the opportunities provided by the environment simulation and manufacturers to enhance their product in order to optimize usability.

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