Automation and Control Engineering Laboratory: Students Perspectives

Celina P. Leão, Filomena O. Soares, Vitor Carvalho, and Rosa M. Vasconcelos

Abstract— **This paper presents a study carried out in order to evaluate the students perception in the development and use of remote Control and Automation educational kits. The study is performed under a statistical analysis of a questionnaire. The questionnaire aims to identify and evaluate the students' opinions regarding the use of didactic kits through the Remote Laboratory in the teaching and learning in Automation and Control subjects. The students' reaction to this test was quite positive. The analysis pointed out that successful results were achieved not only in the learning progress on the Automation and Control fields (hard skills) but also on the development of the students soft skills, leading to encouraging and rewarding goals, motivating their future decisions and promoting synergies in team work.**

Index Terms— **Automation, Control, Engineering Education, Questionnaires, Statistical Analysis.**

I. INTRODUCTION

In this paper, regarding Automation and Control education [1], different technologies and learning environments are described, in order to develop illustrative and interactive situations, as for example, virtual processes, local and remote laboratories and interactive animations. Students can develop web-animation for an Automation and Control topic; students can design a particular experimental rig for local and remote control; students can practice topics related to an Automation and Control subject using web-based learning environments, previously constructed by other students; students can solve exercises with real equipment that others have designed and implemented. In all, this is a dynamic learning task: some students actively participate in the development of the learning content and other students simply use and test them. It is regarded as a team work function.

This study explored educational experiences in Automation and Control subjects where students acted as designers and as final users. The basis of this project is the development of three remote control laboratory kits implemented by the designers' students. These kits were used in Automation and Control lessons as real world examples developed by students for students' knowledge development.

In order to understand the students´ response to the learning through Remote Laboratories, in particular in Automation and Control Engineering, a questionnaire was filled by the end-users students and further analyzed under a statistical test.

It is the researchers believe that the end users students' expectation on this new teaching-learning approach is relevant in the continuity and improvement of this methodology.

The paper is divided in four sections. Section 1 gives an overview of the developed study; section 2 details the three kits implemented and tested in the Remote Laboratory; the students 'attitude evaluation is presented in section three as well the corresponding statistical analysis to the questionnaire. Finally, section four shows the final comments and conclusion of this study.

II. CASE-STUDY DESCRIPTION

Three case-study kits were designed and implemented in the remote laboratory: the "small intelligent" house (SIH), the velocity control of a DC motor (VCDCM) and the temperature control of a classroom (TCC). A brief description of the different kits is performed in the following.

A. The "small intelligent" house, SIH

The first kit is a frame toy house equipped with several sensors and actuators for controlling daily house functionalities, namely: authorized front door opening, inside stair lights, alarm intrusion system and attic temperature control (Figure 1a) [2]. The control was implemented by a PLC (CQM1H-CPU61) from Omron [3]. The staircase illumination is performed by three push buttons placed at different places through the stairs. For the internal illumination, a motion detector was used and whenever it detects movement, a signal is sent to the PLC, activating the light. Regarding the alarm system, whenever it detects an intrusion, there is a light and sound signal. The control function activates and deactivates the alarm. The sound is performed by an independent circuit, a LM555 based timer circuit [4]. The door has a DC motor and a light bulb that is switched on when the door is opened. The attic temperature control is performed by an Omron temperature controller (E5CK) [3].

To control the door, the alarm, the internal illumination and the staircase illumination it was necessary to develop

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dedicated electronic hardware. The monitoring of the “small intelligent” house was developed in LabVIEW graphical programming language [5], as it allows building a virtual environment to be applied as an education tool. The LabVIEW interface enables both virtual simulation and “small intelligent” house remote monitoring and actuating. The direct control is still performed by the PLC. The interface allows also monitoring and testing different proportional, integral and derivative (PID) parameters of the attic temperature control algorithm.

In simulation run, the sensors and actuators of the “small intelligent” house are replaced by switches and colored signals. All the several characteristics created and implemented in the “small intelligent” house, alarm intrusion, main and internal illumination, main door opening/closing, are virtually simulated. For each control, the correspondent front panel and block diagram were developed separately. The definition of the corresponding inputs/outputs of the various “small intelligent” house parts is also made in this front panel (Figure 1b).

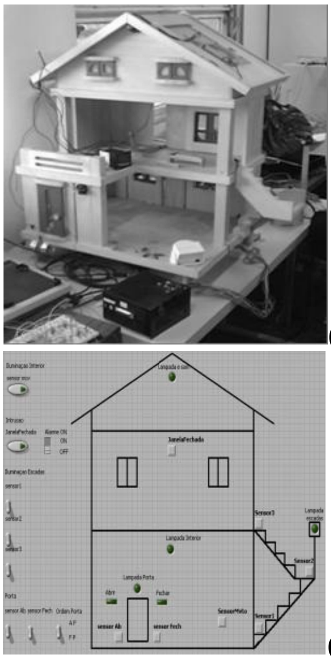
(a)
(b)

Fig. 1. (a) Set-up of the experiment and, (b) LabVIEW front panel interface for the virtual simulation, of the SIH.

The interface also permits the remote control of the ”small intelligent ” house where the remote visualization is performed by a Webcam (Trust, 120 Spacecam), enabling real-time experiments via the Internet.

B. *Velocity Control of a DC Motor, VCDCM*

A remote controlled DC-motor was developed for undergraduate control studies, allowing testing PID controller performance [6]. This system is a supplement to the traditional class teaching, where students can remotely observe how PID control works on the velocity control of a DC motor. The control methodology was implemented in a microcontroller [7].

The remote access and control of the developed system is enabled through t an interface developed using the LabVIEW Web Publishing Tool (Figure 2). An automatic waiting queue is managed by LabVIEW, allowing a single control user. All the facilities available in local control are accessible through the remote interface. Among these functionalities are: choosing different versions of the PID digital algorithm, varying controller gains and changing the velocity reference value.

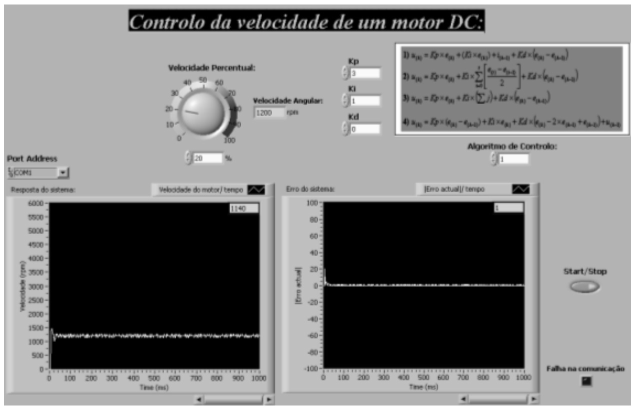

Fig. 2. LabVIEW user interface (*in Portuguese*)

C. *Temperature Control of a Classroom, TCC*

This project was developed as a student final work in the Industrial Informatics course in the Polytechnic Institute of Cávado and Ave. The goal was to remotely monitoring and control the temperature of a scale model classroom It was designed for a resistive temperature sensor with a positive temperature coefficient (PTC) [8-9]; controlled by a PC [10] with custom software developed in LabVIEW using actuators for cooling [11] and warming. It integrates a webcam [12] to observe the activity inside the classroom, as well as the possibility of simulating a temperature disturbance. Figure 3 shows the LabVIEW interface designed.

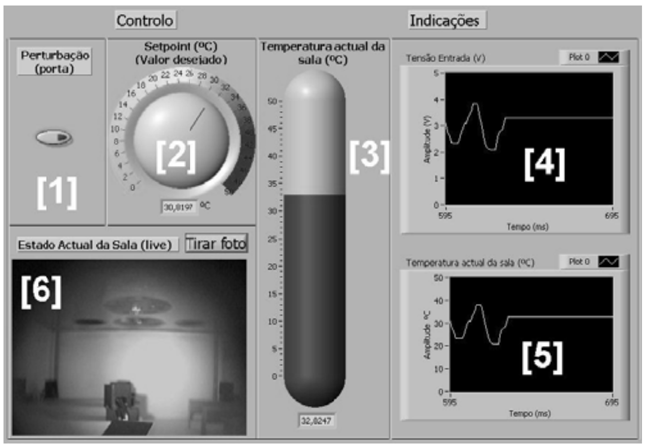

Fig. 3. Application interface [1- Disturbance (door) activation button, 2- Setpoint adjustment, 3- Classroom temperature (ºC), 4- Input voltage over time (V), 5- Temperature over time (ºC), 6- Webcam display] (*in Portuguese*)

III. STUDENT’S ATTITUDE EVALUATION

In order to analyze the feedback obtained from the end user students of the three case-study kits implemented in the remote laboratory, two questionnaires were developed and their results analyzed. The questionnaire was directed to the end-user students.

The questionnaire was developed in order to understand and analyze the students' reaction to the use of didactics kits in the teaching and learning in Automation and Control. It was divided into 6 main parts: (1) student characterization, (2) work environment identification (operating system and browsers identification), (3) didactics kits motivation, (4) didactics kits technical skills, (5) didactic kits soft skills and (6) students habits and attitude characterization during the project. The statistical analysis of the questionnaires was done using SPSS software (Version 17.0) [13].

The questionnaires were distributed to the students and conducted in a traditional classroom where each student wrote his/her answer directly in the questionnaire paper sheet during a period of around 5 to 10 minutes.

A. Students' characterization

A group of 34 students responded to the challenge, with an average around 22 years old, 4% were female, and 91% were students from the third year of the Industrial Electronics Course from University of Minho and attended or attend for the first time the classes of Digital Control (17.6%) and both Curricular Units Digital Control and Automation (82.4%). Most of the students identified Windows XP and Vista (64.6 and 29.4%, respectively) as the operation system used. Internet Explorer was identified by 58.8% of the students and Mozzila by 26.5% as the browsers used to access the didactics kits. The remaining students used both or different types of browsers like Google Chrome. All the three didactics kits were tested. However, due to some difficulties in communications (identified by 57.6% of the students), the students were not able to test all of them: the SIH kit was experimented by 58.8% of the students, both SIH and VCDCM kits were accessed by 32.4% of the students and finally, only 8.8% of the students could test all the three experiments, SIH, VCDCM and TCC. Nevertheless, the results obtained through the questionnaires allowed extracting some conclusions. These communications problem need to be solved in near future.

It is important to state that for 94.1% of the students it was the first time that they participated in this type of experience.

The morning period (9H-12H) was not identified and was not chose n to carry out the remote experience (Figure 4). The University is the place by excellence to access the kits during the lunch period (12H-14H), being the afternoon period (14H-18H) the most used. This gives to the teacher an idea of the study hours that students prefer. The students share the access between the University and home.

B. Didactics kits: analysis results

The objective of this study was to measure the students' degree of concordance concerning their motivation in using the didactics kits as an appropriate tool on their Control and Automation learning process. The analysis was focused on the average value obtained for the 9 items, evaluated in accordance with the level of agreement: 1 – strongly disagree, 2 – disagree, 3 – undefined opinion, 4 – agree, 5 – completely agree. In each item, the student chose only one option. The items considered were the following:

Q1: In general, I was motivated for the use of these kits in the course context.

Q2: In general, I can say that the performance of the kits...

1: … help me to assimilate the concepts presented during the course semester;

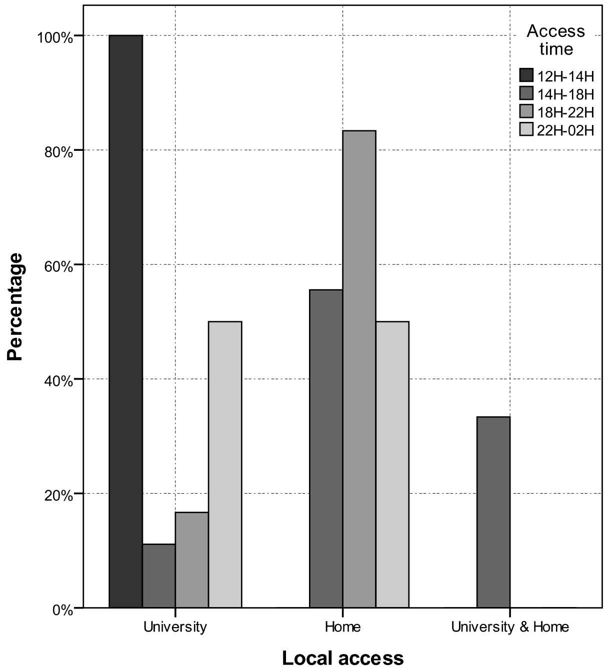

Fig. 4. Students' percentage of local access by time of access.

2: … made my learning more objective;

3: … increases my chances of getting a high final evaluation;

4: … motivate me to the course;

5: … raise my expectations relatively to the assessment;

Q3: Running the kits had nothing to do with my motivation and my interest in this course.

Q4: These kits are suitable for my Control/Automation learning process.

Q5: I recommend the implementation of these kits and activities, in the next school year, as a teaching/learning tool.

Figure 5 illustrates the average value obtained for each analyzed item. The average evaluation was positive (higher than 3) for all the consider items, except for the Q3 item. However, since this sentence was placed in a negative mode, so being less than 3 is a positive perspective.

In order to measure how students perceive the three didactics kits as a tool in their technical skills development in Digital Control and Automation subjects, they were asked to rate a set of five sentences, on a scale of 1 to 5 (the highest value corresponds to a greater effectiveness). The analysis was focused on the average value obtained for the 5 sentences: The implementation of the remote experience:

Q6: has increased understanding of the operation of an on-off controller.

Q7: has increased understanding of the operation of the PID controller.

Q8: allow the visualization of the effect of the off-set reduced when going from a controller P to PI.

Q9: motivated to learn the subjects under study.

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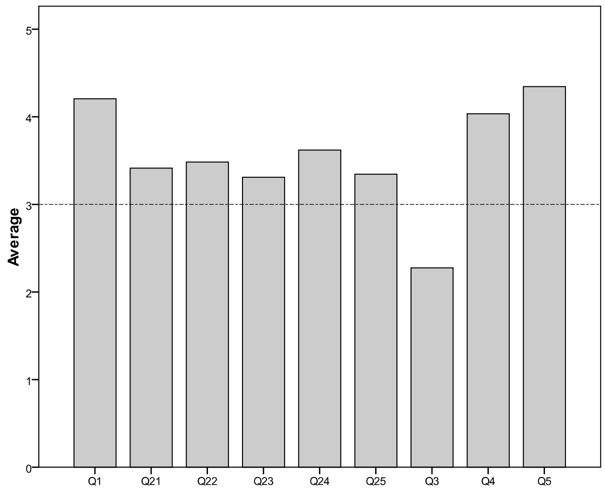


Fig. 5. Average evaluation for the didactics kits students' motivation, for each question.

Q10: in practice the problem of derivative actions in cases with noise.

Figure 6 illustrates the average value obtained for each sentence and for each of the three didactics kits. The average evaluation was different according to the didactic kit tested. It must be pointed out that an average answer lower than 3 does not mean a negative perception, but it means that the student is aware that, for a particular didactic kit, the skill was not achieved (or not applicable to that particular case).

Finally, the students were asked about some soft skills learned from this remote experience, in accordance with the level of agreement: 1 – strongly disagree, 2 – disagree, 3 – undefined opinion, 4 – agree, 5 – completely agree. The student chooses only one option in each item. The analysis was focused on the average value obtained for the 5 items considered as the following:

Q11: to encourage collaborative work.

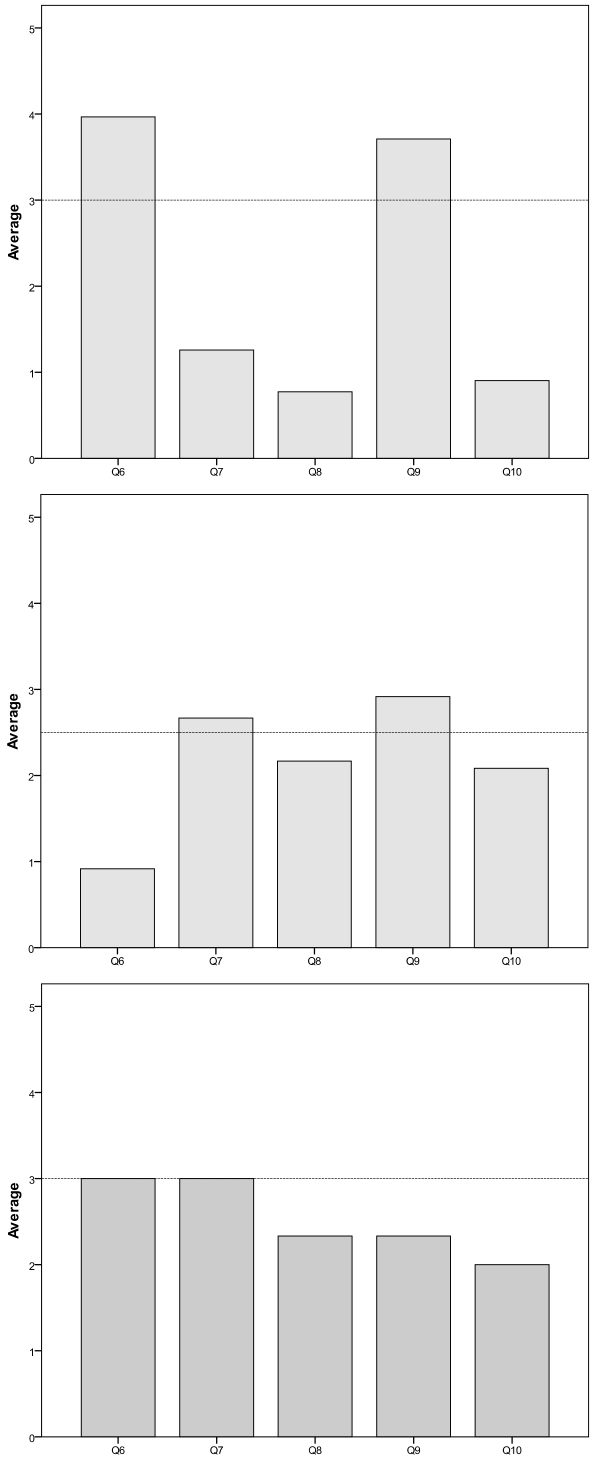
Q12: to stimulate my intellectual curiosity.

Q13: to provide knowledge to my field of study.

Q14: by linking the subject of Digital Control or Automation with others subjects studied.

Q15: The implementation of these experiences increased my expectation of the near future; I will be building new teaching kits.

Figure 7 illustrates the average value obtained for each analyzed item. The average evaluation was positive (higher than 3) for all the consider items, transmitting a positive opinion towards the development and use of remote laboratories to promote the learning process.



(a)

(b)

(c)

Fig. 6. Average evaluation for didactics kits students' didactics kits technical skills (a) SIH, (b) VCDVM, (c) TCC.

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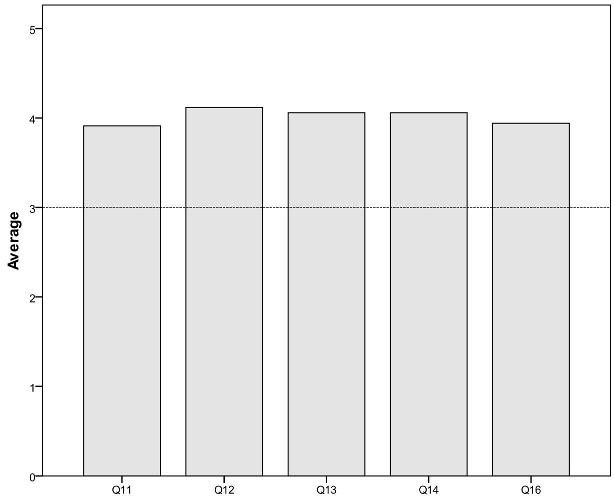

Fig. 7. Soft skills average evaluation of Digital Control and Automation learning process.

IV. Conclusion

Considering the remote experience evaluation, the students fulfilled all the initial requests. The students' relationship establishment between the theoretical and practical concerns of the Automation and Control subjects was highly improved. The learning by experience engages components from the doing and the thinking. All the developed kits can be used by other students as a demonstrative tool in Automation and Control classes.

By using basic statistical concepts, it was possible to understand how students understand the use of new teaching/learning methodologies in the Control and Automation areas.

The developed three didactic kits were introduced as a learning tool in the Digital Control course on the 3rd year of the Industrial Electronics Engineering undergraduate course and in the Process Control course on the 2nd Industrial Informatics undergraduate course. The students' degree of concordance concerning their motivation in using the didactics kits as an appropriate tool on their Control and Automation learning process was very positive and must be continued. To follow the students' opinion, it is authors' believe to carry on this methodology implementing new kits developed by students for students.

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