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Improving student interest with portable laboratory tools in engineering

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Abstract
The desire for improving student motivation and interest in engineering learning have yielded new methodologies for active learning. The present paper presents a new methodology based on project learning and portable learning technology. The goal of the method was to improve the students' confidence and learning in industrial design and prototyping during one semester. The results indicate that students' motivation for learning was very high and it has been maintained during the whole semester. Also, the confidence on their learning and retention ability increased, which indicates that the method had a positive impact on the students.

Keywords: *student motivation, portable laboratory technology, project based learning, confidence, retention.*

1. Introduction

Over the last decades, the University educational methodology in industrial electronics has become more focused on the student motivation and engagement. Most of the subjects in the degree introduced laboratories that are focused on real applications. For example, students from industrial engineering or biotechnology degrees are using in the Graphic Engineering course tools such as 3D modelling, assembling and simulation of mechanic devices as well as biotechnology devices. The idea of the subject is to improve student 3D vision and sketching, as well as to increase their interest so that they perceive the importance of sketching and modelling and graphic engineering not just pure theoretical subjects in the first course of the degree, but as subjects that are important in the everyday

life. Understanding correctly the 3D modelling is important for a correct dynamic simulation as well as for achieving a correct device functionality.

Courses on microcontrollers, circuits, etc… in engineering are usually more interesting for students because they introduce equipment and devices, with which the students can practice directly with the laboratory electronics. Indeed, many universities, introduced in their laboratories small laboratory electronics like Raspberry Pi (Raspberry Pi), Arduino (Arduino), FPGA, etc. These devices are introduced so that the students can learn how to design and build circuits in a simple way. The dimensions of these electronic components and their low price enable the students to build their own devices and practice at home. (Berlung), in his research about the introduction of portable computers in the master"s degree program in Information Technology course, mentioned that an important skill for students is to interact with the computer in any place and to perceive its potential, benefits and limits. The introduction of portable learning tools in the industrial engineering program increases the student confidence and performance. This methodology helps students to improve their knowledges at home in a pleasant and relaxing environment, where they can practice, as much as they need, instead of only few hours in the university laboratory (Carlson). The purposed method also motivates students to attend more to the laboratory sessions, as well as to develop small projects with the information they acquired during the laboratory sessions. In some laboratory sessions, students are not able to develop their practice during the set time. With the portable learning tools, students may easily continue with the work at home or any place, individually or accompanied by colleagues and friends.

Another motivation for using portable laboratory tools is the practical experience (Neville Palmer). Nowadays, the practical experience is relevant when looking for a job. Graduate students usually have good theoretical background and less practical experience. Students learning programming, audio-visual or fine arts, etc… at home are using portable learning tools like: professional computer, camara, paintings, canvas, brushless, etc. Regarding industrial engineering students, the fact of making an electric motor or a whole installations portable is not feasible. To overcome this, laboratory practice can be carried out by using small laboratory tools for simulation, such as raspberry, Arduino or computers with appropriate software. By using these technologies, students are able to practice and learn new engineering tools as 3D modelling, prototyping and simulation.

Finally, the third motivation is the continuous updating of the information (Davis). By using portable learning technology, students and professors may update the information continuously with new methods, models and examples.

2. Case study

The main objective of the presented study is to introduce the portable learning tools in the learning methodology in order to increase students interest and retention.

We will take as reference the example of Berry et al., that introduced Arduino uno Spark Fun Inventor`s Kit in their electrical engineering course.

For the study, six students were selected. All students were studying the Industrial Engineering degree and were coursing the European Project Semester program. All of them were in the third year of their studies. The study was carried out during the Fall semester. The main goal of the students was to develop a simple robotic hand prototype under the supervision of the Professor. Each week a meeting lasting 1-2 hours was carried out together with their supervisors. Students should work every day at least during one hour in the laboratory.

Firstly, the tutor guided the team, by defining the aim and the objectives to be achieved. The timetable of the development was set and the students were encouraged to complete the tasks on time. Each student obtained a special task for the whole semester; it was important to collaborate in the tasks of the other team colleagues during the whole semester. All the hardware and software that was required for the project development was provided by the team tutor.

The team received the kit of components based on Arduino nano, servo motors, step motors, drivers for the steppers, sensors, cables, PLA material and 3D printer, etc. For the development of the prosthetic robotic hand, the team received the files with the phalanges design for the right hand, wires, rubber, and other accessories.

Each week session was based on a clear tutorial focused on one of the needed software and hardware. The lectures were threating topics such as how to program Arduino, 3D modelling with Autodesk Inventor and SolidWorks, how to convert files to STL files and STL files into working files, definition of the research methodologies, definition of the business canvas as well as writing research papers, writing a report, etc.

The „Learning Arduino" course was based on:

- Programming the control of a servo motor by using simple conditions.
- Control several servo motors.
- Control servomotors by using buttons.
- Control servomotors by using flex sensors.
- Control servomotors with EMG sensors.
- Control step motors.

- Defining the time actuation of each finger.

Learning prototyping with Autodesk Inventor and SolidWorks was dealing with the following topics:

- 3D modelling of the prosthetic hand structure
- 3D modelling of the electronics
- Virtual assembling
- Movement simulation

On the other hand, „Prototype assembling" comprised:

- Material selection
- Study of the material characteristics
- 3D printing
- Electronics assembling

Finally, „Reporting" included:

- The use of scientific bibliography search engines as Google Scholar, IEEE Xplore, etc.
- How to search correct papers.
- How to extract information for reports.
- How to write a scientific paper.
- How to write the final working report.
- How to develop the business canvas.
- How to calculate the correct power and electronics. Physic characteristics, etc..
- How to calculate the project costs, etc.
- How to develop the elevator pitch.
- How to realize the power point presentation for the Mid Term Presentation, and Final Presentation.
- How to realize the project video.

The methodology of the course was developed in the following steps:

- Based on the project aims, the tasks were defined in the first session. For the project tasks definition, some creative techniques such as brainstorming technique, Galery Technique, etc. were used. The students actively participated in the problem definition. The main activity was to define the technical and esthetical aspects of the prosthetic robotic hand.
- During the first week, the students must redefine the project characteristics that will be finally used and present the ideas on the next session.

- During the first session, students learned how to search relevant scientific papers on development of prosthetic or robotic hands. They learned aspects such as which are the main words to use and which are the important information in one paper.
- Once students had the idea clear and developed a suitable timetable, the rest of information and tutorials were prepared step by step.

3. Results

During the whole semester, the students were evaluated by the supervisor by means of questions and results about the work. Every week, students explained during 15 -20 minutes the work that they had done during the week. Questions like: Was it hard or easy to find a solution? How do you think to solve this task? Wera sked to the students. After discussing 10-15 minutes with students, the supervisor obtained a clear image of each student‟s work, solving questions such as who dedicated most time to the project, who did each task, who is the team leader, etc..

The main factors for the evaluation were the student interest, motivation and retention.

Regarding on the project interest, 100% of the answers were positive. To the question “From 0 to 10 which is your interest on the project,” the answer was 100% on 10. The main motivation of the project development was the final usage of it. The idea of developing devices for helping disabled people was the main motivation.

One of the positive aspects on the motivation was the level of development. The supervisor allowed them to define the level of complexity of the project development, i.e., from using simple software up to develop automatic prosthetic hand. The method allowed students to define their limits of knowledge.

The final motivation mark of the team is 9,9. They demonstrated a high level of self-efficacy, self-regulation and positive attitude during the whole semester.

The satisfaction received was 9,8 out of 10. To the question “Would like to repeat the experience?” the answer was YES.

4. Conclussions

In the present paper the usage of the portable learning tools and project-based learning is proposed to increase student motivation, confidence and retention. The weekly sessions

provided range from Arduino programming to 3D modelling, assembling, simulation, prototyping, scientific paper writing, decision making, how to do best presentations and videos, how to develop the business canvas, etc.

Results demonstrated that students were very motivated on the project development and the motivation was maintained up to the end of the semester. The learning methodology had positive impact on the students.

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