Enhancing Student Engagement in a Measurement and Control Laboratory Course: Design Strategies and Implementation

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Abstract The paper presents considerations for designing the *Measurement and Control Laboratory* course taught at the Faculty of Physics and Astronomy at the University of Wroclaw, aimed at experimental physics students and students of Applied Computer Science and Measurement Systems. Both course content and hardware solutions as well as choice of teaching methods are considered. The design of the course has been the subject of evaluation by the participants of the course. Further changes were proposed on this basis, taking into account the observations of the lecturers.

Introduction

The Faculty of Physics and Astronomy at the University of Wroclaw offers education in Physics, Astronomy and Applied Computer Science and Measurement Systems. The study plan for students in the Applied Computer Science and Measurement Systems and Experimental Physics (graduate studies) includes classes on measurement and the control process.

The course used to follow a traditional format: students received precise instructions, performed tasks in class, and then wrote reports. However, students showed limited engagement and struggled with drawing conclusions, especially with tasks requiring applying knowledge in new contexts. The question we ask in this paper is how can we design courses to get students engaged? To address this, proposed changes aimed to increase involvement and problem-solving skills. The paper outlines these changes and evaluates their implementation in a pilot course.

Literature research and theoretical background

The Arduino [1] platform is frequently used in education, including physics [2] and other subjects, as a convenient tool especially in a field of measuring and control [3]. It also enables the creation of more complex projects, providing ample opportunities for independent student work. Project-based and inquiry-based learning are efficient teaching strategies for learning new topics and strengthening student involvement [4], which is crucial for creating effective courses [5].

Methodology

A measurement and control laboratory course consisting of 45 hours (3 hours for 15 weeks) was implemented from February to June 2023. The course was attended by 48 students.

The first major alteration was the choice of platform and technical solutions to implement the course, especially to enable and support independent work of students. It was decided to use the open source electronic prototyping platform Arduino.

The second important aspect was modification of course outline. In connection with the planned changes, students were asked to fill out a pre-course survey about their previous courses and their knowledge and experience with microcontroller programming. The survey also included a question about their willingness to take the course in the form of a project.

The survey was completed by 33 from 48 students. Based on the information in the questionnaire, the students were divided into 6 groups of 8 students each. One group consisted of students who took the course entirely as a project. The other 5 groups had laboratory classes combined with a mini project. Students who carried out the activity in the form of a project could work independently or in a group of up to 4 people. They independently proposed the topic of the project and the method of implementation. However, they were obliged to consult with the teacher.

For the other 5 groups, the course consisted of two main phases: lab work and mini-project. During the lab phase, students worked in pairs to learn Arduino-related concepts and documented their learning in portfolios. The mini-project stage allowed students to choose a topic and receive guidance from teachers as they planned, executed, and reported on their projects. They had the freedom to work during scheduled classes or on their own time, using lab facilities and consulting with faculty.

The final stage involved presenting the projects through mini-poster sessions and demonstrations to faculty and peers. A committee selected the best project and an audience award was given. There was also a voluntary evaluation questionnaire at the end of the course.

Results

A pre-course survey was conducted to gather information about the students' technical knowledge and skills, familiarity with the Arduino platform, and their interest in implementing a project instead of traditional laboratory classes. Out of the 48 students enrolled in the course, 33 completed the survey. Surprisingly, only 6 students expressed a desire to implement the course in this format and provided their own equipment resources. The remaining students chose to take the course in the traditional laboratory format.

Teachers observed that the students in the laboratory group seemed committed to their tasks and projects. When it came to working strategies, some students only worked during class time, some preferred to work at home, and a significant number worked both inside and outside of class. There were also differences in the way students formulated their topics, with most being able to choose independently while others needed a predetermined topic from a provided list.

Conclusions

Overall, the course provided students with practical experience, independence in their projects, and the opportunity to showcase their work. The satisfaction of completing a project was also a significant benefit. The pilot course implementation and analysis showed that the adopted form was effective in increasing student participation and motivation. The project presentation part was incredibly rewarding for the students. Changes for future editions include a self-development task and better transition between laboratory and project phases. Collaboration among teachers and experts was key in creating successful pilot activities.

References

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