ENGINEERING PHYSICS LABORATORY

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Abstract
A common problem in engineering education at the universities of applied sciences is that mathematics and particularly physics are considered among students to be only supporting subjects. Furthermore, some of the students have as a background vocational studies where the focus is on practical work leaving more theoretical subjects with less attention. Therefore, a number of our students finds physics difficult which in conjunction with a low level of motivation and interest to study these subjects is a real problem. In this paper we present an attempt to increase the motivation level for a mixed group of engineering students within a laboratory course in physics. Traditionally, our physics laboratory exercises consist of a number well defined task. The students are supposed to complete all measurements according to the given instruction and report their results in a written report. In this attempt to increase the student activity in the laboratory a larger design-build problem is replacing a number of traditional exercises. As a result of this change an increase of activity in the laboratory could be observed. Unfortunately the actual physics learning outcomes involved in the design-build project were not achieved or then the learning outcomes were placed too high.

Keywords: design-build, physics, laboratory, exercise

Introduction

General

The number of applicants to degree programs in Information Technology and Civil Engineering programs at Finnish universities of applied sciences are relatively low. In 2007 there were only about 2.1 applicants for each position and about 250 positions were not occupied by students [1]. These numbers are also representative for Turku University of Applied Sciences (TUAS) with the exception that all places are usually filled.

The applicants initial education is both vocational upper secondary schooling and general upper secondary schooling. The latter one is more theoretical but the students can choose between an extended or a short curriculum in mathematics. They may also choose to read physics or not to read physics. Raija Tuohi et al. [2] did study the initial knowledge of engineering students from 1999 to 2003. In this study they also recognized the school background and found that 66.4 % had a general upper secondary school backgound and 39.9 % of these had passed the extended mathematics curriculum. This leaves more than the one half of the students with a shorter curriculum in mathematics or with a vocational background. Furthermore, the differences in educational background also increases the differences in studying techniques. According to the study by Tuohi et al., 27 % of the admitted students had an other alternative as their first choise position [3] a fact that also affects the motivation level. This variety of backgrounds is a demanding starting point both for the students and teachers.

Physics laboratory exercises at Turku University of Applied Sciences

Traditionally physics laboratory exercises at TUAS are implemented so that the student group is split into subgroups of 2 – 4 students. The course starts with a lecture about laboratory safety and one common laboratory task. Even though the task is common every student reports the results individually. After this, every subgroup has their own task but the subgroup writes one report in common. The tasks rotate between the subgroups so that every group solves every task, see Table 1.

Table 1: The figure shows the rotation of tasks between sub groups. The date for the task are shown for each group.

	Physics Laboratory 240SXX Group 2	Basic Measurement; Multimeter	Theory	Atomic spectra	Theory	The temperature dependence of a thermistor	Theory	Young's modulus; Elasticity in le	Theory	Nuclear safety	Theory	Oscilloscope
Subgroup	Name	13.9.	20.9.	27.9.	4.10.	11.10.	18.10.	1.11.	8.11.	15.11.	22.11.	29.11.
1	Student 1											
1	Student 2											
1	Student 3											
1	Student 4											
2	Student 5		22.11.	29.11.	20.9.	27.9.	4.10.	11.10.	18.10.	1.11.	8.11.	15.11.
2	Student 6											
2	Student 7											
2	Student 8											
3	Student 9		8.11.	15.11.	22.11.	29.11.	20.9.	27.9.	4.10.	11.10.	18.10.	1.11.
3	Student 10											
3	Student 11											
3	Student 12											
4	Student 13		18.10.	1.11.	8.11.	15.11.	22.11.	29.11.	20.9.	27.9.	4.10.	11.10.
4	Student 14											
4	Student 15											
4	Student 16											
5	Student 17		4.10.	11.10.	18.10.	1.11.	8.11.	15.11.	22.11.	29.11.	20.9.	27.11.
5	Student 18											
5	Student 19											
5	Student 20											

The required measurements are thoroughly described in the laboratory instruction booklet [4]. The group does the measurements and records all measurement results. In some cases, there is time to start the work on the report during the laboratory session but usually there is some work to be done out side the scheduled time. The assessment of the course is based on the work during the sessions, the quality of the report and a final exam. The final exam involves a practical part and a theoretical part. The learning outcomes in the traditional laboratory course are that the student should be able to do accurate measurements and report results.

Case study: The physics laboratory at the Salo unit

Background

The engineering unit located at the Salo campus is small compared to the engineering units located at the Turku campus. This makes it a suitable environment for testing new methods without putting students in an unequal position. An other fact that made this student group an interesting target group was that it was inhomogeneous and big differences in motivation was to be expected.

The goal for this study was to see if a short design-build project can be used to increase the student activity and thus increase the students possibility to reach the defined learning outcomes.

This implementation of the laboratory course was a combination of a traditional course and a design-build project. Exercises from the fields of optics and electricity were adopted from a traditional course where as mechanics exercises were replaced with a design build-project. The subject for the design build project was chosen to fulfill the criteria cheap and already tested. A "spaghetti bridge building contest" fulfilled both criteria. Similar design-build projects have been used at several different universities Johns Hopkins University [5]. The learning outcomes from the traditional laboratory course were adopted but modified by adding measurement design and strength estimation to suit this implementation.

The structure of the design-build project

The design build project covered the last 4 weeks of the laboratory course. The laboratory was reserved for the group 2 times 3.5 hours per week but they also had access to it during other times. The topic the first session the project was to introduces the project. Furthermore, the students were supposed to agree on how the strength of the bridge should be measured, i.e. design the measurement, and also agree on other rules for the competition e.g. should the deck of the bridge be solid. A short introduction to strength calculations was included. The rest of the laboratory sessions were used for building the bridge, short reporting sessions and the final testing. A brief report on the chosen design of the bridge was given the second week and a report on the strength estimate was given the third week. A final report was planned to close up the project.

The student group

In this implementation a group of 10 civil engineering and 10 information technology students participated. The civil engineering students were second year students where as the the information technology students were third year students. Both groups have had theory based physics courses during their first and second years at TUAS. Thus the information technology group was expected to have a slightly broader view on physics. They had also been found to slightly more actively participate in the education.

The implementation

The task to agree upon the rules and design the measurement system was surprisingly difficult for the students. Especially the design of the measurement caused a lot of problems and in fact it was partly postponed. The final set of rules was:

- Two identical bridges should be built using a maximum of 2 kg spaghetti and two tubes of glue (provided by the teachers).
- The minimum bridge-span should be 50 cm and the maximum width 10 cm.
- The bridge should have a solid deck.
- The strength of the bridge should be measured at the middle of the bridge using weights attached to a 1 cm wide and at least 11 cm long metallic plate.
- The bridge with the highest strength/cost ratio would win. The cost should be determined from the total amount of used material, including the waste.

The design and build phase did proceed as expected. All groups started to work and a clear increase in motivation could be observed. But a clear difference in attitude towards the task was also evident. The groups from the civil engineering side showed less interest in the design phase. Most of the groups did some kind of planning of the bridge. Two groups did use computerbased design tools in their planning. None of the groups were able to do strength calculations and even the estimates were quite poor.

The idea that all groups should build two bridges was also too optimistic, only three groups completed both bridges and only one group produced two almost identical bridges. However, all groups built at least one bridge. One problem that caused some delay was that stored parts of the bridges in some cases were deformed probably, due to changes in air humidity.

The lack of planning resulted in two too short bridges. Another planning mistake was that four groups used a design that did not allow usage of the planned measurement system. The measurement system was redesigned and all bridges could be tested.

Due to lack of time the assessment requirements were also changed so that the two first reports was given orally. The final report was also changed to a part of the final exam.

Conclusion

The design-build project clearly increased the motivation and thus the student activity. Some student groups did even work outside the scheduled times. The course was a success in this respect but it did not meet the learning outcomes when it come to the strength estimation. The main reasons for this were probably the negative attitudes toward mathematical problem solving and the low knowledge level. The lack of time, which forced changes into the planned reporting practice, did not improve the situation.

However, this kind of exercises can be a useful but it requires a more thorough planning and the plan has to be followed more strictly. The next attempt is to create one larger laboratory exercise in the field of electricity and magnetism as well as improve the mechanics exercise of the course.

References

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