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Experimental examination in electric power technology

Abstract

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Examination in undergraduate physics courses at Uppsala University is by tradition almost exclusively written tests, targeting theoretical skills. This is true also for the relatively new engineering programmes (högskoleingenjörsprogrammen), in spite of them being intended as more practically oriented.

During the last few years, we have worked on making the laboratory tutorial exercises in the course Electric power technology (Elkraftteknik) 3p, machine engineering, more problem-oriented. We have reduced the instructions to a minimum; what is left is only a short description of the problem. Instead, we require the students to plan and steer their activities. Our judgement is that this method has become a success. The students enjoy this approach, they take much more responsibility than before, and their learning has benefited significantly.

These experiences have inspired us to try a laboratory exercise also as part of the examination. The actual task to perform is to find out the circuit solution in a closed box. We use a number of different circuits with a few colour-marked contacts. Students can select the level of difficulty themselves. At the beginning of the test, they are given some information on the content in the black box. If they are unable to solve the problem they can get more information, making the problem less difficult, at the expense of getting less credit for its solution.

At present (autumn 2000), we have used this examination for the first time, and evaluated it by interviews-in-depth. In general, the students are very positive to the idea as such. All critique, however not fierce, is on details in the practical execution. A second round will be carried out during spring 2001, with modifications based on the first-year experiences.

Publications up to now within this and related work:
J. Blomgren, The car approach to electromagnetism, Phys. Educ. vol. 33 (4) (1998) 224.
J. Blomgren, C. Johansson, J. Klug, Laborationer utan instruktion = pedagogik ?, (Laboratory tutorials without instructions = teaching ?), Conference on

quality and development work at universities and colleges, Eskilstuna, January 11-13, 2000. Published at http://www.hsv.se/. (in Swedish)

Experimental examination in electric power technology

Final report of HSV project 001/99

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Summary

Laboratory work has long been a large part of undergraduate studies in physics at Uppsala university. In spite of this, it has rarely ever been part of the examination. In the present project, we have tried to develop methods for practical examination in a course on electric power technology. The actual task for the students has been hidden electric circuits, which they are asked to disentangle the properties of by measurements.

In general, the students are positive to this type of examination. Essentially all of them appreciate the idea as such. The little criticism there is has been focused on practical aspects in how the examination has been carried out. This form of examination is now a standard feature of the present course.

1. Introduction

Examination in undergraduate physics courses at Uppsala university is by tradition almost exclusively written tests, targeting theoretical kills. This is true also for the relatively new engineering programs (högskoleingenjörsprogrammen), in spite of them being intended to be more practically oriented.

During the last few years, we have worked on making the laboratory tutorial exercises in the course Electric power technology (Elkraftteknik) 3p, machine engineering, more problem-oriented. We have reduced the instructions to a minimum; what is left is only a short description of the problem. Instead, we demand that the students to plan and steer their activities. Our judgement is that this method has become a success. The students enjoy this approach, they take much more responsibility than before, and their learning has benefited significantly. These experiences have inspired us to try a laboratory exercise also as part of the examination.

Funds for the development of methods for experimental examination have been granted by the National Agency for Higher Education through its Council for Renewal of Higher Education, project 001/99, during 2000-07-01 to 2001-06-30. This report describes the final results of the project, and the economic aspects of it. This project, and work preceding it, have recently been extensively described in a report for the Uppsala university Development and Evaluation Unit (in Swedish) [1]. This report is enclosed in manuscript form. In addition, a short description of the present project will be presented at the Conference on quality and development work at universities and colleges, Norrköping, September 25-27, 2001 [2]. We refer to these reports for detailed information.

2. Background - Previous development of laboratory teaching

A majority of the tutorial exercises in undergraduate physics studies at Uppsala university have very detailed instructions. The students are thoroughly guided down to the point where almost each turn of a knob is explicitly given. There are boxes where the results should be filled in, and prepared diagrams to plot. Often these tasks are undertaken under time pressure, which makes it virtually impossible to do anything but follow the instructions.

My own experiences from my student time tells me this is not a good learning environment. The exercises which were most beneficial were the ones with the largest amount of freedom in the actual work. This has motivated us to develop a different laboratory methodology [3].

The instructions have been reduce to a minimum. They describe a problem, but not how to solve it. The students are required to be well prepared; they have to present a plan for their work when they arrive to the laboratory. This plan is discussed with the assistants in

the laboratory. It does not have to be "correct", but they must at least have an idea what they want to do.

A very important prerequisite for this method to be successful is plenty of time. The students should not have to work under pressure. Instead, they should have the opportunity to try different solutions, make mistakes or try unfruitful routes, discover this was not very useful, learn from this and still have time to come to a successful solution. Finally, the laboratory has to be well equipped. There should be many different kinds of measuring devices and ancillary equipment. The material should not be so sparse that only one way of dealing with the problem is possible.

The students have given very positive feedback on these changes. It is also evident that they understand much more of the concepts illustrated by the exercises, and they have acquired better practical skills.

3. Examination by laboratory exercises

3.1 General considerations

The successful implementation of new methodology in the laboratory exercises has motivated us to develop these concepts further.

We did not have the ambition to make the entire examination practical. We believe both theory and practical aspects should be tested, and therefore we did not seek to replace theoretical examination with a practical one. Our model is 40 % weight on the laboratory work and 60 % on a written exam. The written exam consists of two parts, where one is on similar issues as the practical test. This part is intended for students who failed the practical test, or were unable to attend it. The remaining fraction of the written exam is on theory, i.e. rather similar to the traditional tests.

3.2 The actual examination

The actual task to perform is to find out the circuit solution in a closed box ("black box"). We use four different circuits with a few colour-marked contacts. Students can select the level of difficulty themselves. At the beginning of the test, they are given some information on the content in the black box. If they are unable to solve the problem they can get more information, making the problem less difficult, on the expense of getting less credit for its solution.

A useful sideeffect of this approach is that the same units can be used also for other courses. The problem can be made anywhere from very easy to very difficult, depending on which information is given. This also makes it possible to vary the problems for the future. Having a set of boxes like this means that it is a question of time until lists circulate on the black market with solutions for different unit numbers. We have prepared them for easy change of identity and circuit content.

Each student gets three hours for the examination, and up to 16 students can be present in the laboratory simultaneously. The work is individual, and no communication between the students is allowed. Students can discuss problems with the teacher, and in addition an assistant is present for practical matters, like replacing batteries in the equipment.

All students take the test the same day. The result is announced after the last group has completed their work. The experimental examination takes place a few days before the theoretical one. Thus, the students know before the standard theory test the result of the practical examination, and they can choose whether or not to take the practically oriented exercises in the written test.

The first year there was no practical re-examination. The students strongly suggested practical re-examination to be used. This is now also the case. It was tested recently with the second-year students, with good results.

3.3 Evaluation

We evaluated the result by interviews after the first season of laboratory examination (i.e. during 2000). Our opinion is that our project is most interesting as a practical development work, more than as cognitive research, and therefore the evaluation should be formative. We wanted an evaluation helping us to find out whether to continue along the chosen lines, and if so, how to proceed.

This also meant that it was more important to get the true opinions and experiences of the students as guidelines for the future, rather than getting a suitable statistical material for quantitative treatment. Thus, we evaluated the results by interviewing a number of students in depth. The students were be selected based on their results (some with top score, some failing, some average), gender (we have noticed gender differences in the appreciation of the other teaching development work in this course) and age (most students are 19-21 years old, but a minor group is substantially older).

The general experience of the whole course was varied. Almost all thought the course would be useful for the future. Both lectures and laborations were highly appreciated. A majority ranked it as enjoying and nobody deemed it boring or bad, but most of them thought it was demanding.

All students thought the idea of practical examination is good, irrespective of their own performance. Also, they concluded that this form of examination was better from learning point of view. Most of them learned new things during the test, while only a single student indicated that the written exam resulted in new knowledge.

A simpler evaluation was undertaken after the second season, and this evaluation essentially corroborated the impressions from the first.

3.4 Similar projects elsewhere

We have searched for similar projects in Sweden and have found six examples in physics and pharmacy. These are described in some detail in a separate report (in Swedish) [1].

References

[1] J. Blomgren, Laborationer – inte bara nödvändigt ont?, Uppsala university Development and Evaluation Unit report, 2001. (in Swedish)

[2] J. Blomgren, H. Henriksson, A. Hjalmarsson, J. Klug, M. Weiszflog, Laborativ examination – går det?, Conference on quality and development work at universities and colleges, Norrköping 25-27, 2001. To be published at http://www.hsv.se/. (in Swedish)

[3 J. Blomgren, C. Johansson, J. Klug, Laborationer utan instruktion = pedagogik ?, (Laboratory tutorials without instructions = teaching ?), Conference on quality and development work at universities and colleges, Eskilstuna, January 11-13, 2000. Published at http://www.hsv.se/. (in Swedish)