

The Formal Modeling of Physics in the First Course of Physics at University Level

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Abstract

Phenomena of physics can be described with different methods including concepts and also experimental and formal presentations. These methods are applied to teaching different ways at different school levels. One of the aims in the physics teaching at the university level is to teach students to form the formal models of physics. The formal modeling of physics is a problem that, that influences learning throughout the physics studies at university. This study has focused on how the students experience the formal modeling of physics in the first course of physics at the university level. Association between mathematics and physics are united to the difficult and useful formal modeling in physics from the view of the students.

Introduction

Students who start the physics studies at university have usually passed a wide syllabus in physics and mathematics at secondary school in Finland. So the students should have good readiness to study physics at university, but yet a great number of students have problems in the first course of university physics (Physics 1 course). These problems show in the failing percent of the Physics 1 course at the University of Turku which was 27 % in the year 2001 and 21 % in the year 2002. The reason for the weak success can be associated with earlier school success, motivation, metacognitive learning strategies of students and combination of previous [1].

The way to approach phenomena of physics in the Physics 1 course differs from secondary school. Formal modeling is the new way to examine the phenomena of physics. The formal modeling means that phenomena of physics are described with formulas of physics including derivation of formulas and explaining connections between formulas and theory of the phenomena. One hypothesis is that difficulty in understanding the formal modeling is one of the reasons for the weak success of the Physics 1 course. This study has focused on how the students experience the formal modeling in the Physics 1 course.

2 Method

2.1 Subjects

Thirty-three students from the Physics 2 course took part this study at spring 2004. The main part of these students passed the Physics 1 course last semester and the rest of the students in the autumn 2002. Only little over half of students of the course were at the place and took part in the questionnaire. Also eleven mathematics students, which were in the Physics 2 course, took part of this study but their answers were not considered.

2.2 Questionnaire

This study is based on the questionnaire, which was done in one lesson of the Physics 2 course. There were three different parts in the questionnaire. First part included questions about the gap between study physics at the secondary school and study physics in the Physics 1 course. These questions were multiple-choice questions and "line test" in which an opinion was marked zero to four on the line.

The second part of the questionnaire contained questions about formal modeling and using mathematics in the Physics 1 course. Questions consisted of open questions, multiple-choice question and three typical physics problems from the Physics 2 course - mechanical, formal modeling and explanation problem. Students evaluated their own view about difficulty and usefulness from each problem and also wrote the argument to their opinions in these three typical physics problems. The third part included questions about the textbook and demonstrations in the Physics 2 course. These questions were not analyzed in this study.

3 Results

The students' opinions about how different things describes studies at secondary school level or in the Physics 1 course have been showed in Figure 1. The results are average values of the answers. Physics studies at university level can be described by calculations with symbols, mind work when considering phenomena in physics and abstractness of physics. Mechanical calculations describe physics studies at secondary school level.

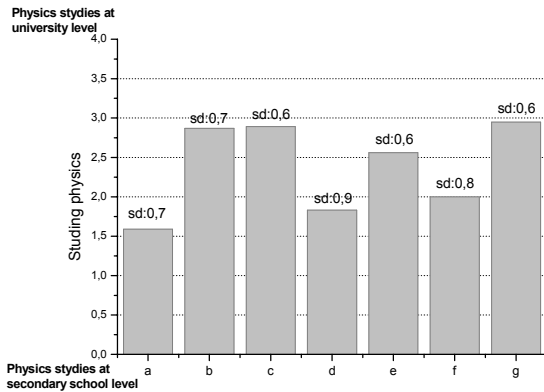


Figure 1. How the different things describe the physics studies at university or at secondary school level. (a) mechanical calculations, (b) calculation with symbols, (c) mind work when considering phenomena in physics, (d) using demonstrations, (e) unity between formulas and phenomena, (f) using formulas and (g) abstractness of physics studies.

More theoretical review of phenomena in physics was needed to reduce the gap between physics studies at secondary school and studies in the Physics 1 course from the view of answers of students. Better knowledge of phenomena of physics and better mathematical skills was also required to reduce the gap. The mechanical calculation skills were experienced to be sufficient after secondary school studies. Naturally the studying physics at university level is more theoretical than at secondary school, so getting smaller the gap between these two levels is important to bring the theoretical review of the formulas to the phenomena of physics to the secondary school.

In the formal modeling part of the questionnaire was asked, why formal modeling has been made in physics? From the answers were observed a few main things:

Formal modeling in physics are made, because

- it gives deeper understanding for the phenomenon of physics;
- it combines the phenomenon of physics and mathematics;
- it combines different phenomena of physics;
- it is a mathematical equipment;
- it simplifies phenomena of physics.

Students seem to know why formal modeling is used but no one did not give direct answers about how for examples formal modeling gives deeper understanding to physics or how it combines mathematics and physics.

In Figure 2. have been presented how difficult different things about formulas in the Physics 1 course were experienced by students. There are no generally used integrals and derivatives in calculus of physics before university level and these seem to be most difficult in things about formulas in the Physics 1 course. Differentiation calculation at the secondary school has

made easier to use mathematical symbols in formulas of physics, which is seen in the answers of student in Fig. 2.

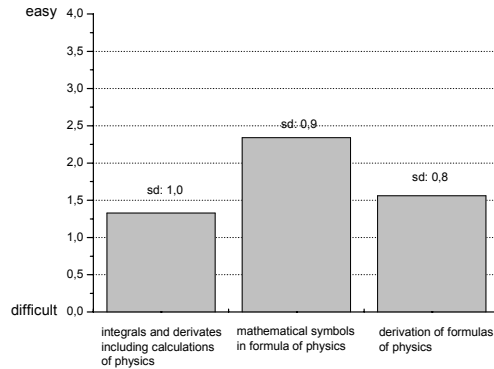


Figure 2. How difficult students experienced different things about formulas in the Physics 1 course?

Students formed their opinion of difficulty and usefulness of three typical problems of physics (mechanical calculation, formal modeling and explanation problems). The formal modeling problems were experienced most difficult and most useful in the Physics 1 course studies. Anyhow, to have to form the formulas by themselves was found problematic, as well as, understanding associations between formulas and phenomena of physics. Obviously, the first is a consequence of the latter. Otherwise, explanation problems were wanted more to teaching because there are so much both mechanical and formal problems in the Physics 1 course. Explanation problems also support conceptual thinking from the view of students. The mechanical calculations were experienced less difficult and useful but their usefulness were noted as a routine problems as a combine the true world situation to the problem of physics.

Conclusions

The formal modeling gives deeper understanding from the phenomena of physics and it is also a combining factor between phenomena of physics and mathematics from the view of students. The formal modeling problems were experienced as difficult and useful at the first course of physics studies although deficiency of concepts also were recognized.

References

[1] ROWELL, J. K. and DAWSON, C. J., First Year University Physics: Who Succeeds? *Research in Science & Technological Education*, 1993, vol. 11, issue 1, p 85-95.