The Role of Mathematics for Physics Teaching and Learning in Upper-secondary school

Andreas REDFORS, Lena HANSSON, Örjan HANSSON and Kristina JUTER

Kristianstad University, SE-291 88, Kristianstad, Sweden

Abstract. The aim of this three-year study is to further contribute to the understanding of how relations between Reality – Theoretical models – Mathematics are communicated in different kinds of instructional situations (lectures, problem solving and labwork) in Swedish upper-secondary physics. A developed analytical framework from the pilot (Hansson, Hansson, Juter & Redfors 2015) is used to focus the analysis of the classroom communication on relations made (by teachers and students) between Reality – Theoretical models – Mathematics. Results from classroom studies during spring 2018 will be reported and discussed at the conference.

1 Introduction

Mathematics is often spoken of as a necessity for physics – e.g. mathematics is the language of physics [1]. In relation to the teaching of physics weak mathematics skills among students is widely discussed since this is viewed as a hindrance for the learning of physics [2]. For example, the TIMSS advance study discusses the decrease in students' mathematics knowledge as an explanation for the decline in Swedish students' results in physics.

The intention and strength of physics is to describe and predict real phenomena by organizing explanations through theories and theoretical models. In the scientific research process empirical and theoretical work is intertwined leading to construction and/or confirmation of theories and theoretical models. The formation of these is an interactive process of discussions, experiments and observations made within the science community. This project uses a semantic view focusing on theoretical models [3], where theoretical models are viewed to form families or classes linking theories with experiments and practices, and where the focus is on the explanatory powers of the theoretical models. The relation between a theoretical model and real world referents and phenomena, is in many ways complex with observations and experiments by necessity embedded in theory and therefore "Theory laden" [4].

The proposed project contributes by introducing a framework that explicitly separates discussions of real phenomena from model-based reasoning in focusing on links made between the entities in figure 1. From this perspective meaning making and explicit discussions of distinctions and relations between theoretical models and reality is central in physics teaching.

Because of the importance of mathematics both in the development and application of physical models and theories, mathematics has an important role in physics teaching and learning. Several studies point to students' problems in transferring mathematical knowledge in modelling of new and applied situations in physics [5].

2 Design and methodology

This project is focusing the normal practice of physics instruction, by the use of video-based classroom observations (lectures, problem-solving sessions and lab-work) and written surveys. The qualitative and partly unconditioned analysis process of the physics lessons was developed in the pilot study [6] based on a model of links between the *reality, theoretical models and mathematics* as depicted in Figure 1. The three sides of the triangle represent possible links between the respective vertices. The analysis is focused on tracing relations

made linking the constituents of the three "worlds" represented by the three vertices of the triangle in the various learning situations.

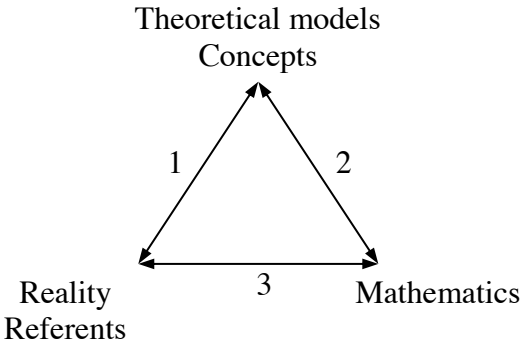

Figure 1. Theoretical models – Reality – Mathematics in physics teaching

We are in the process of contacting teachers who teach both mathematics and physics, striving for a large variation based on the survey about views of 1) the role of the subjects in society and upper-secondary school 2) the nature of physics and mathematics, and 3) the teaching of physics and mathematics. The survey is currently being analysed and results will be presented at the conference.

3 Results

The analytical framework developed in the pilot [6] has been shown to be useful to shed light on the role of mathematics in the practice of an ordinary physics classroom in different instructional settings (lectures, problem solving and labwork). The distribution in time of communicated links between Reality, Theoretical models and Mathematics can be found and analysed. Apart from examining relations made between Reality and Theoretical models, this is also suited for addressing questions about the use of mathematics in physics instruction, and whether the classroom communication "get stuck" in a technical use of mathematics [2, 5, 6]. The analytical framework is used in a renewed and extended data gathering in classrooms, which will be presented at the conference.

4 Conclusion

The proposed focus on teachers with differing views of the overall aim and goals of physics education, the nature of physics, the role of theoretical models and mathematics, will contribute results that not only will constitute significant values to the international research community, but also be a core feature of future professional development of practising teachers.

Acknowledgements

This four-year project is supported by the Swedish Research Council (721-2008-484).

References

[1] Pask, C. (2003) Mathematics and the science of analogies. *American Journal of Physics* 71(6), 526-534.
[2] Uhden, O., Karam, R., Pietrocola, M. & Pospiech, G. (2012). Modelling Mathematical Reasoning in Physics Education. *Science & Education* 21(4), 485–506.
[3] Adúriz-Bravo, A. (2012). A 'Semantic' View of Scientific Models for Science Education. *Science & Education* 22(7), 1593-1611.
[4] Hanson, N. R. (1958). *Patterns of Discovery*. Cambridge: Cambridge University Press.
[5] Kuo, E., Hull, M. M., Gupta, A. & Elby, A. (2013). How Students Blend Conceptual and Formal Mathematical Reasoning in Solving Physics Problems. *Science Education* 97, 32–57.
[6] Hansson, L., Hansson, Ö., Juter, K. & Redfors, A. (2015). Reality – Theoretical Models – Mathematics: A ternary perspective on physics lessons in upper-secondary school. *Science & Education*, 24(5-6), 615-644.