Mathematical Reasoning Requirements to Solve Tasks in Physics Tests

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Introduction

Mathematics and Physics are closely intertwined and mathematical reasoning is assumed to be essential in the work of professional physicists, in addition when learning physics and thus when solving physics tasks. Some of the difficulties students encounter when learning physics likely relate to their use of mathematics and how they reason mathematically (Bing, 2008; Nguyen and Meltzer, 2003). Lithner (2008) discusses how learning difficulties in mathematics can be explained by what kind of mathematical reasoning is used by students. Another assumption is that National tests have an effect on both teaching and learning, not at least in stressing what is covered in the taught curriculum. This on-going study thus investigates the nature of mathematical reasoning needed from a student in Swedish Upper Secondary School, in order to solve physics tasks on Physics tests from the National Test Bank, in cases where mathematical reasoning is applied.

Theoretical framework

The study presented here uses the definition of mathematical reasoning and a framework developed by Lithner (2008). Depending on which mathematical foundation that is used, the framework distinguishes between Creative Mathematically Founded Reasoning (CMR) and Imitative Reasoning (IR). To be CMR there has to be some novelty in the solution and the argument supporting the strategy should be plausible and anchored in intrinsic mathematical properties. If it is enough just to recall an answer and writing it down, or if following an algorithm step by step will give the right answer without any demands of novelty the task is categorised as IR. The research question for the study is *What is the distribution of tasks requiring either Creative mathematically founded reasoning or Imitative reasoning in the Physics tests from the Swedish National Test Bank?*

Method

The distinction described above is in this study used when analysing the kinds of mathematical reasoning required of upper secondary school students in order to solve tasks on ten tests from the Swedish National Test Bank in Physics. The object

of study is the reasoning requirements of an average student and no students with their actual solutions are included. The method for the analysis is earlier used in e.g. Palm, Boesen and Lithner (2011). The tests in the National Test Bank are developed by the Swedish National Agency of Education as an assessment support and most of the material is classified as secret. Of the 36 tests developed so far, ten were randomly chosen and each test comprises approximately 21 tasks. In the analysis both textbooks in mathematics and physics are considered and also a physics handbook, which students are allowed to use during the tests. Physics tasks solvable without using mathematical reasoning, i.e. solutions only including physics facts or mathematical subject areas not covered in the textbooks in mathematics, are categorised as non-mathematical reasoning.

Result and Analysis

A preliminary result indicates that it is necessary to reason mathematically to solve three-fourth of the tasks. Approximately two-fifth of the tasks could be solved with IR and one-third required CMR. Considering the reduction of complexity, to equate the learning history with the textbooks, there could be a larger number of tasks for which it is sufficient with imitative reasoning. As mentioned above, previous studies have shown that imitative reasoning and rote learning can lead to learning difficulties in mathematics. It can then be reasonable to assume that using mathematical reasoning based on surface properties when solving physics tasks also can contribute to learning difficulties of physical concepts.

References

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