Compromise between mathematics and physics in teaching: instructors' views on the role of mathematics in advanced physics courses for teachers

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Abstract. Learning physics is challenging, in part due to its deep connection to mathematics. What part does mathematics play in in-service teacher education? We have studied an MSc program for science teachers in Israel, where advanced physics courses are taught by physicists. One of the program's design principles is that the graduate be in command of mathematics and understand its relevance for physics. Using semi-structured interviews with the instructors, we sought to understand the value they assign to the above principle. Several views emerged, some distinct from the original principle: one, mathematics as providing coherence, two, mathematics as secondary to qualitative understanding, or three, adapting topics to the teachers' abilities.

Introduction

The interplay between physics and mathematics is one of the reasons that make physics teaching and learning so challenging. Already at the secondary school level, Bagno and Eylon (1) showed that most students represent relationships between physical entities in mathematical form, but are not able to employ qualitative representations. The students' approach does not align with experts' reasoning, in which qualitative arguments are common.

Naturally, a physics teacher should learn physics in order to teach it (2). Since mathematics plays a major role in physics, research has focused on several domains pertaining to their interrelation in learning (3). For example, Schwalbach and Dosemagen (4) showed that contextualizing calculus in physics problems deepened secondary school students' semantic and procedural knowledge. Another avenue for research is the compromise between mathematics content versus physics content in advanced physics courses for teachers. Eylon et al. (5) studied how the instructor of a quantum mechanics course for teachers reduced the course's mathematical load, focusing on developing a qualitative "sense of understanding" of quantum mechanical principles. One is then inclined to ask: What determines the ratio of mathematics to physics content in advanced physics courses for secondary teachers?

Methodology

There are several opportunities in Israel for in-service physics teacher professional development (PD): few-hour workshops, professional learning communities, and MSc/PhD degrees in science education. An advanced degree is an opportunity for teachers to deepen their content knowledge, in particular regarding the role that mathematics plays in physics. The Rothschild-Weizmann (RW) Program for Excellence in Science Teaching at the Weizmann Institute of Science (WIS) is an MSc program that combines courses about pedagogy as well as discipline-specific content courses, often going far beyond the knowledge taught at school. The program aims to enhance teachers' confidence and motivation by providing opportunities to advance their knowledge and participate in professional development activities. The curriculum for physics teachers includes advanced courses in classical mechanics, statistical physics, electromagnetism, quantum mechanics, particle physics and astrophysics. Prior to the beginning of their first semester, the students attend an intense two-day workshop focusing on mathematical tools for physics. A mathematics course taught by the same instructor as the workshop continues in parallel throughout the entire first semester. Evidently, a design principle of the RW program is that its graduates be

in command of mathematics and understand its relevance for physics. How the program's different instructors perceive the principle will likely affect their teaching. The research question we set to study therefore is: **What value do the instructors assign to the design principle mentioned above, and how does it manifest itself in their teaching?** The qualitative study involves semi-structured interviews with physics instructors in the RW program, who have recently taught them at least twice. Interviews are transcribed and independently coded by two members of the research team, reaching consensus by discussion. As a former teaching assistant, the first author has a previous acquaintance with the program.

Preliminary Results and outlook

So far we have interviewed three instructors. Our preliminary results indicate that several profiles emerge: one who wishes to convey a coherent picture of physics based on differential equations, contrary to the segmented secondary school curriculum,

> *"I wanted to reach Maxwell's equations, so they (the teachers) see how all of these…things, that in school are completely separate…you talk about… electrostatics in the beginning, and about magnetic fields at the end, how the entire picture looks."*

A second profile emphasizes physical reasoning over mathematics, because such qualitative reasoning can reach the classroom:

> *"I stop myself from dealing with the mathematical formalism…I find it important that they demonstrate…that conceptual understanding…because it has a chance of passing on to their students. The formulas have no chance."*

A third profile assigns value to physics knowledge, offering an alternative design principle; choosing subjects according to the teachers' level of mathematics:

> *"There are enough subjects (to choose to teach)… if the difficulty is mathematics, then (I will choose) those that require less mathematics… There is so much to know… there's a lot of value in that (knowledge)… (I learned to) avoid things that are too abstract or mathematical."*

The instructors' personalities and teaching experience affect their view on the centrality of mathematics in physics teaching. Interestingly, our results have uncovered a gap between the program's intended purpose and the way in which its instructors interpret it in their teaching.

References

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