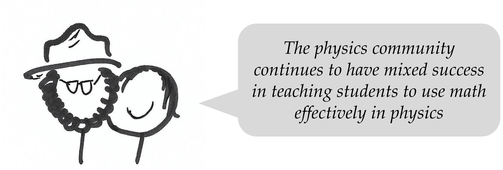
Pre-service teachers' views on the role of mathematics in the teaching and learning of physics

Introduction

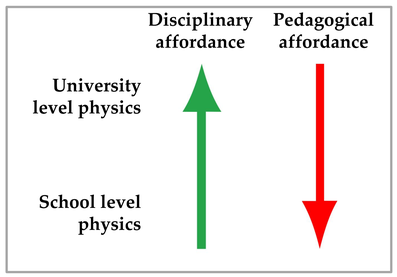
Mathematics is commonly seen as playing a fundamental role in the understanding of undergraduate physics. Being good at mathematics is a strong indicator of success in physics. But there is a problem, as Redish and Kuo explain [1].



For the pre-service physics teacher, this complex and confusing area is further complicated by the shift from university to school level physics.

Theoretical Perspective

Mathematics in undergraduate physics uses multiple representations (e.g. graphs, equations). Each has a **disciplinary affordance** - the agreed meaning making functions it provides for the discipline; and a **pedagogical affordance** - its aptness for teaching in a particular educational context. Often there is an inverse relationship between these two [2].



Pre-service teachers have to negotiate between the tools and resources used to *do* physics and those best suited to help others *learn* physics.

Research Question

How do pre-service teachers perceive the role that mathematics plays in the learning of physics at university and school level?

Method

Entire cohort (n=13) of pre-service physics teachers training on a one year postgraduate course at an English university. Two questionnaires during year and interview at end, reflecting on views.

Findings: The dominant narratives

Views on the role of mathematics in the study of physics at university

The necessity of mathematics to be successful in undergraduate physics

For the first two years it's essentially just the maths stuff. So, they drill you, drill you before you get to the actual physics side of things.

There can be a disconnect between the physics and the mathematics

Sometimes I felt like I couldn't connect what we learned in maths lectures to what we'd learned in other physics modules ... I couldn't connect the two.

Success in mathematics can mask a lack of conceptual understanding in physics

Everybody on the course gets 'good' at maths, not everyone gets good at the physics.

Views on the role of mathematics in the study of physics at school

A focus on conceptual understanding be should be emphasised

I'm more interested in them explaining to me how things happen and why. And explaining the concepts behind it, rather than getting the right numbers.

Many students had limited levels of mathematical competence

Rearranging equations, even if it's quite simple, they'll often fall down.

The teachers had to provide extra support for the mathematical demands

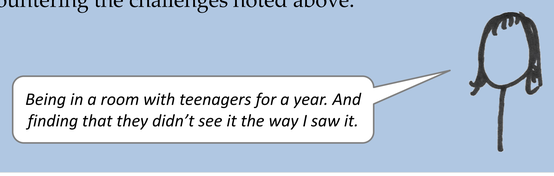
Graphs, I did a lot of stuff with graphs... because they cannot seem to do graphs.

A tension between exam success and conceptual understanding

I don't think that they are blocked off from the conceptual stuff without being able to do the maths. I think that they might be blocked off from the [exam] marks.

Changes in views during the training year

A very large proportion of the cohort noted that during the year they had revised their view of the role that mathematics plays in the learning of physics at school level, often after encountering the challenges noted above.

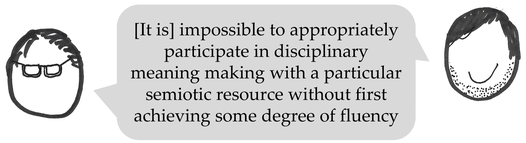


Conclusions and Implications

For our pre-service teachers, there seemed to be two interrelated processes as they navigated the transition from success in undergraduate physics to success in teaching school physics.

A **disciplinary orientation**, acknowledging that mathematics is the language of physics, whilst recognising that fluency in the mathematical representations is a necessary but not sufficient condition for success in undergraduate physics.

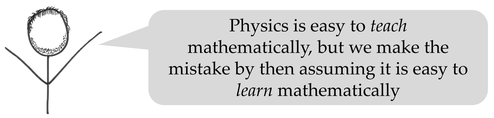
A **pedagogical orientation**, in which they stepped outside their own competence in the mathematical aspects of physics, developing an understanding of the challenges that students may face and crafting a response to that. Rather than removing all mathematics from their teaching, they identified what disciplinary mathematical resources were critical to learning physics (e.g. algebra and graph drawing) and committed time to support students to become fluent in them. This seems to support the view of Airey and Linder [2].



The pre-service teacher choices were further complicated by external factors, such as exam preparation, which dictated to some extent the content that they could teach.

We suggest that the terms **disciplinary** and **pedagogical affordance** can provide a means of framing expert-novice dialogue with pre-service teachers, allowing them to explore the challenges they face regarding the mathematical requirements of learning physics.

Hewitt [3] notes below an easy assumption to make. We hope that this work can help pre-service teachers become more reflective and be able to feel confident to make their own pedagogical decisions.



References (full set with QR download)

[1] E. F. Redish and E. Kuo, Sci. Educ. 24, 561 (2015).

[2] J. Airey and C. Linder, in Mult. Represent. Phys. Educ. (Springer, Cham, 2017), pp. 95–122.

[3] P. G. Hewitt, Am. J. Phys. 51, 305 (1983).

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James de Winter[1,2], John Airey[1,3]

[1]*Division of Physics Education Research, Department of Physics, Uppsala University, Sweden*

[2]*Faculty of Education, University of Cambridge, United Kingdom*

[3]*Department of Mathematics and Science Education, Stockholm University, Sweden*

james.dewinter@physics.uu.se