EXAMINING PHYSICS TEACHERS' VIEWS OF MATHEMATICAL KNOWLEDGE FOR SCIENCE TEACHING

Marina Milner-Bolotin[a], Rina Zazkis[b]

[a]Department of Curriculum and Pedagogy, University of British Columbia, Vancouver, Canada

[b]Faculty of Education, Simon Fraser University, Burnaby, Canada

THEME:

Mathematics and science teaching and learning; Teacher education and professional learning; Mathematics and science connections; Mathematics knowledge in physics teaching.

BACKGROUND AND AIMS

This study aims to explore mathematics and science connections in secondary science teaching. Specifically, we investigate how prospective and practicing science teachers (P&PST) view the role of mathematics in science learning and how they are able to incorporate their own pedagogical content knowledge (PCK) (Shulman, 1987) in mathematics to teach science concepts. The examination of mathematics-science connections is especially important in physics learning (Milner-Bolotin & Zazkis, 2021), as it explores the tension between physics concepts (Hake, 1998) and their applications to problem solving (Deslauriers et al., 2011) . There are at least four reasons to focus on mathematics and physics problem solving. First, physics problem solving relies heavily on students' ability to apply their mathematical knowledge to physics contexts. Second, mathematics captures important conceptual ideas of physics and allows for a deeper study of the relationships between physical quantities, which would have been difficult otherwise. Third, scientific method is based on the ability to predict and empirically verify the outcomes of experiments that often require extensive mathematical knowledge (Windschitl et al., 2008). And fourth, in the age of ubiquitous technological tools for collecting and analyzing data (Milner-Bolotin, 2012, 2016; Stampfer et al., 2020), students' ability to interpret experimental evidence using their mathematical knowledge becomes paramount (Milner-Bolotin, 2020).

The three research questions we will answer in this study are:

1) How do P&PST view the role of mathematics in science learning?
2) How do P&PST identify and build on the mathematical connections in problem solving?
3) How do P&PST navigate the tensions between conceptual understanding and procedural mathematical knowledge in science contexts?

METHODOLOGY

The data is composed of two complementary sources: the interviews with P&PST in the context of teaching 1-D kinematics (McDemott et al., 1987) and the analysis of secondary physics textbooks. We chose this topic because it has strong connections between mathematics and science, as it bridges basic calculus concepts (i.e., derivative, integral) with the physical concepts of linear motion (speed, velocity, and acceleration). This topic also has clear graphical representations that can be studied using widely available tools in physics classrooms, such as Video Analysis, motion detectors and computer simulations (Staacks et al., 2018).

Interviews: To examine P&PST pedagogical approaches and their ability to connect mathematics and science in their lessons, we will use a "lesson play" approach suggested by Zazkis et al. (Zazkis & Marmur, 2018; Zazkis et al., 2013). During the interviews, P&PST will be asked to respond to a task in which they will need to suggest potential pedagogical approaches for an imaginary dialogue between a teacher and a group of students learning the concepts of uniformly accelerated rectilinear motion in and provide a commentary elaborating on their instructional choices. The topics selected for the task were chosen intentionally as they provide authentic and rich opportunities to bridge mathematics and science concepts while challenging teachers to consider key mathematical concepts of ratios, slope of a graph, rate of change, derivatives, and integrals, and their role in science. The task provided the beginning of the dialogue, that featured a hypothetical student's confusion related to the interpretation of the 1-D motion graph. P&PST will be asked to extend this dialogue through describing envisioned instructional interactions that could have ensued and justify their instructional choices.

Textbook analysis: We will also analyze secondary physics textbooks to examine how mathematics is presented and used in teaching 1-D kinematics.

RESULTS AND CONCLUSIONS

We are collecting and analyzing the data now and will present our results during the MACAS conference.

REFERENCES

Deslauriers, L., Schelew, E., & Wieman, C. E. (2011). Improved learning in a large-enrollment physics class. *Science*, *332*(6031), 862-864.

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, *66*(1), 64-74.

McDemott, L., Rosenquist, M. L., & Zee, E. H. v. (1987). Student difficulties in connecting graphs and physics: Examples from kinematics. *American Journal of Physics*, *55*(6), 503-513.

Milner-Bolotin, M. (2012). Increasing interactivity and authenticity of chemistry instruction through data acquisition systems and other technologies. *Journal of Chemical Education*, *89*(4), 477-481. http://pubs.acs.org/doi/abs/10.1021/ed1008443

Milner-Bolotin, M. (2016). Rethinking technology-enhanced physics teacher education: From theory to practice. *Canadian Journal of Science, Mathematics and Technology Education*, *16*(3), 284-295. https://doi.org/10.1080/14926156.2015.1119334

Milner-Bolotin, M. (2020). Deliberate Pedagogical Thinking with Technology in STEM Teacher Education. In Y. Ben-David Kolikant, D. Martinovic, & M. Milner-Bolotin (Eds.), *STEM Teachers and Teaching in the Era of Change: Professional expectations and advancement in 21st Century Schools* (pp. 201-219). Springer. https://doi.org/https://doi.org/10.1007/978-3-030-29396-3

Milner-Bolotin, M., & Zazkis, R. (2021). A study of future physics teachers' knowledge for teaching: A case of a decibel sound level scale. *LUMAT: International*

Journal on Math, Science and Technology Education, *9*(1), 336-365. https://doi.org/10.31129/LUMAT.9.1.1519

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform *Harvard Educational Review*, *57*(1), 1-23. http://her.hepg.org/content/j463w79r56455411/

Staacks, S., Hütz, S., Heinke, H., & Stampfer, C. (2018). Advanced tools for smartphone-based experiments: phyphox. *Physics education*, *53*(4), 045009. https://doi.org/10.1088/1361-6552/aac05e

Stampfer, C., Heinke, H., & Staacks, S. (2020). A lab in the pocket. *Nature Reviews Materials*, *5*(3), 169-170. https://doi.org/10.1038/s41578-020-0184-2

Windschitl, M., Thompson, J., & Braaten, M. (2008). Beyond the scientific method: Model-based inquiry as a new paradigm of preference for school science investigations. *Science Education*, *92*(5), 941-967. https://doi.org/https://doi.org/10.1002/sce.20259

Zazkis, R., & Marmur, O. (2018). Scripting tasks as a springboard for extending prospective teachers' example spaces: A case of generating functions. *Canadian Journal of Science, Mathematics and Technology Education*, *18*(4), 291-312.

Zazkis, R., Sinclair, N., & Liljedahl, P. (2013). *Lesson play in mathematics education: A tool for research and professional development*. Springer.