In-field and out-of-field teachers' integration of a Massive Open Online Course in kinematics into their instruction of physics

Asnat R. ZOHAR, Inbal STONE, Shulamit KAPON

Faculty of Education in Science and Technology, Technion - Israel Institute of Technology, Haifa, Israel

Abstract. We developed a Massive Open Online Course (MOOC) in Kinematics for secondary school students. We present findings from a study that examined its implementation in classrooms taught by in-field (i.e., teachers with strong academic background in physics) and out-of-field teachers (i.e., teachers with limited background in physics and its teaching). Data include semi-structured interviews with 11 teachers (7 out-of-field, OoF, and 4 in-field teachers, IF) and data mining of their students' (*N*=391) work in the course.

Introduction

The shortage of physics teachers is a severe global issue, where many secondary school physics classes are taught by out-of-field (OoF) teachers – with limited background in physics and the teaching of physics [1]. Several studies have noted that OoF teachers need to invest considerable efforts to learn the disciplinary content, and struggle to transform it into effective instruction (e.g., craft explanations, prioritize core ideas, facilitate and guide students' problem-solving, understand students' difficulties, generate authentic and illustrative examples, etc.) Accordingly, students of OoF teachers often exhibit lower learning outcomes and disengagement [2].

Most OoF teachers feel stressed and anxious when they have to teach topics out of their field of expertise [2]. Teachers, as professionals, traditionally perceive themselves as the central source of knowledge in the classroom. Hence expecting teachers to traditionally teach a subject, for which their level of expertise does not significantly exceed that of their students, is unfair. However, teachers are much more experienced learners than their students, and are experts in planning and managing students' learning. We hypothesized that an incorporation of an appropriate Massive Open Online Course (MOOC) in physics in a blended instruction mode (i.e., integrating online and face-to-face instruction) might alleviate OoF teachers' disciplinary disadvantages, while capitalizing on their non-disciplinary professional strengths. This setting can potentially position teachers as mentors of learning rather than the source of knowledge.

We are currently piloting the implementation of the first chapters of a MOOC course in kinematics for advanced level 9th graders that aims to develop students' mathematical modelling skills and conceptual understanding. We also provide online professional development for the implementing teachers, and are studying the implementation of the course in their classrooms. Research questions: (1) In what ways did the teachers implement and integrate the MOOC into their instruction? (2) How did the disciplinary background of the teachers influence the variability of implementations and the students' learning outcomes?

Method

The educational context of the study was a pilot implementation of the first three chapters of the *Physics of Motion – Mathematical and Computational Modelling of Motion* - a MOOC for 9th grade students studying mathematics at the A-Level. In Chapter 1, students learn that position is a vector quantity and to communicate position they need to provide a distance from a reference point together with a direction in space. They also learn to mathematically represent position in one dimension. In the second chapter students learn to model motion in one dimension as a function of position vs. time while using different representations, and to move flexibly between these representations. Then they learn about displacement, explore its vector nature, and its difference from path. In the third chapter they learn the concept of velocity and its vector nature, model motion in constant velocity in one dimension using various representations, and engage in related problem solving (one and two bodies). The PD was fully virtual. The asynchronous part was dedicated to the teachers' work as learners in the course environment. The synchronous meetings were built on this experience and focused on pedagogy and the instructional design of the implementation of the course in the classroom. The teachers also shared and discussed concrete implementations in their classroom during the PD.

The participants in the study were teachers who participated in the online PD and who agreed to participate in the study (7 OoF and 4 IF teachers). Data on the implementations were collected through semi-structured interviews with these teachers (1.5-2 hours each). Data on the students' (N=391) learning were collected through data mining.

Findings

Both the OoF and the IF teachers presented quite similar perceptions of students' learning. They indicated that the MOOC promoted independent learning, enabled differentiated teaching in the classroom, and enhanced students' motivation and interest in physics. However, they described very different implementations. The OoF teachers devoted a great deal of effort and time to preparing their lessons, and they were frustrated when they were often unable to correctly predict their class progress. They struggled to find relevant examples or activities; they used the course materials in teacher-centered instruction rather than letting the students work individually (the opposite of what we hoped they would do); they avoided teaching the more challenging topics, and experienced difficulties responding to students' questions. In contrast, the IF teachers had more realistic planning strategies, easily integrated their own demonstrations and examples, and encouraged students' individual work; namely, they allowed advanced students to proceed on their own, which gave them more time to help other students.

All the teachers (IF & OoF) said that they enrolled in the PD as piloting teachers since they perceived it as an opportunity to support their students in developing novel learning skills, and that they significantly enhanced their content and pedagogical knowledge. They described differentiated teaching as highly challenging, and discussed the related technical obstacles. However, while the IF teachers' description of these experiences reflected curiosity, enthusiasm, and satisfaction, the OoF descriptions reflected difficulties, struggles, and low motivation.

While the average scores of students of the IF teachers, and their participation in the course remained quite steady throughout all three chapters (average scores of 89, 83, 83 for the fraction of the students who took the test: 88%, 88%, 85%). By contrast, the average scores and the students' participation in the classrooms of the OoF teachers decreased significantly as the complexity of the context increased (scores of 84, 73, 57 for the fraction of students who took the test: 92%, 83%, 62%).

In the presentation we will delve into these differences and discuss their implications for the professional development of IF and OoF physics teachers.

References

[1] E. McLoughlin and D. Sokolowska, Physics teacher professional learning, in *The International Handbook of Physics Education Research: Teaching Physics*, edited by M. F. Taşar and P. R. L. Heron, pp. 15-1–15-22, AIP Publishing, Melville, New York, 2023.

[2] L. Hobbs and G. Törner (Eds.), *Examining the phenomenon of "teaching out-of-field": International perspectives on teaching as a non-specialist*, Springer, 2019.