Teachers TPACK: promoting self-monitoring in physics problem solving through digital activities

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Abstract. A variety of research-based instructional strategies have been designed to promote students' self-monitoring in physics problem solving but few are implemented, either because of structural constraints or teachers' perceptions. Although digital activities can help teachers cope with structural constraints their perceptions may still pose a challenge. In this study we focused on teacher leaders and their experiences with digital activities in a professional learning communities program and in their high school physics classrooms. Interviews with 10 teacher leaders revealed that while they acknowledged the positive aspects of these activities, they overlooked their role in promoting self-monitoring in physics problem solving.

Introduction

The literature highlights the need to develop self-monitoring in students' approaches to problem solving (e.g. planning an approach to solve a problem based on physics principles versus surface features, reflections on the solution process, etc. [1]). Developing self-monitoring in students' problem solving requires teachers to quickly diagnose and evaluate how their students approach problem solving and guide them accordingly. This poses a dual challenge for teachers. In the domain of pedagogical content knowledge, teachers need to know what defines self-monitoring in problem solving and be familiar with students' difficulties and the instructional strategies that can address them. In terms of the practice, research based instructional strategies commonly involve intense teacher-student and peer interactions [1] that consume significant class time and require teachers to have elaborate management skills. Therefore, teachers rarely explicitly scaffold students' self-monitoring in problem solving [2].

Theoretical Framework and Research Questions

Digital activities have been developed to help physics teachers foster students' self-monitoring when solving problems. The activities differ in attributes such as the forms of diagnosis and feedback, the level of interactivity and the aspects of self-monitoring that these activities are aimed to promote. TPACK is a theoretical framework that interrelates teachers' knowledge of technology, pedagogy and content, and identifies the challenges teachers face when trying to implement digital activities in their instruction [3].

Professional development (PD) programs can assist teachers in acquiring aspects of TPACK. Studies have described design principles for effective PD frameworks [4] including active learning, peer interactions, and collaborative reflection on practice. These principles have been implemented in a national network of Professional Learning Communities (PLCs) for high school physics teachers [5]. A central theme in the PLCs in 2021-2023 was digital activities that promote self-monitoring in solving physics problem.

This study examined the perceptions of the physics teachers who lead these PLCs - the Teacher Leaders (TLs). It explores two research questions: a) what are the TLs' perceptions of the goals of the digital activities? b) what strengths and weaknesses do the TLs see in these digital activities?

Methods

The TLs are experienced high school physics teachers in schools that represent various socioeconomic backgrounds. They participated in a PLC of TLs where they experienced the following three digital activities, intended to promote self-monitoring in problem solving: a) an AI tool titled *GrouPer*, which provides teachers with group-oriented diagnostic information about their students [6]; b) a reflection questionnaire following videos with exemplary solutions; c) a computer problem-solving coach [7]. The TLs experienced each of these activities as learners, and then discussed potential advantages and challenges. In subsequent PLC meetings, they collaboratively reflected on the implementation of these activities in the classroom and shared their insights and dilemmas. The TLs then led similar PD sequences in their own PLCs.

The data included semi-structured retrospective interviews with the TLs focused on the TPACK theme in the PLCs, video documentation of the TLs' meetings and artefacts that the TLs produced. Twelve TLs who led PLCs from 2021 to 2023, in pairs, were interviewed. They were asked to reflect, in pairs, on their experiences with the digital activities both as physics teachers and as PLC leaders. The qualitative analysis combined both bottom-up and top-down categories.

Findings and Conclusions

The preliminary findings showed that the TLs perceived the main goals of the digital activities to be promoting of conceptual understanding and assessing students' achievements. The goal of promoting self-monitoring in physics problem solving was less clear-cut when the interviewees were asked directly about the learning goals, but came up when they discussed the central strengths of the activities. They appreciated the personalization of the activities, making it possible to adapt feedback to the individual learner. They also discussed the emphasis on learning processes such as reflection and generalization. On the other hand, they disliked the cumbersomeness of the activities, e.g., their length and tight structure, and preferred activities that are more flexible and adaptable to their students. The findings shed light on teachers' perceptions of integrating digital activities to promote self-monitoring in physics problem solving, and contribute to refining the design principles of these activities and PD processes to support their implementation.

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