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Empirical study

Teacher value for professional development, self-efficacy, and student outcomes within a digital mathematics intervention

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ABSTRACT

We examined teacher self-efficacy within the context of a suite of mathematics learning games, Spatial Temporal Mathematics (ST Math) to analyze the associations between teacher value for professional development and self-efficacy, and the associations of both with student achievement outcomes. We found that higher teacher valuing of ST Math professional development was associated with higher self-efficacy for teaching ST Math, and that teacher self-efficacy had a small positive association with student achievement, although the latter result was not replicated in a subdivision of the sample. These associations provide information on how teacher perceptions and self-beliefs about interventions and professional development may drive implementation and student outcomes.

1. Introduction

Self-efficacy, the belief in one's ability to accomplish desired outcomes, has a powerful effect on people's behavior, motivation, and success or failure (Bandura, 1997). Teacher self-efficacy, considered to be a teacher's perception of her or his capability to "organize and execute courses of action required to successfully accomplish a specific teaching task in a particular context" (Tschannen-Moran, Woolfolk, Hoy, & Hoy, 1998, p. 233), is one explanation for the gap between what teachers know and what they do. Over thirty years of research supports the notion that teachers' self-efficacy beliefs are related to the learning goals that they set, the effort they invest in teaching, and their persistence and resilience in the face of difficulty and setbacks (e.g., Ashton & Webb, 1986; Guskey, 1994; Haney, Wang, Keil, & Zoffel, 2007; McKinney, Sexton, & Meyerson, 1999; Timperley & Phillips, 2003). Clearly, teacher self-efficacy is important to consider when understanding and planning for student learning. In the present study, we examined teacher self-efficacy as it relates to the implementation of computer-based instruction within the context of a suite of mathematics learning games, Spatial Temporal Mathematics (ST Math).

We situated this study within a larger evaluation project of ST Math and its impact on student achievement. Although ST Math is a digital intervention that is delivered individually to students, according to MIND Research Institute (MIND), the creators of ST Math, teacher knowledge, support, and facilitation are components of successful ST Math implementation (Mind Research Institute, 2017). Therefore, one important area of evaluation of ST Math concerns how teachers learn to implement the ST Math software and the subsequent impact of implementation on program participation and student learning. Teacher professional development (PD) provides an avenue through which teachers learn how to use and implement classroom interventions and allows teachers to refine their current skills and practices, as well as keep abreast of new knowledge, theories, and methods (Borko & Putnam, 1996). Prior research suggests that high-quality PD can improve teacher practice, but there is less evidence for how teacher PD may be related to proximal outcomes, including self-efficacy beliefs, and their ultimate effects on student achievement (Karabenick & Conley, 2011; Wallace, 2009). The goal of this study was to investigate the relationship between teacher perceptions of ST Math professional development and the impact of these perceptions on both teachers and students. Specifically, we examined the association between teacher value for ST Math professional development (value for PD), teacher self-efficacy for implementing ST Math, and student achievement. We were also interested in whether teacher self-efficacy influenced student access to software content, as access to such content provides a path through which students may attain higher mathematics achievement.

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This work complements previous research on ST Math. Prior work on the effect of ST Math is mixed: Correlational studies have shown positive associations between use of ST Math and student achievement (e.g., Graziano, Peterson, & Shaw, 1999; Martinez et al., 2008; Peterson et al., 2004), but a recent randomized experiment as part of the larger evaluation project showed only very small effects of ST Math on achievement (Rutherford et al., 2014). Research by Tran et al. (2012) extended the study of ST Math effects to teacher outcomes, and found no treatment/control differences within the same sample used by Rutherford et al. (2014). However, they did find variation in teacher self-efficacy and implementation among treatment teachers, noting that the integration of ST Math into daily instruction was positively associated with teacher self-efficacy and changes in instructional practices. Within the current paper, we investigated such variation with a sample that included different teachers and students and extended the work by Tran et al. (2012) to investigate how value for PD can be a potential avenue through which teachers develop greater self-efficacy for implementing ST Math, and how this self-efficacy can result in enhancements to teacher and student use of ST Math, and ultimately, achievement.

2. Background and theoretical framework

2.1. Teacher self-efficacy

Self-efficacy is defined by Bandura (1977) as the beliefs that a person holds about their own abilities to perform a particular task. These beliefs influence the level of effort people expend, their persistence when working through challenges, and their resilience in the face of failures. Thus, the strength of people's conviction in their own effectiveness is likely to affect whether they will try to cope with given situations, including those situations requiring change (Bandura, 1977). For example, teachers may view a new intervention as important in achieving particular student outcomes, but if they do not believe that they can effectively implement it, they will be less likely to use it in their classrooms.

Extensive research has been conducted on teacher self-efficacy, defined by Tschannen-Moran, Woolfolk, Hoy, and Hoy (1998) as a teacher's "beliefs about his or her capability to organize and execute courses of action required to successfully accomplish a specific teaching task in a particular context" (p. 233). There is compelling evidence indicating that teachers' beliefs in their abilities to instruct students may account for individual differences in teacher effectiveness; teachers' sense of efficacy has been related to their classroom practice and to student outcomes, including students' self-efficacy beliefs, motivation, and achievement (e.g., Anderson, Greene, & Loewen, 1988; Ashton & Webb, 1986; Cannon & Scharmann, 1996; Midgley, Feldaufer, & Eccles, 1989; Ross, 1992; Ross, Hogaboam-Gray, & Hannay, 2001). Teachers who feel more efficacious tend to use a greater variety of instructional strategies and are more likely to try new teaching strategies, including those that may be more difficult to implement (Hami, Czerniak, & Lumpe, 1996; Riggs & Enochs, 1990). Further, teacher self-efficacy has been correlated with classroom instructional strategies and a willingness to implement educational innovations (Tschannen-Moran et al., 1998). Teachers with higher self-efficacy have been found to be more willing to implement new programs (e.g., Donnell & Gettinger, 2015) and more effective when implementing new programs than teachers with lower self-efficacy (e.g., Berman & Laughlin, 1977).

It is also important to note that Bandura (1977) considered efficacy beliefs to be situationally specific—that is, related to a particular context. For example, a teacher might feel efficacious at teaching math but struggle with implementing math-based instructional software. Over recent years, there have been a number of studies that have examined teacher self-efficacy as it relates to technology. Teaching with technology is difficult for many teachers because technology tools are always changing, which often results in teachers being perpetual novices in the process of technology integration and implementation (Mueller, Wood, Willoughby, Ross, & Specht, 2008). According to Angeli and Valanides (2009), effective technology integration depends on a consideration of the interactions between technology, content, and pedagogy. Thus, technology integration requires that teachers understand the technology tool itself as well as the specific affordances of the tools that, when used to teach content, enable students to learn more difficult concepts more readily. When teaching with technology, it is not sufficient for teachers to know how to use the technology or to understand the content. It requires that teachers expand their knowledge of pedagogical practices across multiple aspects of planning, implementation, and assessment. According to Ertmer and Ottenbriet-Leftwich (2010), "although knowledge of technology is necessary, it is not enough if teachers do not also feel confident using that knowledge to facilitate student learning" (p. 261). In fact, some research suggests that self-efficacy may be more important than skills and knowledge among teachers who implement technology in their classrooms (Wozney, Venkatesh, & Abrami, 2006). In their study of teacher perceptions and practices regarding technology implementation, Wozney et al. (2006) found that "teachers need to believe that they can successfully implement the innovation within their own context; if not, they may neither take the initial risk nor continue to persevere in implementing it" (p. 195). These findings lend support to the idea that professional development around the implementation of educational technology should be designed with the intention of enhancing teachers' expectations of success.

2.2. Professional development as a source of teachers' self-efficacy beliefs

Tschannen-Moran et al. (1998) suggested that teacher efficacy is a malleable trait, one that is influenced by the teacher's performance and experience. If teacher efficacy is malleable, it follows that it can change over time and with support. Bandura (1977) proposed four major influences on self-efficacy beliefs: mastery experiences, verbal persuasion, vicarious experiences, and physiological arousal. The most powerful of these is mastery experience—for teachers, this includes successful prior teaching experiences (Tschannen-Moran & Hoy, 2007). Verbal persuasion has to do with the verbal interactions that a teacher has with important others, both about her or his success and about the prospects for success in the teaching context. Vicarious experiences are those in which someone else models the target activity. Both verbal persuasion and vicarious experiences can occur during teacher PD. When someone with whom the teacher identifies performs well, the teacher's self-efficacy should increase. Thus, depending on the nature and design of PD experiences, PD may have an influence on teacher self-efficacy (Ross & Bruce, 2007; Tschannen-Moran & Hoy, 2007; Tschannen-Moran & McMaster, 2009).

Earlier work on teacher PD and self-efficacy has indicated that there is a relationship between the two. Ross (1994) found that teacher self-efficacy could be enhanced through district-wide professional development, suggesting that the knowledge that teachers gained though PD was associated with positive change in their efficacy beliefs. In relation to educational technology specifically, Anderson et al. (1995) found that if teachers were provided with a couple of weeks of familiarization with educational software, they seemed to adapt to using the technology with their students, noting, however, that there was some evidence that achievement gains were higher the second year the teacher worked with the