Researching How Physics Technology in an Elementary Mathematics Methods Course Impacted Preservice Teachers' Efficacy

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Abstract:
Preservice elementary teachers generally have little background in physics or physics education. Five weeks of content using technology (motion sensors and data loggers) was integrated across seven courses taught by three different instructors. Data were gathered from preservice teachers (n = 193) using the Mathematics Teaching Efficacy Beliefs Instrument at a large public Hispanic Serving Institution in the southwest United States. Results showed statistically significant improvements in the Personal Mathematics Teaching Efficacy subscale, but not in the Mathematics Teaching Outcome Expectancy subscale.

Keywords: physics education; technology integration; STEM; preservice elementary teachers, efficacy beliefs

Overview

In order to address the physics void and to improve educational STEM backgrounds, we integrated physics into an algebra-based content course for preservice elementary and middle school teachers. Our goal was to provide them with an opportunity to deepen their understanding of mathematics content by incorporating physics activities contextualized through algebra. Using interrelated mathematics and physics concepts such as slope, function (linear, quadratic, and non-linear), and the equation of a straight line, preservice teachers explored algebra using technological tools and physical movement. Interconnecting physics and mathematics is natural, as there is a focus on making sense of mathematical representations of physical movement. Our integrated intervention focused on mathematical ideas of function, slope, linearity, and the physics of motion applied to real-world contexts. The curriculum was purely integrative in nature.

Literature Review and Conceptual Framework

Apart from the use of science activities and contexts in mathematics instruction, there are many reports of the specific difficulties involved in the mathematical preparation of preservice teachers. There is a need to address preservice teachers' struggles in mathematics (Greenberg and Walsh, 2008). In their study, they looked at algebraic instruction and they recommended that there be a continued focus on algebraic ideas such as variables, equations and graphs in order to support a more conceptual development of ideas. Specifically, they describe the need for algebraic instruction that focuses on constants, variables, equations, graphs, and functions. There recommendations are also content ideas supported by Thompson and Carlson (2017).

While there is a push to engage preservice teachers in more meaningful lessons focused on conceptual understanding of slope, variables, equations and functions, there are challenges. For example, studies highlight the problems and problems learners have deeply understanding algebraic concepts (Byerley & Thompson, 2017; Stump, 2001; Walter & Gerson, 2007). In a study by Stump (1999) preservice teachers had great difficulty understanding the concept of slope even though there was a specific emphasis on the topic throughout the course.

In the present manuscript, we used physics as a context for algebraic ideas by emphasizing real-world physics examples (Grawe, 2011; Hitt, 2002; Hughes-Hallett, 2003) using technology. Our intervention consisted of physics-infused algebra content using technological tools for elementary and middle school preservice teachers, taught a five-week physics related algebra intervention and measured changes in the MTEBI (Enochs, Smith & Huinker, 2000).

Data were gathered before the intervention and after the intervention. In total, 212 students completed the pre-survey, and 196 completed the post-survey. Statistical analyses used matched pre- and post-surveys (n = 193). Some students completed more than one survey; in those cases, the first completed survey was used for analysis and the other survey responses were removed. The preservice teachers were enrolled in several different classes taught by three different instructors.

Results

After completing a pre-intervention survey (about four weeks into the semester) and a post-intervention survey (about 11 weeks into the semester, a t-test was used to see any significant results. Sample sizes were equal, supporting the use of t-tests and offering the most powerful statistical approach for our sample (Zimmerman, 1987). The results of the two subscales (PMTE and MTOE) can be seen in **Table 1**.

Table 1. Descriptive statistics for the MTEBI subscales

	Pre		Post					
	M	SD	M	SD	t	df	p	Cohen's *d*
PMTE	43.67	6.33	45.21	6.67	3.93	192	.0001	.24
MTOE	28.18	4.06	28.46	3.88	0.96	192	.34	.07

Significance of the work

After participating in physics-infused algebra curriculum, preservice teachers showed statistically significant results in relation to the PMTE subscale, but not the MTOE subscale. There were more people who increased their scores from the pre- to post-survey across both subscales than did not. Their sense of efficacy regarding the teaching of mathematics increased while their perceptions regarding their beliefs about mathematics instruction and student outcomes did not change. Our results likely show that they improved their efficacy regarding teaching mathematics but did not see changes in how they can impact on student outcomes. There are often challenges associated with changing preservice teachers' mathematical beliefs (Swars et al., 2007) and mathematical beliefs are quite complicated, complex and mediated by a number of factors (Handal, 2003). While our results showed some improvements, we recognize the complexity of mathematical beliefs.

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