Chapter 27
Promoting Higher Student Mathematics Achievement in Online Settings: Introducing PHiSMAOS

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ABSTRACT

This chapter describes how the authors structured effective online mathematics content courses for pre-service teachers (PSTs) using the promoting higher student mathematics achievement in online settings (PHiSMAOS) conceptual framework. This framework focuses on the mathematics teacher educator (MTE) view from which they are using their technological content knowledge (TCK) to develop their PSTs' own technological knowledge (TK), content knowledge (CK), and TCK when in an online mathematics classroom setting. The PHiSMAOS conceptual framework then wraps this reality in the concepts of growth mindset and productive struggle, providing a pragmatic way for MTEs to productively promote growth mindset in PSTs' mathematics content classrooms in online settings. This framework was developed using grounded theory research techniques from data consisting of exit cards, video-recorded discussions, assignments, and test scores across seven semesters of the authors' courses. Implications for MTEs, use in K-12 settings, and further research are also discussed.

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INTRODUCTION

In March of 2020, the authors' students, all undergraduate elementary mathematics pre-service teachers (PSTs), left for Spring Break and never returned as COVID-19 spread across the globe. While the authors' classes did resume, the setting, and modalities in which those classes took place were exceptionally different from the beginning of the semester. In addition, while the authors had experience teaching online courses before, those courses were not targeted for PSTs who had planned to take a face-to-face course. Also, the authors' experiences in teaching online primarily lay in graduate mathematics content courses with students expecting an online environment and who had already successfully navigated the collegiate environment at least once. As the authors rapidly joined the rest of the world in creating online meaningful, lasting mathematical learning experiences overnight, they found themselves facing additional unique problems on top of the traditional problems already facing their PSTs.

Traditionally, the authors' university, Sam Houston State University, is an institution with approximately 45% first generation college attendees, about 60% labeled at risk, 24.7% Hispanic undergraduate population, and over 75% of the students working while pursuing their degree (https://www.shsu.edu/about/facts.html). This demographic is much more likely characterized as underprepared for college level work, especially in mathematics and English (Atherton, 2014; Boden, 2011; Melzer & Grant, 2016; Terenzini et al., 1996) and requiring additional support for success (Eveland, 2020; Ives & Castillo-Montoya, 2020; Ward et al., 2012). Furthermore, Perin and Holschuh (2019) found in their review of the literature that underprepared postsecondary students benefitted from approaches that included teaching of discrete skills, providing strategic instruction, incorporating new and multiple literacies, employing disciplinary and contextualized approaches, using digital technology, and integrating reading and writing instruction. However, Perin and Holschuh (2019) further noted that the field has yet to develop a clear theoretical framework pointing to how teaching underprepared students might improve. In addition, prior to COVID-19, many of the authors' PSTs at this institution have struggled with mathematics anxiety based on pre/post data every semester/term since Fall 2017 on PSTs' self-reported levels of mathematics anxiety. This data showed an average of 53.5% (N=432 PSTs) reported moderate to extreme levels of mathematics anxiety on the first day of class. Furthermore, recent research has shown an interconnectedness between math anxiety and a person's mindset towards mathematics (Tassell et al., 2020).

Beginning Fall 2018, one of the authors began restructuring courses to include growth mindset principles when planning activities, interacting with PSTs, helping them set individual growth goals for each course, and grading and assessing PSTs (Dweck, 2010). Up until COVID-19, preliminary data had shown increases in PSTs' self-reported comfort levels with teaching mathematics and decreases in their overall self-reported levels of anxiety by the end of the course from previous semesters, overall higher grades with more As and Bs, higher retention of PSTs, and better classroom attendance. Starting in Fall 2019, the same author implemented further supports to encourage productive struggle, which the National Council of Teachers of Mathematics (NCTM) (2014) defined as "opportunities for delving more deeply into understanding the mathematical structure of problems and relationships among mathematical ideas instead of simply seeking correct solutions" (p. 48). These efforts included the creation of guided notes and a vocabulary graphic organizer to scaffold lecture material, vocabulary development, and PST in-class discussions. Then, to motivate PST persistence, the author refined early semester one-on-one interviews (Hunt & Stein, 2020) and feedback experiences to create a more reassuring classroom environment. Again, preliminary data collected through student exit cards in Fall 2019 suggested these efforts were better in helping PSTs to identify the big ideas of each lesson and reduced over-all student