

Research Article

Pre-service teachers' mindset and persistence in college algebra and statistics units of practice

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Abstract

Understanding the mindset and persistence traits of pre-service teachers (PSTs) is significant as these traits impact future teacher engagement with classroom materials and their future work by influencing student performance. PSTs' persistence in two college courses was measured, and pre- and post- course scores were compared looking at if their mindset and persistence improved over their content courses. Our study would recommend reconsidering the standards and course expectations of engagement, what improvements can be made to learning in various modalities, and that CoVid-19 PSTs may be more accepting and flexible. Shifts to learning, the challenges, and methods should be studied and compared to pre-CoVid-19 studies to understand CoVid-19 shifts in ideologies, both in the moment and long term.

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Introduction

Teacher education programs (TEPs) have evolved from apprentice training into bachelor's programs. Many educators sought to complete undergraduate and graduate degrees focused on pedagogical methods, specific content areas, and/or administrative decisions during the CoVid-19 pandemic. The majority of classroom experiences and learning towards a bachelor's degree before CoVid-19 was done face-to-face (f2f), with anecdotal stories of taking courses online or virtually. However, CoVid-19 drastically changed how teacher candidates may be expected to engage, learn, and teach in their careers as educators. Teacher candidates who started their degree programs before and during CoVid-19 may now be approaching their current coursework (and future classroom) with changes to their mindset and persistence, particularly in mathematics.

Pre-Service Teachers (PSTs) are potential educators seeking certification to teach in particular grade bands and in a specific content area such as science, English, or mathematics (as was the focus of this paper). PSTs are a unique population as they have dual views when engaging with course materials. First, PSTs are students in their current learning experiences and second, they are future educators who have the potential to influence hundreds of students over the course of their careers. This duality can take multiple positive (or not so positive) twists or turns that could influence PSTs' mindset and persistence. These changes may also extend to PSTs' future students. (Chen et al., 2014; 2018; 2021).

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Initial mindset studies considered 5th grade students' views of their learning and ability (Diener & Dweck, 1978). Now, almost 40 years later, Boaler and Dweck (2016) have expanded-and refined-the definitions of mindset and persistence for use in the mathematics classroom. Research about a growth mindset – the belief that PSTs have not yet learning enough and having a fixed mindset- the belief that PSTs cannot learn anything new, is not the sole variable to consider (Gutshall, 2014; Pelletier et al., 2020; Stephens et al., 2022). PSTs also need the persistence to continue learning (Chen et al., 2014). Duckworth and Quinn (2009) use the idea of grit - the persistence to achieve long-term goals and ambitions. Both mindset and persistence have seen positive-outcome studies (Andersen & Nielsen, 2016; Broomhead et al., 2012; Burnette et al., 2018; Clements et al., 2011; Daly et al., 2007) and mixed-outcome studies (Brougham, 2016; Burnette et al., 2018; Orosz et al., 2017; Rhew, 2017). Recently, Author et al. (2020) suggested that PSTs who engage in professional learning focused on challenging tasks that engaged the PSTs in understanding their mindset and persistence can show changes to their mindset and persistence in weekly sessions over five weeks.

Literature Review

The recent global pandemic changed how educators engage with their current students and how future teachers engage in learning the craft of teaching. For many PSTs across TEPs, this included learning via virtual or hybrid conditions. With such immediate changes, the mindset and persistence of many, including PSTs, may have shifted. Our study focused on PSTs' mathematics content courses where learning materials aligned to CCSS-M state standards but focused within the units of practice of College Algebra and Statistics for those intending to teach 8th grade and below.

Mindset

Mindset, as defined by Dweck and Leggett (1988), is a person's established set of attitudes given a particular topic, particularly whether intelligence and talent are of a fixed or malleable quality. While mindset is often viewed as a motivational variable, with entity or incremental views of motivation explaining a person's approach to a situation, mindset can be a cognitive or behavioral pattern as well. A person with a performance-oriented, or helpless behavior pattern, will work to gain positive judgments of their efforts and avoid negative judgments of their social attributes. A person with a developmental, or learning, mindset (also known as a mastery-oriented behavior pattern) will be concerned with increasing their social competence and developing relationships. Those with fixed-mindset focus on their ability to successfully complete tasks when challenged; whereas those with growth-mindset focus on not yet having the ability to successfully complete tasks when challenged (Boaler & Dweck, 2016; Dweck, 2006). Behavioral patterns as an individual can move between categories even throughout the same situation.

Interventions to influence mindsets have become increasingly prevalent in the literature (Author, 2020; Cartwright & Hallar, 2018; Cribbs et al., 2021; Lee et al., 2021). Yeager and Dweck (2012) described a number of interventions aimed at improving student mindset, as well as four key components to help develop mindset: goals, effort, attribution for setbacks, and engagement despite setbacks. Studies have focused on the first and second components-goals and effort, respectively (Duckworth & Quinn, 2009; Lin-Siegler et al., 2016; Robertson-Kraft & Duckworth, 2014; Schmidt et al., 2017; Yeager & Dweck, 2012). However, not many studies have focused on using the third and fourth components-attribution for setbacks and engagement despite setbacks. Our study focused on the mindset PSTs had as they approached mathematics content courses from as future educators.

Research with PSTs has shown that mindset does not necessarily change during their university experience, but that PSTs can change their view of how working with students can be impactful (Pelletier et al., 2020). In a study of PSTs (both at the beginning of their program and research on those in their final clinical experience), Gutshall (2014) noticed that while some first semester PSTs had a fixed mindset regarding ability, almost all of those in their final clinical setting had shifted towards a neutral or growth mindset. PSTs who understand classroom priorities and risks associated with a more fixed or growth mindset, while teaching and engaging their future students, may assist with easing the current mathematics anxiety levels.

Persistence

Previous K-12 studies defined *persistence* as how students continue to engage in mathematical tasks despite facing challenges (Boaler & Staples, 2008) and students' perception of challenging mathematics tasks (Howard, 2008;

Montague & Applegate, 2000). For example, Hong et al. (1999) noticed when growth mindset students attempted challenging tasks, they felt residual feelings of accomplishment and persistence. For higher education students, Shen, Miele and Vasilyeva (2016) suggested that knowing how challenging tasks were perceived may suggest why persistence was demonstrated. Influencing students' persistence may likely require professional development by classroom teachers.

PSTs' prior learning experiences and in-service educators' professional development can impact interactions with students (Gutshall, 2014; Truax, 2018). The importance of professional learning begins during preservice experiences and should not be ignored until teachers are in the field (Menanix, 2015), especially in regards to how students approach mathematical tasks. There has been insufficient research into persistence in higher education, particularly how PSTs approach mathematics content courses from the perspective of future educators (Hourigan et al., 2016; Lazar, 2007; Yorke & Knight, 2004), which this study looks to address. Unlike other university-level students, PSTs are students who are developing their conceptualization of persistence, instructional practices, and perception of challenging tasks from the perspective of both a student and a future educator.

PSTs

PSTs' engagement with mindset and persistence professional learning opportunities may lead them towards a growth mindset and increasing their persistence when challenged (Author, 2020). Furthermore, shifting PSTs' professional mindset and persistence early in their educational programs may shape how they affect the mindset and persistence of future students. Engaging PSTs in coursework that includes a focus on their mindset and persistence is multi-fold.

First, PSTs are a unique population who are learning how to engage with their future students while engaging in more abstract methods of the concrete concepts learned in their K-12 coursework; however, some PSTs are still developing their mathematical understanding as a student themselves (Campbell et al., 2014). Second, PSTs will be educating multiple generations of students. As such, PSTs are one of the largest groups that are going to influence and consistently engage with individuals under the age of 18. Finally, within each K-12 classroom there are future generations of educators. By engaging with growth mindset and persistence during K-12 education, the changes in classroom culture can result in greater mathematical understanding (Fraser, 2018). By building mindset and persistence into preservice programs (Paunesku et al., 2015) as long-term practices rather than one-time experiences (Aronson et al., 2002; Blackwell et al., 2007), multiple generations of educators will be influenced. Therefore, including practices in content courses, such as the units of practice that include College Algebra and Statistics, PSTs engage in TEPs with the ability to promote changes in views of intelligence might be an effective way to change how future K-12 students view mathematics.

University level mathematics content

Although there are many mathematical areas PSTs will engage with during their training toward becoming an educator as part of their university-level mathematics content courses, the two areas of focus for our study took place during the units of practice focused on Algebra and Statistics.

College Algebra. College algebra (which includes material from high school Algebra II and Pre-Calculus courses) has long been part of remedial mathematics course sequences (Bailey et al., 2010), with research demonstrating enrollment in remedial courses having mixed effects (Boatman & Long, 2018; Calcagno & Long, 2008; Martorell & McFarlin Jr, 2011; Scott-Clayton & Rodriguez, 2015). Some studies saw a benefit, such as when university students took corequisite courses for Algebra, the classes that focused on using learning strategies focused on mindset concepts saw better test scores (Montalbano, 2021). Additionally, Florida's college system explored remedial mathematics programs success reforms attempted were researched and perceived as having changed the attitudes of stakeholders within the institution which likely resulted in student perceived success (Mokher et al., 2020). However, Ngo and Kosiewicz (2017) noticed that at California Community College, students enrolled in a multi-semester Algebra course saw significantly decreased student persistence and success. Thus, it is necessary to continue to study the benefit of direct teaching of learning mindset and persistence strategies in College Algebra courses.

Statistics. Statistics is another university level course that is often required. Positive results from Schau and Emmiöglu (2012) found that 2,200 university students' attitudes towards statistics decreased or stayed constant as they progressed through their statistics course. Whereas Carlson and Winqvist (2011) negative results indicated that when statistics

courses had over 250 students experience a semester-long workbook statistics curriculum that students had more confidence in their ability to perform and understand statistics and noticed they liked statistics more. Yet when compared to the control group, students still thought statistics was more difficult when the workbook was used. More recently, Xu et al. (2020) noticed mixed results when they considered that for approximately 2,000 students surveyed that the analysis demonstrated that students' statistics attitudes vary considerably across statistics instructors. Moreover, students' expected grades are instructor-associated are changes that form from students' positive attitudes about statistics.

Our Study

Understanding the mindset and persistence of PSTs is significant as research often reacts to learning outcomes based on standardized testing of elementary and secondary students. Could improving PSTs' mindset and persistence make a difference in their engagement with materials and in the long-term future adjust their future students' scores by reducing student anxiety? By studying mindset and persistence of PSTs, changes can be made to classroom instruction in a proactive rather than reactive manner. The researchers know this question is longitudinal and unanswerable at the current research level with CoVid-19; however, the researchers propose to start by looking at the difference between two PSTs groups enrolled in elementary content-based mathematics courses focusing on the units of practice of College Algebra and Statistics.

Having persistence assists in PSTs understanding that there will be bad days, but the next attempt they makes holds the possibility of success. PSTs need this practice from the student perspective and know how to assist their future students to productively struggle. As PSTs have continued to develop and learn during CoVid-19, this is ever more significant as PSTs face teaching and engaging students using alternative methods while also being challenged to redefine classroom management and associate with parents, administration, and other educational professionals. Therefore, our research questions were:

- Did the mindset and persistence of PSTs shift when engaging in coursework over two units of practice that used college algebra and statistics in face-to-face delivery methods before and during CoVid-19? Furthermore, did PSTs mindset and persistence change over the course of each individual unit?

Method

This study was guided by the concepts of PSTs' mindset and persistence while engaged in mathematics content-specific coursework. IRB approval was obtained, and data collected from elementary PSTs' content coursework in different states. Southern University State data was collected during the Fall 2019 semester before any indications of CoVid-19 were being mentioned in the classroom and class ran f2f as typically had been done in previous semesters. Northeastern State data was collected during the Fall 2020 semester while CoVid-19 continued to evolve. Classes for the studied at Northeastern State were done in a hybrid fashion with Day 1 each week with half the class f2f one day, the other half attending remotely; Day 2 each week had students shift attending opposite of the previous class period, and Day 3 each week alternating f2f versus remote each week. This study looked for differences in mindset and persistence for PSTs in pre- and during-pandemic groups.

Data sources

After obtaining IRB approval and PST consent for each study, comparisons within each group and between groups were analyzed. This study took place on two college campuses during the PSTs mathematic-specific content coursework required for state licensure. Southern University State was a small liberal arts college (SMLC) in a larger midwestern city, where the primary sources of employment are multiple medical centers/hospitals, several other SMLCs, and various manufactures/factories.

All data for Southern University State was collected and completed before CoVid-19 was known to exist in the United States. Southern University State Unit One covered topics that are commonly found in College Algebra coursework such as number systems and their representations, creating and understanding sets etc. Unit Two covered

statistical topics that are found in foundational statistics coursework such as probability, the normal curve, z-scores/using tables, etc. Northeastern State was a medium-sized university in a small midwestern city, where the primary sources of employment were the local hospital, the university, and a manufacturing factory. All data for Northeastern State was collected and completed using CoVid-19 mitigation procedures for research and teaching as the university was f2f for the 2020-2021 school year.

Participants

Participating PSTs were mostly in their freshman/sophomore years of post-secondary education and also include several transfer students. PSTs were taking the courses as part of elementary or early childhood state licensure program and their major degree requirements. Approximately 25 PSTs from Southern University State and 150 PSTs from Northeastern State were eligible to take the surveys. Demographically, Southern University State had 1 PST of color and 24 white PSTs while Northeastern State had 3 PSTs of color, 123 white PSTs, and the remaining did not identify. Participating PSTs consented, completed each survey at least once, and completed the coursework. Due to the nature of online survey's, some PSTs submitted surveys multiple times. Only the original submission was used. PSTs participation in the study included short surveys about their mindset and persistence several times during their coursework. Only survey data was collected, and no follow up interviews or surveys were asked to be completed after course completion. Participating PSTs were included in the data set when they engaged with the surveys each of the three times: pre-unit 1, post-unit 1/pre-unit 2, and post unit 2. Based on the inclusion criteria, 17 PSTs participated from Southern University State and 102 PSTs from Northeastern State were included in the final analysis.

Table 1. Participants demographics based on university attending

Race	<i>Southern University State (SUS)</i>		<i>Northeastern State (NS)</i>	
	Male	Female	Male	Female
Students of Color	1	0	0	3
White/ Caucasian	4	12	4	95

Measurement instruments

To analyze PSTs' mindset and persistence, two quantitative measures were used before and after each unit. The post-survey of unit 1 also served as the pre-survey of unit 2. The 8-question Theory of Intelligence scale was used to measure PSTs' mindset (Dweck, 2006; Levy et al., 1998), and PSTs' persistence was measured using the 8-question Grit-S scale (Duckworth et al., 2007).

Theory of Intelligence. The *Theory of Intelligence* was used to measure PSTs' mindset that was validated by Levy et al. (1998). Responses were validated between the 3-item and 8-item correlated between 0.83 and 0.92 (Levy et al., 1998) and has been used in studies with both undergraduates and PSTs (Choi, 2018; Christopher, 2018; Gutshall, 2014; Kassae, 2016). Our study used the 8-question version. The survey consists of two subscales: fixed-mindset and growth-mindset questions which have been modified to have a focus on mathematics. If the original question asked respondents to rate the degree to which, "Your intelligence is something very basic about you that you can't change very much;" the mathematics-adapted questions were, "Your math intelligence is something very basic about you that you can't change very much."

Grit-S. The Grit-S (8 questions) was used to measure the PSTs' persistence and was adapted from the 12-item Grit-O (Duckworth & Quinn, 2009). The Grit-S is shorter and psychometrically stronger. The Grit-O and Grit-S surveys were determined to show adequate internal consistency and interrelation with $r = .59$ ($p < 0.001$), after multiple comparison studies were completed. The Grit-S 8-item measure has two subscales, the perseverance of effort factor and the consistency of the interest factor. The Grit-S questions were adapted to look at students' trait-level perseverance and passion for long-term goals in mathematics. When the original question asked respondents to rate the degree to which, "I am a diligent worker," the adapted question was, "I am a diligent worker in math class."

Collection procedures and analysis

Participating PSTs accessed and completed the survey using an secure online link. PSTs completed the same survey three times over two, specific units of practice aligned between the Southern University State that was also covered in Northeastern State. The pre-survey was completed at the start of both courses of the fall semester, mid-survey was completed between units, and a post-survey that was completed at the end of the second unit. Surveys for Southern University State were allowed to be completed during the course in person or online within 5 days of opening; however, due to CoVid-19 mitigation measures, Northeastern State surveys were given solely for PSTs to complete on their own and were open for 5 days each time. In both courses extra credit points were offered for completing the survey measures (approximately a grade increase of 5% overall). PSTs participation in the study was not connected to their ability to receive the extra credit; they were offered alternative assignments to gain extra credit if they chose not to participate in the study.

The survey consisted of three parts: the first part asked for specific course/instructor information and other demographic data; the second part asked mathematics-focused variations of the Theory of Intelligence questions; the third part asked mathematics-focused Grit-*S* questions.

To answer the question of mindset/persistence shifts occurring within the two units of practice, scores were looked at individually for each university group. To find if each PSTs' mindset and persistence had improved, PSTs' ending scores were compared to their starting score, then divided by the starting score and multiplied by 100 to find the percentage value of better for mindset and persistence. PSTs shifts in mindset and persistence were labeled as positive, neutral, or negative based their percentage value.

Results

Our first research questioned considered whether the mindset and persistence of PSTs change, for the better, when engaging in coursework over two units of practice that used College Algebra and Statistics in f2f delivery methods before and during CoVid-19. Table 2 compares each universities' PSTs that demonstrated improved mindset and persistence scores within the college algebra and statistics units of practice. Northeastern State offered multiple sections across multiple instructors, whereas Southern University State offered one section of each course taught by the same instructor.

Table 2. Shift in mindset and persistence by university

Unit of Study	Southern University State		Unit of Study	Northeastern State	
	Mindset	Persistence		Mindset	Persistence
College Algebra ($n = 13$)*	3	3	College Algebra ($n = 85$)*	34	44
Statistics ($n = 17$)*	12	5	Statistics ($n = 88$)*	40	40

*PSTs with a negative shift were not counted as a shift

During f2f delivery to PSTs at Southern University State, three student's mindset and three PST's persistence improved, shifting towards a growth mindset and higher persistence levels, respectively, after engaging with College Algebra materials. Additionally, during f2f delivery of statistics twelve PST's mindsets shifted more towards growth mindset and five PSTs shifted towards higher persistence levels.

During hybrid delivery at Northeastern State, 34 PST's mindset and 44 PST's persistence improved, shifting towards growth mindset and higher persistence levels, when engaged with College Algebra materials. During hybrid delivery of statistics content, 40 PST's mindsets shifted more towards growth mindset and higher persistence levels.

For f2f delivery the number of PSTs surveyed as shifting their mindset for the better increased 300%; whereas in the hybrid course the number of PSTs who surveyed as shifting their mindset for the better increased approximately 188%. Based on the values of mindset and persistence during hybrid learning, PSTs self-reported less shifts towards a growth mindset but more PSTs self-reported shifts towards higher persistence levels.

Discussion

Programs within teacher education have evolved over the last century as the majority have placed a greater emphasis on classroom engagement and experiences. Before CoVid-19, few universities offered the option of using virtual/remote

learning and rather focused on f2f engagement and instruction with PSTs. However, CoVid-19 drastically caused almost all universities to pivot towards some variation of online or hybrid learning for PSTs. Having these experiences has changed how teacher candidates were expected to engage, learn, and teach in preparation for their future educational careers. Therefore, this study focused on looking at PSTs who were in the beginning stages of their programs before/during CoVid-19 to consider if improvements to their mindset and persistence could be observed via a self-reported survey, taken in their mathematics-content coursework.

PSTs during this study were early in their content/methods course sequence moving towards initial teacher certification. Our study saw similarities to the Gutshall (2014) study that noticed many of the participating PSTs saw their mindset improve – moving towards having a growth mindset. While some of these same PSTs' mindset moved more towards a growth mindset after the second focused unit of practice, as in Gutshall's study, PSTs mindset shifted as they progressed through their content and methods coursework. Improved PSTs mindset and persistence was starting to occur as growth mindset and higher persistence language and tasks were used within PSTs coursework.

Our study results found similarities to Panuesku et al. (2015) where long-term practices that incorporated mindset and persistence actions within coursework (rather than one-time experiences) saw the improvement of PST's mindset and persistence that could positively influence their future students' mindset and persistence in mathematics. PSTs showed improvement of their mindset and persistence in the majority points throughout the semester. As the research into mindset and persistence stems from social cognitive theory (Bandura, 1977), the differences in mindset and persistence improvement between the College Algebra and Statistics units can be explained because self-efficacy is strictly task-specific: measuring statistics self-efficacy will allow you to observe significantly better outcomes than looking at the broader measure of "math" self-efficacy (Pajares, 1996; Pajares & Miller, 1995; Perney & Ravid, 1990; Sesé Abad et al., 2015; Vigil-Colet et al., 2008; Williams, 2014).

Knowing that PSTs will demonstrate these shifts over the courses as they prepare for initial certification, they can likely continue working to improve their views of mindset and persistence in their own future classrooms. PSTs are preparing to be classroom teachers, thus understanding how to teach curriculum while still developing their mathematical understanding as a student (Campbell et al., 2014) will assist in understanding how to phrase feedback and choose tasks that may allow for shifts in their own future students' mindset and persistence. If PSTs take these improved views of their own mathematical mindset and persistence into their methods coursework and other coursework, this can assist with the change of views on multiple strategies, methods, and answers from their own future students. Similar to Mokher et al.'s (2020) recent study on remedial mathematics programs, our PSTs were surveyed with the perception of having changed their views while engaging with mathematics content and their views of success. PSTs' shifts towards a growth mindset and higher persistence levels in prerequisite mathematics content coursework could affect their how PSTs approach their methods courses. Within methods courses PSTs typically are not relearning materials, but rather engaging in the various strategies that focus on engaging their future students and/or strategies to approach tasks that will gain similar end products with differences during the interim steps. Adjusting PST mindsets towards growth and higher persistence prior to their enrollment in methods courses could positively impact their own thinking and their engagement with their future students, particularly when PST engage in challenging tasks.

Limitations and Recommendations

One major limitation of this study was the introduction of CoVid-19. The time of the second school data collection there was mask mandates, cleaning mitigation, and social distancing attempts while classes were held in an adjusted f2f manner. All PSTs were part of contact tracing, but all data collection was done before a vaccine was developed or available to PSTs. Thus, a limitation of this study was the lack of evidence collection to control for the potential outside influence of the ongoing pandemic as well as lack of evidence collection that might allow for a correction of the data collected from the study group that was not aware of the way that the pandemic would shift their daily lives and professional practice.

An additional limitation was a heavy focus on non-BIPOC due to the location of each higher institute of education and the students that attended the universities. The campuses were diverse for their location in ways such as age of students, age of faculty, sexuality, and political views. The lack of BIPOC in the elementary and early-childhood classroom is mirrored in the lack of PSTs of color in this study that can later be seen as role models in their future classrooms. Along similar lines, there are major differences between the number of PSTs that participated in mathematics educational courses and the study at Southern University State and Northeastern State during the pilot semesters of the study. Thus, these results can be applied under similar circumstances, but cautiously applied or generalized to more diverse locations or universities with early childhood and elementary TEPs.

The authors of this study have the following recommendations as CoVid-19 will continue to impact classroom learning at all levels. First, standards and course expectations of engagement with f2f learning with students does not allow this shift in mindset and persistence for PSTs to just occur. We recommend that mindset/persistence (ideas/activities/trainings) are implemented consistently throughout PSTs content and methods coursework. Second, PSTs will be engaging future students who also experienced CoVid-19 learning times and can understand what improvements can still be made to learning in various modalities, so these PSTs have awareness of current student needs. The improvements that PSTs envision should be heeded as they have a unique view and experience in the field. Third, PSTs are likely to be more accepting and flexible as they enter their future classroom about issues such as student illness, alternative engagement and teaching methods/strategies, and assessment methods, so these PSTs may be more open to engage with research-based resources, methods, and grading procedures. Going forward CoVid-19 is likely to continue to impact PSTs and how they will engage with mathematics courses as students and in their own future classrooms for years to come. The shifts to learning, the challenges, and methods should be studied and compared with pre-CoVid-19 teaching, when possible, to understand how much, CoVid-19 may have shifted ideologies in the moment and long term.

In conclusion, understanding PSTs' mindsets and persistence will have a significant impact for their engagement with teaching materials and for their future students' potential performance. PSTs' mindset and persistence in two college courses were measured and pre- and post- course scores were compared looking at how their mindset and persistence improved during the course. Educators will continue to see the shifts in learning and impact of CoVid-19 in their future classroom, yet research needs to understand how as future educators, PSTs, will take their own mathematical mindset and persistence into their future classrooms.

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