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Quantitatively Investigating the Effects of Multiple Strategies on Pre-Services Teachers' Mindset and Persistence

Amanda Meiners (Professor)[1*], Kyong Mi Choi (Professor) [2], Dae Hong (Professor)[3]

[1] Northwest Missouri State University, ameiners@nwmissouri.edu
[2] University of Virginia, kc9dx@virginia.edu
[3] University of Iowa, dae-hong@uiowa.edu

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Pre-service teachers (PST) are students who are developing their mindset, persistence, instructional practices, and perception of tasks from two perspectives: as current students and as future teachers. As part of a larger study with PSTs engaged in a mindset intervention, this study quantitatively investigated PSTs mindset and persistence. During professional development (PD), PSTs engaged in multiple strategies (MS) tasks that promoted changes to PSTs mindset and persistence. PSTs' mindset pre- and post- PD were categorized after attending at least 4 interventions as fixed, mixed, or growth using the *theory of intelligence*, and their persistence as high or low using the Grit-*S*. Changes in categorization were noticed and explored for reasons of what could be done to make mindset interventions more effective such as consistently using challenging mathematics tasks with more open ended answers and focusing on discussion based mathematical lessons.

Keywords: mindset, persistence, multiple strategies, pre-service teachers, intervention
MESC Classification: A30

MSC2010 Classification: 97A30

I. INTRODUCTION

In education, *mindset* is the core beliefs students have about their own learning and the possible change(s) that learners may or may not be conscious of (Dweck, 2006). There may be parts of activities students believe they can complete, while there may be other

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* Corresponding Author: ameiners@nwmissouri.edu

parts of the same activities they do not feel as comfortable and confident completing (Boaler & Dweck, 2016). Students' self-evaluation can cause them to fear facing challenges, thus what intervention can be done to more effectively reduce students' fears.

Interventions using mindset facilitate the development of students' view of their intelligence, while lessening the fear of being challenged (Boaler, 2016; Bostwick et al., 2017; Broomhead, Skidmore, Eggett, & Mills, 2012; Brougham, 2016; Howard, 2008). Research using mindset interventions, guides students to develop their intelligence and how they can expect their intelligence to change. In addition, a mindset intervention can boost students' confidence about their potential, their willingness to engage with challenging tasks, and their desire to persist in learning. Previous mindset-based intervention strategies used Dweck et al. 's (1995) dichotomic framework viewed the world from two perspectives: fixed mindset and growth mindset (e.g., Boaler & Dweck, 2016; Donohoe, Topping, & Hannah, 2012; Dweck, 2000; Dweck & Master, 2008; Mueller & Dweck, 1998; Orosz, Péter-Szarka, Bőthe, Tóth-Király, & Berger, 2017; Yeager & Dweck, 2012).

As research continues exploring mindset interventions, intervention adaptations have focused on influential changes and benefits of mindset. In mathematics classrooms, mindset intervention outcomes have been conflicted (Brougham, 2016; Burnette, Russell, Hoyt, Orvidas, & Widman, 2017; Orosz et al., 2017; Rhew, 2016). The positive outcomes of using a mindset intervention (Andersen & Nielsen, 2016; Broomhead, Skidmore, Eggett, & Mills, 2012; Burnette et al., 2017; Daly, Martens, Barnett, Witt, & Olson, 2007) provided key considerations while other studies adjust mindset intervention materials. For example, using a mindset intervention Orosz et al. (2017) sought to determine if grade point average (GPA) of 55 high achieving, tenth graders could be further increased. However, no significant GPA increases occurred, other findings demonstrated the mindset intervention promoted a growth mindset that students maintained throughout the intervention. The negative out comes of using a mindset intervention include Orosz et al. (2017) that used Dweck et al.'s (1995) mindset intervention with 112 Hungarian tenth-grade students for five weeks with 55 students attended all workshops and taking all pre and post measures. Students' beliefs about intelligence were examined in a posttest three weeks later, and their mindset was found to still be malleable. However, when their mindset when tested an additional two months later (four months from the original pre-test date), students' beliefs about intelligence had returned to pre-intervention levels for students who had not continued to use the growth mindset core beliefs discussed during the intervention sessions.

Promoting mindset and using MS in the mathematics classroom are moves towards best mathematical practices (Leinwand et al., 2014; NCTM, 2000, 2012) and such models have been used for some time (Blackwell, 2007; Yeager & Dweck, 2012; Boaler &

Dweck, 2016; Lynch & Star 2014a; 2014b). However, research has not considered how mathematics best practices as defined by the National Council of Teachers of Mathematics (NCTM; Leinwand et. al, 2014) affect PSTs' mindset and persistence, particularly when challenging mathematics tasks are used. Additionally, mindset interventions in K-12 classrooms make be more likely to continue if PSTs experienced a mindset intervention as student before implementing as a teacher in their future classroom. With this purpose in mind the research question was, after using a mindset intervention combined with the instructional practice of MS, *what can be done to make mindset interventions more effective?*

II. LITERATURE REVIEW

Dweck and her colleagues began investigating when students categorized their learning experience as "successful," and when they categorized it as a "failure" over four decades ago (Diener & Dweck, 1978, 1980; Dweck & Leggett, 1988). Their research deepened researchers' understanding of students' views of learning and helped interpret beliefs about adapting when challenges arise in various areas of their life. In education, mindset considers how open students are towards learning a skill, concept, or content area (Boaler, 2016). Recently, there has been a resurgence in research using a mindset intervention. Some studies have described conflicted results (Brougham, 2016; Burnette, Russell, Hoyt, Orvidas, & Widman, 2017; Orosz et al., 2017; Rhew, 2016), and others have described positive outcomes (Andersen & Nielsen, 2016; Broomhead, Skidmore, Eggett, & Mills, 2012; Burnette et al., 2017; Daly, Martens, Barnett, Witt, & Olson, 2007).

1. WHAT IS MINDSET?

In education, observing students' fear of challenges when doing puzzles or while engaged in other challenging tasks has two different meanings (Dweck & Leggett, 1988; Farnell, 2017). These meanings relate to mindset and have been separated as *a fixed mindset*, students feel their abilities are limited, and *growth mindset*, students feel their abilities are flexible. These different meanings prompt students to contemplate how their mindset presumes what is or is not a priority (Dweck, 2006). Is the priority based on success, fame, or fortune? Do students want to be viewed as perfect or put on a pedestal? Or would they prioritize putting in the effort to overcome challenges, even at the risk of revealing their weaknesses to others?

For PSTs and in-service teachers, it is important they understand their own individual priorities and risks. Understanding their previous experiences before they were a teacher may affect their student's willingness to engage in challenging tasks because that may affect how they instill mindset concepts in their future students. For example, Gutshall (2014) used a mindset intervention with pre-service and in-service teachers comparing pre- and post-intervention views of intelligence. At the end of the intervention, participants left with an understanding that intelligence was flexible. If pre-service and in-service teachers learn methods that include tasks that prompt their students to learn towards a growth mindset, it may expand their own core beliefs about mathematics and guide them to open their students to recognize and attribute failure as an essential part of learning.

Understanding students' thinking about mathematics is not new; rather, what has changed is recognizing and categorizing students' mathematical mindset and persistence (Boaler & Dweck, 2016; Dweck, 2006). Boaler (2016) described a mathematical mindset as the beliefs students have about their abilities in mathematics. Students' mathematical mindset may vary and shift their perception after the intervention of their own mathematical abilities (Boaler & Dweck, 2016). Similarly, teachers' understanding their own beliefs can lead to developing a mathematical mindset that may lean towards a fixed or growth mindset (Boaler & Dweck, 2016) that are passed along to students.

Mathematical mindset is now a continuum that has evolved from research-based theories using a dichotomous mindset framework. The split nature of mindset emerged from the theory of intelligence (Diener & Dweck, 1978) and continued with the questions of self-theory (Dweck & Master, 2008) to develop into the current framework of mathematical mindset (Boaler & Dweck, 2016). Like mindset evolving, so has mindset interventions making some more effective to changing mindset and persistence than others. Yeager and Dweck (2012) described four components that may develop participants mindset. Multiple studies have recently focused on the first component-goals and second component-effort (Duckworth & Quinn, 2009; Lin-Siegler et al., 2016; Schmidt, Shumow, Kackar-Cam & 2017; Robertson-Kraft & Duckworth, 2014; Yeager et al., 2015). However, not many have focused on using Yeager and Dweck's (2012) third component-attribution for setbacks and fourth component-engagement despite setbacks as the focus. This study aimed to use a mindset intervention that focused on third and fourth components, to determine *what can be done to make mindset interventions more effective.*

Previous research using mindset interventions demonstrates the conflicted effective results of using a mindset intervention with students. For example, Schmidt et al. (2017) noticed observable differences during daily classroom experiences for 7th and 9th graders. Observed students who received a mindset intervention showed more self-regulation, higher self-efficacy, and increased learning opportunities. However, 7th graders exposed to a mindset intervention did not have any observable changes in their daily classroom experiences; whereas 9th graders exposed to a mindset intervention described increased self-regulation, self-efficacy, and interest while being able to maintain their levels of skill and learning. Additionally, previous research focused how over time mindset intervention effectiveness may fade without continued support. For example, McCutchen et al. (2016) conducted a longitudinal study that linked growth mindset students to test scores to decline at a slower rate than those with a fixed mindset but both groups saw a decline when intervention was not continuous. Thus, mindset intervention in mathematics for students to retain effects may require researchers, teachers, parents, and students to offer continuous support.

2. MINDSET AND PERSISTENCE

Research has considered the effects of in-service teachers' mindset and persistence on their instructional practices, beliefs, and mindset (Blad, 2015; Jones, 2017; Swann & Snyder, 1980). Shifting teachers' professional beliefs may take place during professional development (PD) or intervention once in service or before they enter the teaching profession as PSTs. Using what teachers learn during PD, they can influence their students' perception, mindset, motivation, and persistence (Truax, 2018). Shifting teacher's professional beliefs towards improving their students' mindset and persistence towards understanding the subject materials (Menanix, 2016), specifically, while students engage in mathematics tasks, does not begin after they enter their classrooms. Shifting in-service teachers' mindset and persistence about mathematics is a process that starts during their Higher Education programs and experiences.

Insufficient research has considered students' mindset or persistence in higher education (Yorke & Knight, 2004), particularly for students who are PSTs (Hourigan, Leavy, & Carroll, 2016; Lazar, 2007). Also, of Yeager and Dweck's (2012) four mindset components-goals, effort, attribution of setbacks, and engagement in setbacks- reach has focused on goals and effort. The overall study focused on the mindset components of PSTs' attributions for setbacks and engagements in setbacks, with the lens of how mindset interventions could be made more effective for future research.

Additionally, using a mindset intervention with PSTs' mathematics remains largely unexplored; specifically, investigating how, and if, intervention is effective in changing PSTs' mindset and persistence when they are asked to engage with challenging tasks that use of multiple strategies (MS). This is significant as, PSTs will eventually be teaching in their own classroom. Also, a mindset intervention that uses these ideas may boost the confidence about potential, their willingness to engage with challenging tasks, and their desire to persist in learning. Studying PSTs' when completing challenging mathematical tasks is particularly important because they affect their future students. Therefore, it is important that their teacher education preparation include analysis of their own mindset and persistence about mathematics.

Pre-Service Teachers (PSTs)

For pre-service teachers (PSTs), the relationship between their own beliefs and goals they hope to achieve in their future classrooms becomes more recognizable as they come closer to obtaining their teaching credentials. PSTs' view of their perceived effort while engaging in mathematical tasks is an extension of their personal mindset (Boaler & Dweck, 2016), specifically, how they define being successful in mathematics and what it means to increase their mathematical understanding. As part of their methods classes, PSTs' course work may include the ideas of a mindset intervention without focusing solely on a mindset intervention (Fraser, 2017). Using qualitative methods when a mindset intervention was used in Scottish PST courses, Fraser (2017) identified four broad themes. These themes include a) embarking on the process, b) classroom culture and teaching, c) outside the classroom, and d) pupil approach to learning, all of which are supports apart from classrooms that promoted a growth mindset through teaching and learning. PSTs who lean towards a growth mindset may emphasize how the amount of the perceived effort helps them build their content knowledge connecting the concepts. On the other hand, PSTs with a fixed mindset may view the role of perceived effort as a lack of their natural talent or the inability to reach the achievement level of their growth mindset peers without putting in a substantial effort.

One of the goals of a mindset intervention is to lean students' view of intelligence towards a growth mindset. PSTs that understand student's perspectives of how to engage in challenging tasks and, as a teacher, are able to develop challenging mathematical tasks that create growth mindset discussions may help make mindset inventions more effective. Thus, having PSTs recognize their mindset before and after mindset intervention may more effectively facilitate and engage their future students during challenging mathematics tasks.

Embedding long-term mindset intervention into PSTs course work may create steady classroom changes influencing how PSTs engage with challenging tasks and what methods they implement to engage their future K-12 students in challenging tasks (Paunesku et al., 2015). Recent studies showed that steady changes are more influential than single, compact intervention strategies that only focus on mindset for a short time, sometimes referred to as one-off interventions. As Brougham (2016) unexpectedly found, using purely a growth mindset intervention did not lead to any improvement in students' core GPA scores. Whereas after three sessions, Aronson et al. (2002) found a 0.21 GPA increase, and after eight sessions, Blackwell et al. (2007) found a .31 difference in GPA between treatment and control groups using a mindset intervention. Paunesku (2013) also found using a growth mindset intervention increased students' mathematics completion rates and mastered more concepts. Thus, if one-off mindset interventions continue at the K-12 level, the impact may be minimal.

In conclusion, as the concept of mindset developed, researchers noticed that there were distinct mindsets, fixed mindset, and growth mindset as part of a continuum with the mixed mindset at in between (Boaler & Dweck, 2016). In the field of mathematics education, this is significant as a mathematical mindset provides a way to associate students' beliefs about their intelligence and how they engage in mathematical tasks. For PSTs, there are implications for how they will instill the ideas of mathematical mindset into their future students and how using a mindset intervention could more effectively develop these implications.

III. RESEARCH METHODLOGY

This study was part of a larger study that was guided by the concepts of persistence, MS, while using a mindset intervention. As PSTs completed challenging MS mathematics questions, the strategies they choose to use were theorized to be based on their mindset, and how they persisted. PSTs' knowledge of MS informed the research on how mindset and persistence were affected when PSTs use the instructional practice of MS during PD based on a mindset intervention. This view of MS, mindset, and persistence is shown in Figure 1 and was framework that guided the larger study. The current smaller study investigated what can be done to make using a mindset intervention more effective.

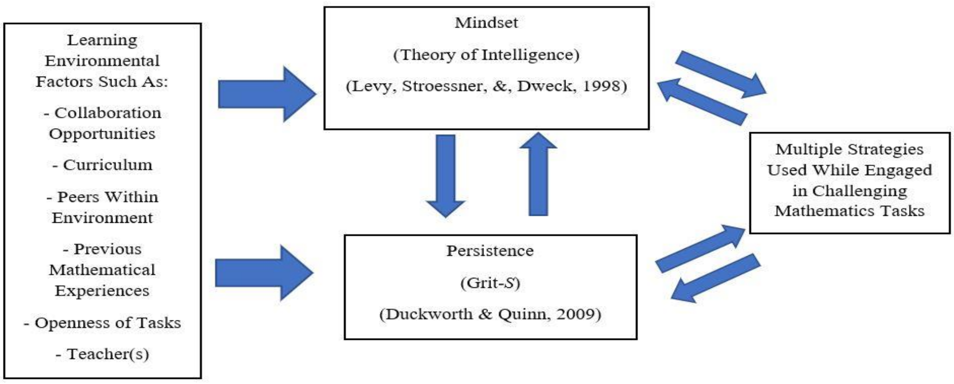

Figure 1. Theoretical framework and focus for study

1. PARTICIPANTES

The researcher met and spoke with the TEP opportunities liaison several times in the Spring 2018 semester, before the beginning of the study. This liaison published opportunities available to PSTs each semester to meet certification requirements each semester where PSTs across eight content areas (art, English, foreign language, mathematics, music, science, social studies, and elementary) were admitted into the teacher education program (TEP) as elementary or secondary PSTs. Typically, more elementary than secondary PSTs were admitted. Participants self-selected to attend and engage in PD opportunities offered by The College of Education TEP at large mid-western university in the United States. A five-session series of interventions were advertised through the college's online event calendar system and introductory TEP course work. Table 1 outlines how data were collected and address the previously stated research question.

Table 1. Data Phases

Phase 1. Obtained consent from PST participating take the pre-survey measures of the Theory of Intelligence and *Grit-S.* PSTs attend a series of 5 workshops that work through 4-8 mathematical tasks they may or may not find challenging focusing on using the instructional practice of MS, persistence, and mindset. At the end of the series of 5 intervention workshops, participants complete the complete the post survey measures of the Theory of Intelligence and *Grit-S* .		
Phase 2. Tallied survey data of PSTs who fall into categories of:		
FL→ fixed mindset low persistence	ML→ mixed mindset low persistence	GL→ growth mindset low persistence
FH→ fixed mindset high persistence	MH→ mixed mindset high persistence	GH→ growth mindset high persistence

As a part of a larger study, 78 PSTs participated in a series of survey and met the following inclusion criteria: 1) they were PSTs of The College of Education at the large mid-western university in the TEP 2) the PST attended a minimum of four of the intervention sessions held and 3) took both the pre- and post-survey measures. 12 PSTs met inclusion criteria with 6 as elementary, 4 secondary-3 math specific, and 2 K-12 music specific.

2. DATA DESCRIPTION

Measurement Instruments

To analyze PSTs' mindset and persistence, two quantitative measures were used pre- and post- intervention. The 8-question theory of intelligence (Levy, Stroessner, & Dweck, 1998; Dweck, 2006) was used to measure PSTs' mindset, and the 8-question Grit-*S* (Duckworth et al., 2007) was used to measure PSTs' persistence. Survey scores were categorized based on the combination of the theory of intelligence options (fixed, mixed, and growth mindset) and the two options (low and high persistence) of the *Grit-S* surveys.

a) Theory of Intelligence. To measure PSTs' mindset, the *Theory of Intelligence* was used. Levy, Stroessner, and Dweck (1998) conducted five validation studies and found the 8-item scale to be compatible with the original 3-item mindset measure. Moreover, responses to the 3-item and 8-item measures in two validation studies were correlated between 0.83 and 0.92 (Levy et al., 1998). The 8-item measure has been used both with undergraduate students and PSTs (Choi, 2018; Christopher, 2018; Gutshall, 2014; Kassaee, 2017). The Theory of Intelligence surveyed where PSTs were on the mindset continuum before and after participating in the mindset intervention. The questions consist of two subscales: the fixed mindset subscale and the growth mindset subscale.

b) Grit-S. The *Grit-S* was used to measure the PSTs' persistence. The researcher measured the PSTs' persistence when challenged before and after participating in the intervention. The 8-item Grit-S is adapted from the 12-item *Grit-O* (Duckworth and Quinn, 2009), and is shorter and psychometrically stronger. In previous studies, these two surveys were determined to show adequate internal consistency and interrelation, $r = .59$ ($p < 0.001$), when studied with students at West Point, national spelling bee contestants, adults older than 25, and students in grades across 7th to 11th. This 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 specific to mathematics. If the original question asked then to rate the degree to which, "I am a diligent worker," the math adaptation questions were, "I am a diligent worker in math class." Originally, another question asked, "I am a hard worker," whereas the mathematics adapted question asked PSTs, "In math class, I am a hard worker."

Although many studies have used the theory of intelligence (Bostwick, Collie, Martin, & Durksen, 2017; Cartwright & Hallar, 2018), the Grit-*S* surveys (Akos & Kretchmar, 2017; Galla et al., 2014), or both (Orosz, Péter-Szarka, Bőthe, Tóth-Király, & Berger, 2017; West et al., 2016; Wilson, 2017), there is not a particular cut off score that establishes a fixed, mixed, or growth mindset and high or low persistence. In this study, the theory of intelligence survey was scaled using a one if PSTs completely disagreed with a statement, and a seven if they completely agreed with the statement. Knowing that the fixed, mixed, and growth mindset split is approximately 40/20/40 (Dweck, 2006), individual PST's Post-PD scores were categorized as outlined in Table 1. Therefore, a PST with a Post-PD score of 1 to 3.4, was considered a fixed mindset, a score of 3.4 to 4.6 was a mixed mindset, and a score greater than 4.6 was considered a growth mindset. A Post-PD score higher than 4.6 was categorized as growth mindset. To determine High and Low Grit-S score, PSTs with a score of 3.5 or less were considered to have low persistence and PSTs with a score above 3.5 were considered to have high persistence (Duckworth & Quinn, 2009).

3. DATA COLLECTION PROCEDURES

Procedures

IRB approval for the larger study was obtained before interventions began. Additionally, prior to the beginning session of PD, the survey for this study was generated using Qualtrics software (version September 2018). This software used an online platform for PSTs to consent as well as take the pre- and post-survey measures. The following steps generally outline the rest of the data collection process. PSTs took the pre-survey at their first attended intervention session before any intervention took place. To increase students' participation in the intervention, monetary gift cards were raffled for those who met the attendance requirements of the intervention and had completed the surveys. After all intervention sessions were completed, students took the post-survey measures, at which time demographic data were also collected. After the intervention was completed and survey measures were tallied, students' scores were tallied and were placed into one of the six categories, as described in Phase 2 of Table 1.

a) Intervention Procedures. Intervention sessions were held for five consecutive weeks, with PSTs choosing which sessions they attended. During the intervention, PSTs were asked to look for more than one way to complete the proposed challenging task(s) during that day's session. In addition, the ideas of mindset and persistence were discussed multiple times throughout each intervention session. PSTs completed readings about mindset and persistence while engaged in tasks using MS.

The intervention consisted of five, approximately 60-minute intervention sessions about mindset, persistence, and MS tasks. The MS tasks each had multiple correct answers, where the answer depended on how PSTs decided to approach the task. Each session opened with a short discussion about mindset or persistence, followed by a mathematical task from OpenMiddle™ using MS that PSTs could use in their future classrooms. Most attendees intended to teach students in K-12. To find a balance between these grade levels, most of the tasks chosen fell in the grade levels of fifth to ninth grade to best overlap with PSTs' preparation for their possible future classrooms. As per the request of the college hosting the intervention, PSTs could attend intervention sessions as a series or they could attend as many or few sessions as they wanted. While the central focus from session to session connected to the ideas of mindset, persistence, and MS, students who had not attended previous sessions were still able to participate because the individual session's central focus was independent of previous sessions. For each session, there was a mathematics concept objective and a mathematical practice objective that aligned with the current National Council of Teachers of Mathematics (NCTM) standards, the state core standards, the NCTM Standards of Mathematical Practice (SMP), and the NCTM Mathematics Teaching Practices (MTP). The overall central focus of the interventions used MS in mathematics classes, with each session theme more focused on the mathematical topic being used based on the sessions' state standards. Variations of these materials were successfully piloted in previous studies with middle school students and middle school teachers.

IV. RESULTS AND DISCUSIONS

As part of the larger study, attending PSTs were asked to complete the pre- and post-survey. The initial sample included 78 PSTs who attended at least one intervention session. 12 PSTs attended at least four sessions. PSTs were included because they had completed both pre- and post-surveys 1) Theory of Intelligence and Grit-*S* survey results, and their 2) they met participation (at least four sessions attended) requirements. The Theory of Intelligence survey identified PSTs' mindset, and the Grit-*S* survey identified PSTs' persistence pre- and post- intervention.

Table 2 shows each PST's mindset categorized scores. Based on their scores, each PSTs' mindset and persistence fell into the following categories: 1) fixed mindset, 2) mixed mindset, and 3) growth mindset.

Table 2. PSTs' Mindset Pre-, Post-Scores

PST Mindset Category	Pre				Post			
	n	Mean	SD	Range of scores	*n*	Mean	SD	Range of scores
Fixed	1	3.375	N/A	N/A	2	3.375	0	3.375
Mixed	6	4.186	0.293	3.75 to 4.6	4	4.1875	0.2.39	4 to 4.5
Growth	5	5.625	0.619	4.875 to 6.5	6	6	0.742	4.875 to 6.75
Total (*N*)	12	4.719	0.933	3.375 to 6.5	12	4.958	1.237	3.375 to 6.75

As shown in Table 2, half the PSTs who participated in the study left with a growth mindset, a third left with a mixed mindset, and a sixth left with a fixed mindset. The growth mindset PSTs had scores ranging from 4.875 to 6.75, a mean growth mindset score of 6 out of 7, and a standard deviation of 0.742, whereas the fixed mindset PSTs (n = 2) scored the same value of 3.375.

Table 3 shows PST's persistence categorized scores. Based on their scores, each PST's persistence fell into the following categories: 1) low persistence and 2) high persistence.

Table 3. PSTs' Persistence Pre-, Post-Scores

PST Persistence Category	Pre				Post			
	n	Mean	SD	Range of scores	*n*	Mean	SD	Range of scores
Low	1	2.5	N/A	N/A	0	0	N/A	N/A
High	11	4.48	0.55	3.75 to 5.625	12	4.76	0.631	4 to 5.75
Total (*N*)	12	4.313	0.775	2.5 to 5.625	12	4.958	1.237	4 to 5.75

As shown in Table 3, all the PSTs who met the inclusion criteria demonstrated high persistence on the post-survey. The average persistence score was 4.76 (n =12), with a standard deviation of 0.631, and scores ranging from 4 to 5.75 (scale 1 to 7; above 3.5).

To demonstrate the change between PSTs' pre- and post-intervention survey scores, Table 4 shows this matrix.

Table 4. Number of PSTs Categorized Based on Theory of Intelligence and Grit-S Scores

		Mindset Scores (Theory of Intelligence)		
	Persistence Scores (Grit-S)	Fixed	Mixed	Growth
Pre	Low	0	0	1
	High	1	6	4
Post	Low	0	0	0
	High	2	4	6

Each PST was placed in appropriate cells based on their post-intervention scores. It should be noted that there were no PSTs whom both held fixed or mixed mindset beliefs and had low persistence before or after the intervention. However, there was 1 PST with a growth mindset and low persistence before the PD started that transitioned to having a growth mindset with higher persistence after intervention. In addition, the 2 PSTs who surveyed as having a fixed mindset and higher persistence did not include the previously fixed mindset, high persistence student. Both the PSTs in the post PD fixed mindset higher persistence group transitioned from the mixed or growth mindset groups. Furthermore, the majority of attendees started with a high mixed mindset or growth mindset and after the five weeks of intervention surveyed into the high growth mindset category.

Table 5, is a matrix that shows the transition of how many PSTs decreased, maintained, or increased their mindset and persistence during the duration of the intervention for each of the six groups described in Table 1 Phase 2.

Table 5. Matrix of PSTs Category of Post-Survey Mindset and Persistence Transitions

PST Group Category	Mindset			Persistence		
	Increased	Maintained	Decreased	Increased	Maintained	Decreased
FL	0	0	0	0	0	0
FH	0	1	1	2	0	0
ML	0	0	0	0	0	0
MH	1	0	3	3	1	0
GL	0	0	0	0	0	0
GH	4	1	1	4	0	2

Both PSTs with a fixed mindset and high persistence increased their persistence.

As part of the larger, qualitative study to investigate the effects of a mindset intervention based on using MS, the effects of what happened to those who took the pre- and post-survey after attending 4 intervention sessions were analyzed. As previous research in mindset intervention, most of the changes to PSTs' mindset and persistence were positive; however, the results are discussed based on the research question, *what could have made the mindset intervention in this case (and likely other previous research) more effective*?

V. CONCLUSIONS

This study investigated PSTs' mindset and persistence while engaged with challenging mathematics tasks involving MS during intervention. Similar previous studies such as Romero et al. (2014), Farrington et al. (2012), and Snipes et al. (2012), considered participants' mindset and persistence. This study strives to fill in several gaps in the research, particularly for PSTs' mindset and persistence, using MS in combination with a mindset intervention, and possibilities for what could make interventions more effective. Combining a variety of interventions changed participants mindset and persistence.

The results of this study demonstrate the complex nature of mindset (Dweck, 2006) and persistence (Duckworth, 2007) from their learning environment that affect changes to PSTs' mindset and persistence. While PSTs engaged with challenging tasks using MS, there appears to be a relationship between the changes from a mindset intervention as part of the larger study has begun to emerge. For the PSTs investigated, there is evidence that their mindset and/or persistence were affected when MS were available to use. This demonstrates that PSTs' mindset and persistence pre- and post-intervention may depend on the tasks they are asked to engage. Thus, while having a high level of persistence did align with a PSTs use of MS, this did not mean the PST's mindset would automatically align completely with a growth mindset. However, high levels of persistence acted as an advantage for using MS, regardless of the PST's mindset.

As the researchers began to analyze the data collected for this study, as part of the larger study, there emerged a distinctive caution of using the mindset intervention that some parts of intervention seemed to be more effective for some PSTs than others. Further analysis of the survey data showed that after PSTs engaged with challenging tasks, there were connections between PSTs mindset and persistence. There are several considerations future studies can incorporate for mindset interventions to be more effective.

First, when instilling a mindset intervention, consistently using challenging tasks during intervention while knowing the mindset PSTs come with to the intervention is essential to shifting PSTs' mindset and persistence categorization. Unlike previous studies that using mindset intervention materials that focused on the goals and effort, participants had pre- and post-intervention; this study focused on the third-attribution for setbacks- and fourth component- engagement despite setbacks- that Yeager and Dweck (2012) described. PSTs engaged with tasks in a non-graded, low pressured setting. Interventions that incorporated challenging tasks along with the third and fourth components of mindset allowed PSTs to engage in MS tasks while PSTs experimented in shifting their mindset and persistence. Yeager and Dweck (2012) described those with a growth mindset; a setback means they need to work harder or alter the strategies they have chosen to use. Changes to PSTs' engagement saw that failure did not mean they were reasoning incorrectly, but rather they must continue to engage and reason with tasks using strategies PSTs thought through.

Second, Mathematics Teacher Educators (MTEs) and others who want to use a mindset intervention, consideration needs to be more focused on creating a low-pressure mathematical setting focused on undoing solely one correct or incorrect way of completing the task. MTEs should consider how PSTs use MS to engage with challenging tasks. In the classroom, PSTs' success or not should be based on if they consider different strategies to get them towards a correct solution, rather than simply obtaining correct answers. Creating these situations include using MS tasks, such as those in OpenMiddle™, having students demonstrate multiple ways to solve tasks (i.e., multiple representations and/or strategies), when obtaining the same answer, or developing mathematics tasks that are discussion-based.

PSTs who are not going to be, nor likely want to be interacting with mathematics need guidance in carefully developing the equations and algorithms needed for tasks, instead of perpetuating the cycle of supplying the algorithms/procedures to their future students. Although PSTs used MS while working with challenging tasks, they did not have a specific way of deciding if a strategy was working or not. Most PSTs and their groups stayed thinking about the task using a particular strategy and then checking if that would work. This guess and check strategy leant itself well to the open-ended and multi-correct answer questions that were posed during intervention. Once answers were solidified, then PSTs would look for the other correct answers furthering their current understanding of the task. Often PSTs used their previous answer(s) to simultaneously discuss the considered correct answers while looking for a formula or looking for a more efficient way to complete the task. For MTE to make a mindset intervention more effective, they can help PSTs understand that using guess and check in mathematics classes is a suitable method of learning and engaging with challenging tasks.

Third, effectively using a mindset intervention will also require MTEs and in-service mathematics classroom teachers to consider discussion-based lessons about mathematics. After PSTs have multiple experiences of mathematics course work that focused on the traditional lecture style, undoing that is not very easy. First, both in-service teachers and PSTs will need to learn to effectively allow their students to guide themselves towards one strategy and then exploring other strategies that the NCTM has named as a productive struggle (Leinwand et al., 2014). However, in-service and PSTs must first understand the task well enough themselves before seeking out others as well. While engaging with challenging tasks, this means they will need to look towards other resources such as listening to other small groups, waiting for the whole group discussion to begin, or reminiscing about previous mathematical coursework where similar concepts were procedurally taught.

The results of this study demonstrate the complex nature of mindset (Dweck, 2006) and persistence (Duckworth, 2007). While PSTs engaged with challenging tasks using MS, there appears to be a relationship between the changes initiated from a pure mindset intervention as part of the larger study has begun to emerge. This section focused on the connections between mindset and MS, and the PSTs' views of the connections. Finally, the implications and recommendations of the study and future research suggestions are explored.

IMPLICATIONS, RECOMMENDATIONS, and FUTURE RESEARCH

The following section focuses on the implications, recommendations, and future research possibilities based on the current study. While several patterns were found throughout the survey data, the results are limited in their generalizability due to the overall small sample size of the PSTs that participated in the study. Although 78 PSTs attended intervention over the five weeks, between both semester offerings, only 12 took both the pre- and post-surveys and attended the required 4 sessions. Additionally, the survey measures were self-reported from PSTs who self-selected to attend, so such a small sample size might not best depict the use of the mindset scale in the PST population. Although typical quantitative studies have shown a mindset intervention to work for large groups of students (Paunesku et al., 2015), these studies did not look at specific cases or categories of PSTs' mindset. Therefore, the power of this study is minimal but gives insight for future research with PSTs, mindset interventions, and the use of MS.

Furthermore, at this time, no studies have been conducted using the Grit-*S* to look at PSTs' persistence on a larger scale either, particularly in the case of categorizing students' persistence as high or low. This study looked to branch out from simply investigating whether a mindset intervention works or not and instead focused on the challenges and changes that come with implementing a mindset intervention and what may affect implanting a mindset intervention effectively.

Based on the results in this study, the researcher recommends the following for TEPs, particularly those that affect mathematics teachers. First, MTEs' teaching PSTs would find it beneficial to give the theory of intelligence and Grit-*S* survey pre- and post- as part of regular coursework. This way, rather than assuming where student mindset and persistence lie on the continuum, a progression of changes can be determined over the PSTs time in the TEP (Hourigan et al., 2016).

In addition, PSTs should engage with mathematics tasks that help them recognize and work through their productive struggle to improve upon their persistence and mindset. This also allows the teacher to be more likely to group PSTs heterogeneously (Boaler & Dewck, 2016). There is some trickle-down from MTE's through PSTs' learning experiences about non-direct teaching approaches; however, the teaching practices in the classroom are not being used to their full potential. Therefore, it is the recommendation of the researcher that more mathematics courses at the K-12 level focus on engaging students in the concepts, rather than the procedures of the mathematics materials.

Moreover, the sample here was from university-sponsored program as part of an overall series where the attendees were exposed to the mindset intervention. Attendees were simultaneously taking classes towards their teaching degree, and already accepted into their educational programs of choice. For this reason, results may be slightly skewed in favor of PSTs, whose university coursework was already using persistence and MS. In addition, there was no control group in this study; therefore, this did not allow for an investigation of the difference intervention made on attending PSTs mindset, persistence, and use of MS as opposed to PSTs who are in methods coursework that includes MS but do not focus on their mindset or persistence. Thus, further analysis should consider samples of PSTs from multiple sites and from various teacher preparation programs.

Another limitation of this study was the small number of PSTs who showed low persistence on the Grit-*S* survey. PSTs clustered into high persistence both before and after intervention, so future research will need to consider looking at qualitative characteristics such as the PSTs focus and experiences in the program to determine more specific differences amongst the PSTs. Future qualitative research exploring what may or may not affect PSTs mindset and persistence before and during a mindset intervention will further expand what is known about Yeager and Dweck's (2012) third and fourth mindset components.

A final limitation of the current study was, few PSTs in the current study showed a fixed mindset on either the pre- or post- theory of intelligence survey. This limited patterns of analysis to the mixed and growth mindset categorization of PSTs. Additional mixed methods studies are suggested to compare how surveys align with how PSTs engage with challenging tasks and describe what they do during tasks. From a methodological point of view, the researcher is aware that qualitative analysis is more demanding and could cause more problems than analyzing questionnaires, but quantitative types of methods do not consider the complex interaction of participants' mindset and their persistence when tasks are determined as challenging for them, particularly if MS is involved.

In conclusion, categorized data suggests there are shifts in PSTs' mindset and persistence during challenging mathematics tasks. The current study highlights based on Yeager and Dweck's (2012) third and fourth components PD that uses a mindset intervention shifts PSTs' mindset and persistence, specifically when PSTs engage with challenging mathematics tasks. There is not a simple or quick solution; however, MTEs implementing challenging tasks that allow for the use of MS during PSTs coursework could ignite changes. Engaging PSTs from both the student and teacher perspective could infuse the ideas of mindset, persistence, and MS during challenging mathematics while implemented during their coursework. Therefore, focusing on future students cannot be centered without spotlighting PSTs' mindset, persistence, and how they practice engaging in using MS in their future mathematics classrooms.

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