PRE-SERVICE MATHEMATICS TEACHER BELIEFS AND GROWTH MINDSET

ASSESSMENT PRACTICES

Brandie Elisabeth Waid

Submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy under the Executive Committee of the Graduate School of Arts and Sciences

COLUMBIA UNIVERSITY

2018
ABSTRACT

Pre-service Mathematics Teacher Beliefs and Growth Mindset Assessment Practices

Brandie E. Waid

Research from the fields of psychology and education suggests that a student’s mindset (beliefs about their intelligence or ability) has a tremendous impact on their setting of goals, reactions to setbacks and failures, and academic performance (Aronson, Fried, & Good, 2002; Blackwell, Trzensiewski, & Dweck, 2007; Dweck, 2000; Dweck, 2006; Good, Aronson, & Inzlicht, 2003; Good, Rattan, & Dweck, 2012; Hong, Chiu, Dweck, Lin, & Wan, 1999). It has also been found that teachers’ mindsets do not necessarily predict their students’ mindsets, namely because teachers do not always teach in ways that align with their mindset. Instead, their beliefs about the nature of mathematics have been found to predict student mindset (Sun, 2015). This may be because if teachers believe that mathematics is a subject of creativity and sense making (a multidimensional belief), they are more likely to teach in ways that emphasize conceptual development and reasoning (practices that convey a growth mindset to students), no matter their personal mindset. Whereas if teachers believe mathematics is more about the rote learning of facts and procedures (a one dimensional belief), they will present it as such (practices that convey a fixed mindset to students). The purpose of this study is to explore the relationship between pre-service mathematics teachers’ beliefs and the mindset messages conveyed through their assessment practices. The study focuses on two beliefs: (1) beliefs about mathematics and (2) beliefs about ability (mindset); and three assessment practices: (1) the assessments pre-service teachers create, (2) the feedback they provide students on those assessments, and (3) the next steps they propose after analyzing student performance on the assessment.
Using a mixed-methods approach, this study combines a beliefs survey with an in-depth examination of assessments, and accompanying commentaries, submitted by six pre-service mathematics teachers. Assessments and commentaries were evaluated to determine the degree to which the described (and displayed) practices conveyed growth mindset messages, accomplished through the use of pre-existing rubrics created for the educative Teacher Preparation Assessment (edTPA), along with principles of grounded theory and the research on teaching practices that promote growth mindsets in students.

Results suggested that having a growth mindset had some relation to pre-service teachers’ (1) planning of growth mindset assessments, (2) use of multiple representations in assessments, and (3) providing of feedback related to students’ efforts. Whereas pre-service teachers with fixed mindsets appeared to leave (1) more technical feedback and (2) more feedback overall. Additionally, stronger multidimensional views appeared more related to the pre-service teachers’ (1) planning of growth mindset assessments, (2) use of multiple representations in assessments, (3) praising a student’s use of a solution method or property, (4) attempting a “strengths-needs” feedback structure, and (5) allowing students to resubmit work. Weaker multidimensional views appeared related to teachers leaving feedback that praised a students’ grade.

Findings of this study suggest that interventions aiming to change teacher mindsets may be insufficient for ensuring teachers engage in growth mindset practices. Instead, interventions should focus on changing teacher beliefs and practice concurrently (Philipp, 2007). Providing pre-service teachers with more specific training in the types of assessment practices that convey growth mindset messages to students, as well as requiring them to routinely reflect on their beliefs and practice, may help to accomplish these goals.
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ACKNOWLEDGEMENTS

I would like to begin by thanking my teachers throughout the years, who have provided me feedback, guidance, and encouragement. I would like to thank Terri Sebring and Dr. Theoni Soublis, who ignited in me a passion for education. Without your support and friendships throughout the years, I would not be the educator I am today. Dr. Stuart Weinberg, thank you for the opportunities you have provided me here at Teachers College. I have enjoyed our time working together and will be forever grateful for the chance to work beside you. I have become a better mathematics teacher educator because of you. To Dr. Bruce Vogeli and Dr. Philip Smith, who read many drafts of my dissertation and provided invaluable feedback, thank you for your patience and your encouragement. To my advisor, Dr. Nicholas Wasserman, and committee chair, Dr. Erica Walker, thank you for providing me with the guidance, insights, and encouragement needed to finish this degree and move into the next steps of my career. I’d also like to thank the remaining members of my committee, Dr. Jessica Riccio and Dr. Maria Rivera Maulucci, for their time and feedback, as well as Krystle Hecker, Elyse Blake, Juliana Fullon, and Betty Ann Driver for making the process of moving through the program easier.

Thank you to the many friends who have supported me throughout this process, especially Arundhati Velamur, Rebecca Johnson, Nicole Fletcher, Mengmeng Cao, and Lucretia Glover. A big thank you to my brother, Gavin Waid, who read every draft of every chapter in this dissertation. You are my best friend and I appreciate you more than words can express. To my parents, Robert and Carol Waid; my grandparents, Manolo and Dulce Diaz; my aunt, Ivonne Diaz, and the rest of my family – thank you for the love and support you’ve provided throughout my life and throughout this degree. You have helped me to get where I am today both academically and personally, and I love you dearly.
Finally, to my partner Jenn – thank you for being my rock throughout this process. You bring so much peace and joy into my life. Your love and encouragement have helped me finish this project. I love you and am grateful to have you by my side. I cannot wait for our next chapter.
DEDICATION

To my crazy, Cuban American family.

Con todo mi amor.
Chapter I

INTRODUCTION

Need for the Study

Are you a “math person”? Is mathematics ability something you are born with or is it something you can cultivate through effort? According to psychologist Carol Dweck (2006), the answers provided to these questions give insight into a person’s mindset. Individuals with a growth mindset believe fundamental characteristics such as intelligence or ability can be cultivated through effort. People who hold a fixed mindset, on the other hand, believe no matter how much one tries to change these basic characteristics, they remain relatively fixed.

In recent years, much research has sought to determine the impact of mindset on student achievement, especially in the area of mathematics. Studies have found that when students are explicitly taught to have a growth mindset, they experience an increase in test scores, levels of motivation, and school enjoyment (Blackwell, Trzensiewski, & Dweck, 2007; Good, Aronson, & Inzlicht, 2003). Holding a growth mindset has also been linked to higher mathematics achievement in Black, Latino, and female students, even when placed in environments that convey negative, ability-based stereotypes to these marginalized populations (Aronson, Fried, & Good, 2002; Blackwell, et al., 2007; Good et al., 2003; Good, Rattan, & Dweck, 2012). Mindset has been shown to play a role in how individuals explain and respond to success and failure (Hong, Chiu, Dweck, Lin, & Wan, 1999).

In light of these findings, researchers have now moved to explore the ways in which students come to hold growth or fixed mindsets, by exploring the behaviors of both parents and
teachers that serve to predict the mindsets held by children (Haimovitz & Dweck, 2017). Concerning teachers, several studies have indicated that teachers who engage in performance-oriented instruction, which focuses on students performing well (arriving at correct answers quickly) and reproducing or memorizing learned facts and procedures, are more likely to have students who ascribe to a fixed mindset view of intelligence and ability (Park, Gunderson, Tsukayama, Levine, & Beilock, 2016; Schmidt, Shumow, & Kackar-Cam, 2015; Sun, 2015). Such performance-oriented practices may be classified as fixed mindset teaching practices. In contrast, growth mindset teaching practices are those that are mastery-oriented, emphasizing understanding and reasoning, and using student assessments formatively so that they can continue to show their developing understanding (Park et al., 2016; Sun, 2015). Of equal importance are the mindset messages students receive in the form of feedback. When students receive growth mindset feedback—feedback about their effort or process, rather than their ability or correctness—they are more likely to remain confident and motivated and continue to grow after experiencing failure (Mueller & Dweck, 1998).

The aforementioned studies provide evidence that a student’s mindset has some bearing on his or her success in academic environments and there are teacher practices that contribute to student’s development of growth or fixed mindsets. What is less clear is the role a mathematics educator’s mindset plays in the classroom, specifically with regard to teaching practice. Researchers have long held that teacher beliefs influence practice (in some manner), but studies have had mixed results in determining the extent to which teacher beliefs influence practice (Dewey, 1933; Pajares, 1992; Raymond, 1997).

While few studies have been conducted to explore teacher mindset and practice, earlier research indicated that classroom pedagogy and student achievement may be impacted by
teacher mindset. Rattan, Good, and Dweck (2012) conducted a series of studies to explore how mindset may affect the pedagogical practices of a teacher. In one study, a sample of undergraduate students were asked to imagine themselves as seventh grade mathematics teachers given the task of conferencing with a student who performed poorly on the first test of the year. It was found that when these undergraduate students held a fixed mindset they were more likely to select pedagogical strategies and feedback that would be potentially detrimental to student engagement and future mathematics achievement. Such strategies and feedback included comforting students by “explain[ing] that not everyone has math talent – some people are ‘math people’ and some people aren’t” and assigning less homework to students because of low performance, among others (p. 733).

Rattan et al. (2012) conducted a similar study on a sample of graduate students who were serving as instructors or teaching assistants in undergraduate mathematics courses. These graduate students were reported to have studied in math-related fields, but not in the field of mathematics education. As in the previous study, it was found that when these graduate students held a fixed mindset, they were more likely to have low expectations for struggling students and to select pedagogical practices and feedback that would be unhelpful to students’ future mathematics success. While the foregoing studies suggest that a teacher’s mindset can affect practice, they are focused on individuals whose primary professional training may not have been in education.

In recent years a small number of studies have attempted to explore the relationships between the mindset of mathematics teachers, their teaching practice, and the mindset of their students more directly (Haimovitz & Dweck, 2017; Park et al., 2016; Sun, 2015). The findings of these studies have led researchers to believe that the relationships between teacher mindset,
teaching practice, and student mindset may not be as straight-forward as originally believed (Haimovitz & Dweck, 2017). The finding of at least one of these studies, conducted by Sun (2015), even suggests that teachers’ beliefs about the nature of mathematics are a better predictor of student mindset, and (by association) teacher practices that are more likely to orient students to growth or fixed mindsets. The study proposed here will build on existing research by exploring the relationship between pre-service mathematics teachers’ mindset and beliefs about the nature of mathematics and the mindset messages they convey in their assessment practices. In this study, assessment practices will refer to the following: (a) an assessment planned by the pre-service teacher, (b) feedback provided to students on that assessment, and (after analyzing student performance on the assessment) (c) the next instructional steps they propose to further student learning.

**Purpose of the Study**

This study uses instrumental case study methodology (Merriam & Tisdell, 2015) to explore the relationship between pre-service mathematics teachers’ beliefs and the mindset messages conveyed through their assessment practices. This study attempts to answer the following questions:

1. What is the relationship between the mindset messages conveyed in an assessment task created by a pre-service mathematics teacher and his/her (a) mindset and (b) beliefs about mathematics?
2. What is the relationship between the mindset messages conveyed in the feedback a pre-service mathematics teacher provides to students and his/her (a) mindset and (b) beliefs about mathematics?

3. What is the relationship between the mindset messages conveyed by the next instructional steps proposed by a pre-service teacher (after analyzing student performance on the assessment) and his/her (a) mindset and (b) beliefs about mathematics?

**Procedures**

In this study, pre-service teachers were recruited via email after completing a seminar in student teaching as part of a graduate level secondary mathematics teacher education program in a large Northeastern city. The researcher recruited six pre-service teachers, three of growth mindset and three of fixed mindset. Mindsets and beliefs about mathematics were determined using a Beliefs Survey similar to that used by Sun (2015).

In their student teaching seminar, the recruited pre-service teachers were required to submit a portfolio that showcased their planning of a lesson, instruction in that lesson, and an assessment of student learning. For the portfolio, pre-service teachers were also required to respond to several reflective prompts to explain the following: how they took their students’ prior knowledge and strengths and weaknesses into consideration as they planned; how they supported students’ developing procedural fluency, conceptual understanding, and problem solving and/or mathematical reasoning in their lesson; how they might change their lesson to improve student learning; and how they have used assessment to inform future instruction. The
requirements and prompts of this portfolio were developed to mirror those of the Secondary Mathematics educative Teacher Performance Assessment (edTPA) portfolio that pre-service teachers must compile and submit as part of the state’s certification requirements (Stanford Center for Assessment, Learning, & Equity, 2016).

For this study, data analysis focused on the assessment portion of pre-service teachers’ portfolios. In this segment of the portfolio pre-service teachers were required to select an assessment within their lesson and analyze student performance on that assessment. They were then expected to provide work samples of three focus students, representative of whole class performance and trends. Pre-service teachers were also required to describe their feedback to those three students and describe their next instructional steps.

The researcher analyzed the portfolios to determine if the pre-service teacher’s submitted assessment was oriented more towards growth or fixed mindset practices. These assessments were analyzed using a modified version of a rubric, *Rubric 5: Planning Assessments to Monitor and Support Student Learning*, developed by the Stanford Center for Assessment, Learning, & Equity (SCALE), and used nationwide in the scoring of edTPA Secondary Mathematics submissions. This rubric assesses the extent to which the submitted assessments monitor students’ development of procedural fluency, conceptual understanding, mathematical reasoning, and problem-solving abilities. The five levels on this rubric were then evaluated in terms of the degree to which the assessment conveyed growth or fixed mindset messages to students, as described in the existing research on growth mindset teaching practices (Boaler, 2016; Dweck, 2000; Dweck, 2006; Sun, 2015). The researcher then used this information to explore the relationship between the degree to which the assessment conveyed a growth mindset message and the pre-service teachers’ self-reported beliefs about mathematics and their mindset.
In order to analyze feedback provided by pre-service teachers, the researcher observed the nature of feedback provided to focus students on the submitted work samples. Feedback was first analyzed holistically by a second SCALE (2016) rubric, *Rubric 12: Providing Feedback to Guide Learning*. This rubric assesses the nature of the feedback pre-service teachers provide to focus students on submitted work samples. *Rubric 12 scores* were then evaluated in terms of the degree to which the feedback conveyed a growth or fixed mindset message, based on previous research on feedback and student mindset (Boaler, 2016; Dweck, 2000; Dweck, 2006; Mueller & Dweck, 1998; Sun, 2015). Again, this information was used to explore the relationship between the mindset messages conveyed in the pre-service teachers’ feedback and their self-reported beliefs about mathematics and mindsets.

In addition, specific feedback provided by each participant was analyzed to determine if any pattern existed between feedback type and beliefs. The researcher engaged in the practice of constant comparison (Glaser & Strauss, 1967) to sort the instances of individual feedback into categories based on similarities. After creating these categories, the researcher calculated the percentage of each pre-service teacher’s feedback instances that had been classified in each category and sought to observe any patterns between these percentages and the participants’ self-reported mindsets and beliefs about mathematics.

Finally, the researcher used a third SCALE rubric, *Rubric 15: Using Assessment to Inform Instruction*, to analyze the next steps that the pre-service teachers proposed based on their analysis of student assessments. *Rubric 15* assesses whether these next steps would provide support to the pre-service teachers’ students in improving their learning related to conceptual understanding, procedural fluency, mathematical reasoning and problem solving. As was the case for *Rubric 5* and *Rubric 12*, existing research on growth and fixed mindset teaching practice
was used to determine which of the five levels on this rubric were more fixed or growth mindset in nature (Boaler, 2016; Dweck, 2000; Dweck, 2006; Sun, 2015). Again, the pre-service teachers self-reported beliefs about mathematics and mindset and their rubric scores were used to explore the relationship between preservice teachers’ beliefs and the mindset messages conveyed in their proposed next instructional steps.
Psychologists and educational researchers have long held that beliefs shape the way we see and interact in the world (Dweck, 2000). Rokeach (1972) suggested that beliefs held by an individual are organized into belief systems with central beliefs at their core and that connect to other beliefs within that system. He proposed that each belief in a system varies in its level of importance, with central beliefs being the most important and the most resistant to change (Pajaras, 1992). In recent years, educational researchers and psychologists have turned their attention to a particular set of beliefs held by individuals, their mindset (also known as self-theories), or beliefs about intelligence and ability (Dweck, 2000). This chapter will begin by exploring research on the relationship of student mindset and interpretations of success or failure, goal selection (mastery vs. performance), and achievement. Following this discussion, the chapter will delve into teaching practices that have been found to promote growth or fixed mindset messages and the alignment of those practices with teacher mindset. The chapter will conclude with research on teacher education that guided the methods used in this study.

Research on Student Mindset

Psychologist Carol Dweck (2000) has spent her career studying the self-theories to which individuals ascribe and she proposes there are two ways people view intelligence and ability, as either a fixed quality, or as something that can be developed over time. In her early research, Dweck called those with stable views of intelligence entity theorists and those believing
intelligence can be developed incremental theorists. In recent years Dweck (2006) has re-coined these self-theories, as mindsets, with entity theorists said to have a fixed mindset and incremental theorists said to have a growth mindset. These mindsets may also be extended to include other personal traits such as personality and character (Dweck, 2006). The remainder of this section will focus on Dweck’s development of these theories, following a similar structure as the one set forth in her *Self-Theories* (2000) book.

Dweck (2000; 2006) has conducted a number of studies to explore the impact of holding a particular mindset in the field of education, especially with regard to student mindset. She has found that holding a particular mindset can affect how students interpret success or failure, the goals they select (mastery vs. performance), as well as their achievement (Blackwell, Trzensniewski, & Dweck, 2007; Dweck & Leggett, 1988; Hong, Chiu, Dweck, Lin, & Wan, 1999). Dweck’s early research with Carol Diener, helped to form the basis for these discoveries (as reported in Dweck & Leggett, 1988). Through a series of studies, Diener and Dweck sought to better understand why some students react to failure with a helpless response and others do not. To explore this, fifth and sixth grade students were asked to complete a survey to predict their persistence in the face of a challenge. Those who were likely to persist were considered to be mastery-oriented and those who were not were considered helpless. Researchers administered a set of eight problems, all of which students would be able to solve, and as the students solved these problems, researchers asked them to explain their thoughts and emotions aloud. During this phase of the research, “all students attained effective problem solving strategies…[and] there was no difference in the strategy level attained by the helpless and mastery-oriented children” (Dweck & Leggett, 1988, p. 257). Following these eight problems, students were given four problems they would be unable to solve and were again encouraged to explain their thoughts and
emotions aloud. In the mastery-oriented group, students remained optimistic and determined to solve the problems through increased effort. These students also “engaged in extensive solution-oriented self-instruction and self-monitoring” and were able to build upon their previously used problem solving strategies to teach themselves “more sophisticated hypothesis testing strategies over the four failure trials” (Dweck & Leggett, 1988, p. 258). In contrast, the helpless students quickly began to feel defeated, attributing their difficulties to a lack of intelligence and feeling that any further effort would be wasted, so they should give up.

To further explore why some students exhibit helpless patterns over mastery-oriented ones, Dweck and Elliot conducted a study to determine if different goals create the previously discussed reactions to failure (as reported in Dweck and Leggett, 1988). Researchers identified two goals: performance goals, which focus on the measuring of performance or ability, or learning goals (also known as mastery goals), which focus on learning new concepts or strategies. Researchers oriented the fifth graders toward one of the two goals by telling the students that the administered tasks would (a) measure performance or (b) provide an opportunity to learn new things. As in the previous study, students were first administered tasks they would be able to complete, followed by more challenging problems. In accordance with their hypothesis, students oriented towards learning goals displayed mastery-oriented responses to the challenging problems, whereas students oriented towards performance goals displayed helpless responses to the challenging problems.

With the close relationship between students’ goals and their responses to failures, researchers began to believe that the real predictor in these areas may lie in students’ beliefs about their intelligence, also known as their self-theories or mindsets (Dweck, 2000; 2006). To explore this idea, Carol Dweck, Yvette Tenney, and Naomi Dinces created passages to
manipulate fifth grade students’ mindset toward either growth or fixed beliefs about intelligence (as reported in Dweck, 2000). These passages discussed the lives of prominent figures such as Helen Keller and Albert Einstein, and how their talents and intelligence were either (a) fixed qualities that they possessed at birth, or (b) qualities they acquired over time, through sustained effort. After reading these passages, students were to choose a task to complete from among four tasks, two of which indicated performance goals and two of which indicated learning goals. Students who read the growth mindset passage were more likely to select a task that indicated the adoption of a learning goal and students who read the fixed mindset passage were more likely to select a task that indicated the adoption of a performance goal. The latter study also served as an indicator that students mindsets may be manipulated, a finding that was supported in a series of studies by Hong et al. (1999).

In a study by Hong et al. (1999), researchers explored the question of whether a student’s mindset influences him or her to make decisions that avoid challenging opportunities, even if it is known that engaging in that challenge will increase future performance. At a Hong Kong University, researchers informed undergraduate freshman that their English proficiency was an important predictor of success in their undergraduate program. Students were then administered a survey that measured their English proficiency, mindset, and how likely they would be to take a remedial English course if one were offered. Students with a growth mindset were more likely to indicate interest in the remedial English course, whereas those with fixed mindsets were more likely to indicate they were not interested, “even when they knew that these skills were essential for their future success and that the remedial course had been found to be effective in improving language proficiency” (Hong et al., 1999, p. 594).
Studies have also shown that mindset predicts student academic performance. At the beginning the academic year, Blackwell, Trzesniewski, and Dweck (2007) measured the mindsets of over 300 seventh graders in an urban middle school and obtained their achievement scores from sixth grade standardized mathematics tests. Over a period of two years, the researchers continued to monitor student achievement by collecting their final fall and spring scores in both their seventh and eighth grade years, a period that researchers describe as difficult for many adolescents. Student mindset was a “significant predictor of … mathematics achievement” over the two-year study (p. 251). Those with growth mindsets showed an increase in achievement, whereas those with fixed mindsets showed a decrease. To build on these findings, Blackwell, Trzesniewski, and Dweck (2007) conducted a second study in which they followed a sample of low-achieving seventh grade students, most of whom were Black or Latino. Blackwell et al. (2007) first measured students’ mindsets, and then implemented an eight-week intervention in which the experimental group was taught that “intelligence was malleable and can be developed” and the control group “had a lesson on memory and engaged in discussions of academic issues of interest to them” (p. 254). Researchers again collected spring mathematics grades from the students sixth grade year, and after the intervention, collected fall and spring mathematics scores for the students’ seventh grade year. Students with a fixed mindset benefitted the most from the mindset intervention, and “their declining grade trajectory [was] reversed following the intervention, while the grades of students in the control group who endorsed more of an entity theory continued to decline” (p. 258). The latter Blackwell et al. (2007) study not only supports the idea that manipulating mindsets can impact student achievement, but also that mindset interventions can positively affect the performance of marginalized populations. Other studies have further explored this idea, finding that holding a growth mindset is linked to higher
mathematics achievement in Black and Latino students (Aronson, Fried, & Good, 2002; Good, Aronson, & Inzlicht, 2003), in female students (Good, Rattan, & Dweck, 2012), and in students of lower socioeconomic status (Claro, Paunesku, & Dweck, 2016).

While Dweck was involved in most of the aforementioned studies, a number of other researchers have explored the role of mindset, with their results supporting the conclusions that mindset plays a causal role in student achievement (Aronson, Fried, & Good, 2002; Good, Aronson, & Inzlicht, 2003), the selection of performance vs learning goals (Robins & Pals, 2002), and reactions to challenges and failure (Robins & Pals, 2002). Studies have also supported Dweck’s findings that mindset can offset stereotype threat for traditionally marginalized or underrepresented populations (Aronson, Fried, & Good, 2002; Good, Aronson, & Inzlicht, 2003). While most of the research supports Dweck’s conclusions in these areas, a small number of studies did not, especially in the area of achievement, finding that mindset and achievement were not significantly correlated (Dupeyrat & Mariné, 2005; Leondari & Gialamas, 2002).

Teaching for Mindset

It is clear from the research that holding a growth mindset may be beneficial for students, but what aspects of instruction orient students toward fixed or growth mindsets? In their study of 424 students and their teachers (58 teachers in total), Park, Gunderson, Tsukayama, Levine, and Beilock (2016) found that teachers who reported using more performance-oriented instructional practices and less mastery-oriented instructional practices, were more likely to have students with a fixed mindset. Park et al. (2016) note, “Findings from our study suggest that by avoiding
performance-based instructional practices, teachers may help children form adaptive, incremental frameworks, which in turn may lead to higher levels of math achievement” (pp. 310-311). What instructional practices are considered mastery-oriented and what practices are considered performance-oriented? According to Ames (1992), such practices refer to classroom structures such as task and learning activity design and evaluation practices. These will be discussed in the following two sections.

**Task Design**

The mathematical tasks that teachers design and administer to students contain not only information about mathematics content, but also “information that students use to make judgements about their ability, their willingness to apply effortful strategies, and their feelings of satisfaction” (Ames, 1992, p. 263). Tasks that are mastery-oriented have been found to engage students in strategic thinking and the development of conceptual understanding. Such tasks allow for multiple solution methods and provide students with meaningful (rather than pseudo) mathematics contexts. Mastery-oriented tasks are also structured to provide every student with a challenge and to be attainable to all students in some way. In contrast, performance-oriented tasks would focus on performance outcomes, memorization, and the reproduction of learned procedures (Ames, 1992).

In her book, *Mathematical Mindsets* (2016), Boaler expounds upon this idea of performance-based, fixed mindset, teaching practices and mastery-oriented, growth mindset, teaching practices. She emphasizes that teaching mathematics for a growth mindset involves valuing mistakes and struggle, which can be accomplished by teaching conceptually and having students make sense of mathematics. This sense making may be realized by encouraging students
to explore connections between ideas and various representations and to use intuition and creativity while constructing their own knowledge. Such teaching captures the true nature of mathematics, the mathematics in which mathematicians engage, which is multidimensional, creative, and collaborative in nature. In contrast, Boaler describes fixed mindset mathematics teaching as one dimensional, focusing on the memorization of facts, formulas or procedures, and emphasizing closed (and often short) mathematics questions with a single correct answer. Such teaching values correctness over process, progress, mistakes, and struggle.

Boaler proposes several suggestions for opening mathematics tasks to make them multidimensional and to allow students “to see math as a conceptual, growth subject that they should think about and make sense of” (p. 34). She proposes that such growth mindset tasks should include at least one of the following elements: (a) multiple solution methods and representations, (b) visual elements for students to engage with and explore, (c) sense making opportunities, as well as opportunities to be skeptical, and to convince one another, (d) inquiry opportunities that require students to come up with their own ideas, (e) explorations before formal methods needed for their solution are taught, and (f) extending tasks to make them low floor high ceiling. These so called “low floor high ceiling” tasks allow all students to engage in mathematics at varying levels. She notes, “one way to make the floor lower is to always ask students how they see a problem” and “a great strategy for making a task higher ceiling is to ask students who have finished a question to write a new question that is similar but more difficult” (p. 84).

Kathy Sun (2015), who conducted a study exploring teaching practices that convey mindset, describes similar aspects of growth and fixed mindset tasks. In fixed mindset classrooms, tasks are typically of a procedural nature, having only one correct method or
solution. In these classrooms, speed and correctness is emphasized over process and learning. Tasks in growth mindset classrooms are more multidimensional and encourage conceptual understanding, the use of multiple solution methods, and reasoning.

**Evaluation Practices**

Another aspect of classroom structure that can be deemed as mastery-oriented (growth mindset) and performance-oriented (fixed mindset), relates to evaluation practices (Ames, 1992). One evaluation practice that has been found to negatively impact the mindset and motivation of students is the use of social comparison, which includes teachers grading on normal curve, announcing highest and lowest scores, and grouping based on ability (Ames, 1992; Boaler, 2013; William, 2011). These practices are performance oriented (fixed mindset), encouraging students to focus on outperforming their peers and on their perceived ability or lack thereof (Ames, 1992). In contrast, evaluation practices that convey a growth mindset provide greater focus on the progress of the individual, and allow students multiple opportunities to master material either through resubmitting work or through other methods focused on improvement (Sun, 2015). This model of evaluation, where learning and moving learning forward comes first, is in line with the practices of formative assessment, also known as assessment for learning. Dylan Wiliam (2011), has written extensively on the use of formative assessment, and describes such assessments stating, “An assessment functions formatively to the extent that evidence about student achievement is elicited, interpreted, and used by teachers, learners, or their peers to make decisions about the next steps in instruction that are likely to be better, or better founded, than the decisions they would have made in the absence of that assessment” (p. 43).
Boaler (2016) describes such formative assessment as “assessment for a growth mindset,” which provides both students and teachers with information about the student’s level of learning, where that learning needs to progress, and how to attain the desired level of learning. Such assessment is not seen as an end product (i.e. it is not summative), but rather serves to collect information for the teacher to select future instructional tasks (their next instructional steps) to better support students in meeting their learning targets (Masters, 2013). In her book *Mathematical Mindsets*, Boaler (2016) provides an example of this process of using learning to inform next instructional steps. She describes a high school mathematics teacher who would encourage his students to answer as many questions as they were able on an assessment. She states, “When they reached a point when the questions became difficult and they felt they couldn’t answer them, he asked them to draw a line across the paper and answer the rest of the questions with the help of a book. When students finished the assessment, the work they had done beneath the line became the work they all discussed in class” (p. 147). In this example, the teacher is able to use assessments as a means to identify where students are in relation to the learning goals, and immediately following the assessment, is able to implement supports for the areas in which students struggled. This use of assessment to plan next instructional steps communicates a growth-oriented message to students, one that conveys that learning is a process and that they may continue to grow their knowledge in the given area.

Like all instructional tasks, in order for formative assessment tasks to be considered as promoting a growth mindset, the tasks should engage students in sense making and deep conceptual thinking. If possible, growth mindset assessments may also make use of representations and connections among mathematical ideas. When grading such assessments, emphasis should be placed on students’ use of strategies, reasoning, representations, and thinking
processes rather than on fixed ideas such as correctness or procedures (Sun, 2015). In essence, a teacher’s feedback on such assessments should be diagnostic. Diagnostic feedback may come in the form of addressing students’ strengths or needs, but it should allow students to reflect on where they are in the learning process and help them to move forward in their learning (Boaler, 2016). When focusing on student strengths, educators should take care in the type of praise used, as person praise and intelligence praise has been found to convey fixed mindset messages, whereas effort and process praise have been found to convey growth mindset messages (Dweck, 2008; Mueller & Dweck, 1998). Similarly, when addressing student needs, teachers should avoid fixed mindset feedback related to correctness and instead use student mistakes as an opportunity to learn and grow (Boaler, 2016; Sun, 2015).

De Kraker-Pauw, Van Wesel, Krabbendam, and Van Atteveldt (2017) add to our understanding of feedback that conveys a growth mindset message to students. They state “growth oriented feedback … guides and motivates students, enhances their learning…., and keeps them persistent, resilient, and focused on the process of learning. It provides specific information… about the progress (and results) of students” (p. 5). De Kraker-Pauw et al. also include a list of examples of feedback that may be considered growth mindset in nature:

- Personal praise and criticism for doing (“well done, you tried very hard”), for efforts made, or strategies chosen.
- Process-oriented: comments on how results have been achieved and can be improved.
- Questions regarding strategies, efforts, possible improvements, alternatives for choices…, hints, cues, dividing in small steps, prompts, suggestions for improvement, and monitoring the process (p. 6).

Similarly, de Kraker-Pauw et al. provide examples of feedback that may be considered fixed mindset in nature:

- Personal praise and criticism for being smart, quick, stupid (“you are a very intelligent person”), feedback directed to traits, characteristics or abilities.
• Results-oriented: Comments on what results have been achieved: correct or wrong answers, giving the correct answer and indicating what is missing (p.6).

It may be useful to note here that feedback that provides “criticism” should not be automatically classified as conveying fixed mindset messages. Instead, one should consider the nature of that criticism (Kamins & Dweck, 1999). Should the criticism be focused on student efforts, process, or strategies (i.e. “for doing”), then the feedback may be considered growth mindset (de Kraker-Pauw et al., 2017, p. 6). Whereas if the feedback is focused on the personal characteristics or traits of the student (i.e. “for being smart, quick, stupid”), then the feedback may be considered fixed mindset (de Kraker-Pauw et al., 2017, p. 6).

**Research on Teacher Mindset**

While many studies have explored student mindset and the ways in which to support students in developing such mindsets, much less research has been conducted on the impact of teacher mindset (Zhang, Kuusisto, & Tirri, 2017). Educational researchers have long held the view that teachers’ beliefs influence practice and have investigated the various ways in which teacher beliefs impact teacher pedagogy (Dewey, 1933; Pajares, 1992). A small number of recent studies, however, suggest that teacher mindset may not predict student mindset (Haimovitz & Dweck, 2017; Park, Gunderson, Tsukayama, Levine, & Beilock, 2016; Sun, 2015). Sun (2015) directly explored the relationship between student and teacher mindset, as well as the mindset messages teachers convey through their teaching practices and the relationships between teachers’ mindsets and their enacted teaching practices. As part of her larger study, Sun administered pre- and post- surveys on beliefs to 40 middle school mathematics teachers. In
addition to mindset, the surveys measured beliefs about the nature of mathematics, expectations, access views, and willingness to experiment. In addition, 3400 students of the 40 mathematics teachers also completed a pre- and post- survey measuring “mindsets, beliefs about the nature of math, performance orientation, and identification with math” (p. 49). Sun found that the mindset of the 40 teachers was not a predictor of their students’ mindsets; instead the teachers’ beliefs about the nature of mathematics predicted their students’ mindsets at the end of the year. In her smaller case studies of seven teachers, Sun also found that teacher mindset and teaching practice were not always aligned. While Sun’s study focused on teacher mindset as a predictor of student mindset and the alignment (or lack thereof) between teacher mindset and practice, she did not explore the alignment between teacher beliefs about the nature of mathematics and teaching practice.

Though not directly testing teacher’s beliefs about mathematics, a study by Schmidt, Shumow, and Kackar-Cam (2015) may be seen as supporting Sun’s conclusions. In their study, Schmidt et al. observed the academic performance of two middle school science teachers’ students after the teachers implemented a six-week mindset intervention. Although both teachers tested as having strong growth mindsets and both teachers’ students showed positive gains in achievement immediately following the intervention, only one of the teacher’s classes sustained those gains. The teacher whose classes continued to show positive gains in achievement (Donna) differed from the second teacher (Celia) in that her classroom instruction emphasized modeling, effective strategies, conceptual development, and mastery. Donna also frequently reminded students of the growth mindset concepts learned in the intervention and used growth mindset language. Donna’s explicit growth mindset messages, along with her mastery-oriented teaching practices, sustained the effects of the mindset intervention. In contrast, Celia valued comparison
of student performance as a motivator and did not reference the language of the mindset intervention following the six-week program. Celia also did not aid her students in acquiring effective problem solving strategies. Instead, she often rushed in to help struggling students and focused on drilling procedural knowledge, placing Celia’s teaching in line with performance-oriented instructional practices. While it was not tested in the Schmidt et al. study, it may be that while both teachers had growth mindsets, they differed in their beliefs about the nature of mathematics, which, in turn, may have led them to engage in more growth or fixed mindset instructional practices.

While holding a growth mindset and teaching in a way that does not convey growth mindset messages may seem contradictory, researchers have found that teacher beliefs and practice are not always consistent. In a study by Raymond (1997), the relationship between elementary teacher’s beliefs and their teaching practice was explored. One particular case in Raymond’s study stood out from the rest. The participant reported traditional beliefs about the nature of mathematics (focusing on algorithms, computation, etc.) but nontraditional beliefs about mathematics teaching and learning (using manipulatives, group work, emphasizing understanding over memorization, etc.). In this participant’s classroom, however, traditional practices prevailed. Raymond (1997) states that this case may suggest (though more evidence is needed) that beliefs about the nature of mathematics more strongly influence a teacher’s practice than do beliefs about teaching and learning. The goal of this study is to further explore this relationship between pre-service mathematics teacher beliefs about ability (mindset) and the nature of mathematics and the alignment of those beliefs with the mindset messages conveyed in the teachers’ assessment practices.
Research on Teacher Education

The present study will explore the alignment of pre-service mathematics teachers’ practice and their beliefs about the nature of mathematics and about ability (mindset). Pre-service teachers provide an interesting opportunity when exploring beliefs because they are often learning teaching practices that ascribe to constructivist (also known as mastery-oriented or growth mindset) principles of teaching, where focus is placed on teaching mathematics multidimensionally. However, in many cases, teachers leave their undergraduate or graduate programs having experienced no change in their underlying beliefs about the nature of mathematics (Pajaras, 1992). Pajaras discusses the unique challenges faced by teachers in the area of beliefs. In most other professions individuals enter new, unfamiliar spaces as novices and must form new “beliefs about” those spaces. Teachers, however, are in a unique position among professionals because they enter the familiar space of a classroom, a space where they have spent years developing well-established beliefs about teaching and learning. The well-established nature of these beliefs makes them very difficult to change, and in many cases teachers’ beliefs are not affected by methods learned in undergraduate and graduate programs of education (Pajaras, 1992).

So how do we ensure that our graduate and undergraduate programs of education have been effective in producing pre-service mathematics teachers who will enter the profession and begin teaching mathematics in a way that promotes this multidimensional, or growth mindset, view of mathematics? Before answering this question, it may be important to provide additional context. While this “mindset revolution” (Boaler, 2013) being advocated by Boaler, Dweck, and other scholars has been grounded in relatively new research developments related to student
achievement, the concept of teaching for a growth mindset, as described by Boaler, is not new. In fact, Boaler (2014) states that growth mindset teaching practices are “entirely consistent with what is known about good teaching and learning” (para. 11).

Over the last 30 years, scholars in mathematics have conducted extensive research on this idea of what “good teaching and learning” entails. The National Council of Teachers of Mathematics (NCTM) helped to lead this effort by releasing their *Curriculum and Evaluation Standards* (1989) and *Professional Standards for Teaching Mathematics* (1991), which emphasized mathematics learning as an active process accomplished through exploring connections, engaging in problem solving, as well as reasoning and communicating mathematically. NCTM described such teaching as that which develops a student’s “mathematical power,” i.e. the necessary capabilities to “explore, conjecture and reason logically, as well as the ability to use a variety of mathematical methods effectively to solve nonroutine problems. This notion is based on the fact that mathematics is more than a collection of concepts and skills to be mastered. It includes methods of investigating and reasoning, means of communication, and notions of context. In addition, for each individual it involves the development of personal self-confidence” (NCTM, 1989, p. 5). In addition to these documents, in 1995 NCTM released its *Assessment Standards for School Mathematics*, which underscored the importance of formative assessment to understand what students were learning and use that information to inform future instructional choices. These three standards documents were later updated in NCTM’s (2000) *Principles and Standards for School Mathematics* and more recently have informed the development of the Common Core State Standards for Mathematics (National Governors Association Center for Best Practices, 2010).
During the last two decades, these principles of “good mathematics teaching” have been further developed by other researchers. In their book, *Making Sense*, Hiebert et al. (1997) build on this notion of teaching for mathematical understanding (or mathematical power), by discussing five classroom dimensions that contribute to an environment that supports and promotes students’ mathematical understandings: “nature of classroom tasks,” “role of the teacher,” “social culture of the classroom,” “mathematical tools as learning supports,” and “equity and accessibility” (p. 23). Throughout the book, the authors describe “core features” of the five dimensions, as well as present classroom examples (p. 12). Many of the core features emphasized are in line with the aforementioned growth mindset teaching practices. Examples include “mak[ing] mathematics problematic,” valuing mistakes and varying solution methods, emphasizing reasoning and communication, and providing tasks that are challenging (but also accessible) to all students (p. 12).

Not long after *Making Sense*, was released, in 2001, the National Research Council (NRC) published an extensive report, *Adding it Up*, in which they synthesized research in the field and “provide[d] research-based recommendations for teaching, teacher education, and curriculum for improving student learning” (p. 3). This undertaking resulted in the creation of a model to better understand the elements of successful mathematics learning, deemed “mathematical proficiency.” The model consists of five strands (procedural fluency, conceptual understanding, strategic competence, adaptive reasoning, and productive disposition) all of which are interconnected. The first strand, procedural fluency, is described as “the skill in carrying out procedures flexibly, accurately, efficiently, and appropriately” (p. 5). Procedural fluency is more than just knowing procedures and may be seen as being similar to what Stein and Smith (1998), in their classification framework of tasks, have described as “procedures with
connections” to mathematical concepts. Conceptual understanding, can be considered the “why” behind mathematical concepts and relates to a student’s grasp of the connections among and between ideas. The third strand, strategic competence (more commonly referred to as problem solving), refers to the student’s ability to engage in mathematizing a problem situation and choosing from an array of solution strategies to solve that problem (National Research Council, 2001). Many of these processes require students to engage in the fourth strand, adaptive reasoning (also referred to as mathematical reasoning), which is defined as “the capacity to think logically about the relationships among concepts and situations. Such reasoning is correct and valid, stems from careful consideration of alternatives, and includes knowledge of how to justify the conclusions” (p. 129). The final strand of their model, productive disposition, sounds very much like Boaler’s (2016) description of a mathematical (growth) mindset and is described as “the tendency to see sense in mathematics, to perceive it as both useful and worthwhile, to believe that steady effort in learning mathematics pays off, and to see oneself as an effective learner and doer of mathematics” (National Research Council, 2001, p. 131). According to Boaler (2016) a productive disposition is developed by engaging students in growth mindset mathematics practices.

The aforementioned model of mathematical proficiency describes the elements of what it means to learn mathematics successfully. This model also informs educators of the necessary elements of successful mathematics teaching. Such teaching should engage students in each of the model’s strands (National Research Council, 2001). Again, this model of “good teaching” is very consistent with the tenants of growth mindset teaching set forth by Boaler (2016) and Sun (2015), by emphasizing reasoning and sense making over correctness and procedures and highlighting the multidimensional nature of mathematics. Going back to the previously posed
question, if we are to ensure that our graduate and undergraduate programs have been successful in producing pre-service mathematics teachers who will enter the profession and begin teaching mathematics successfully, and in a way that promotes a multidimensional (or growth mindset) view of mathematics, we must confirm that they are able to integrate the strands of this model into their teaching practices.

How do we assess a teacher’s ability to incorporate these elements and to teach mathematics successfully? Some educational researchers have advocated that the use of performance-based assessments is the best way to assess teachers in these areas (Darling-Hammond, Newton, & Wei, 2013). Such research has inspired the creation of the educative Teacher Performance Assessment (edTPA) by the Stanford Center for Assessment, Learning, and Equity (SCALE) (McCarthy & Burns, 2016). The edTPA, which is the first national undertaking of a teacher performance assessment, requires pre-service teachers to construct a three-part portfolio that captures their planning (Task 1), instruction (Task 2), and assessment (Task 3) of a learning segment. The development of the edTPA’s Secondary Mathematics assessment is said to have been grounded in the educational research describing successful mathematics planning, teaching, and assessment (SCALE, 2015b). Throughout the edTPA’s Secondary Mathematics assessment, emphasis is placed on a pre-service teacher’s ability to plan for and engage students in three (or four) of the five strands of mathematical proficiency presented by the National Research Council (2001). These strands include: procedural fluency, conceptual understanding, mathematical reasoning, and problem solving. Successful completion of the edTPA requires that pre-service teachers emphasize these strands in their lesson plans, instruction, and assessment of their students. In addition, pre-service teachers must demonstrate the ability to engage in effective methods of formative assessment. (SCALE, 2016a).
For the edTPA’s emphasis on formative assessment and the strands of mathematical proficiency, as well the relation of such practices to teaching mathematics for a growth mindset (as described by Boaler), this study will observe a parallel edTPA task and make use of rubrics developed by SCALE (2016a) to assess edTPA submissions as a means to assess pre-service teacher practice. The parallel edTPA task is almost identical to the SCALE’s (2016a) edTPA portfolio, with the exception that (1) pre-service teachers are to focus on a learning task of one to three lessons (rather than three to five, as required by edTPA), and (2) the portfolio is used as a formative assessment (submitted in the pre-service teachers first of two student teaching placements) in which the pre-service teachers receive extensive feedback on every aspect of their submission. Each task (planning, instruction, and assessment) in the edTPA portfolio has five corresponding rubrics, each scored on a five-point scale, with a Level 1 indicating the work of a pre-service teacher that is not yet ready to teach and a Level 5 signifying that the pre-service teacher is highly qualified (SCALE, 2015a). Level 1 work corresponds to teacher-centered instruction and assessment with a focus on memorization and procedures (one dimensional teaching), whereas Level 5 work corresponds to student centered instruction and assessment with a focus on three or four of the strands of proficiency (multidimensional teaching) (McCarthy & Burns, 2016). SCALE (2015a) has reported on the reliability and validity of these rubrics; however, some educational researchers have questioned these measures, as “most of the research done on teacher performance assessments has been conducted in a different context where the stakes were lower for individual candidates and local evaluators retained some control over judgments of quality” (Clayton, 2018, p. 4). However, due to the formative (and thus lower stakes) nature and local evaluation of the parallel edTPA task, the researcher felt these reported measures of validity and reliability were reasonable for the purposes of this study.
To further narrow the scope of this study, the researcher only viewed Task 3, the final portion of the portfolio, in which pre-service teachers are required to describe an assessment administered to students, analyze student performance, describe the feedback provided, and discuss possible next instructional steps. The decision to use the assessment task of this portfolio was influenced by its emphasis on both the strands of proficiency and formative assessment practices (described previously as important aspects of growth mindset teaching). The specific focus of this study will be on the assessments planned by pre-service teachers, the feedback provided to students, and the use of assessment results to inform future instruction. The SCALE (2016a) rubrics most related to the previously described dimensions are Rubric 5, Rubric 12, and Rubric 15. These rubrics and their alignment with growth or fixed mindset practices will be discussed in greater detail in the next three sections. It is important to note that in classifying the various rubric levels, the researcher considered all levels that did not meet the criteria of growth mindset assessment practices (as described by the research) as fixed mindset in nature. In reality, some of these levels may be considered as conveying a more middle or mixed mindset message; but determining such a classification was out of the scope of this research. While the researcher will refer to the specific rubric levels throughout this study, the levels are treated as less important than the classification as conveying fixed or growth mindset messages. Thus, these rubrics will be treated more as a binary measure of either growth or fixed mindset assessment practices.

**Rubric 5: Planning Assessments to Monitor Student Learning**

SCALE’s (2016a) *Rubric 5: Planning Assessment to Monitor and Support Student Learning* evaluates a pre-service teacher’s submitted assessments to determine the extent to
which they “monitor students’ conceptual understanding, procedural fluency, AND mathematical reasoning and/or problem-solving skills” (SCALE, 2016a, p.18). This rubric was slightly modified from its original form because Rubric 5 is intended to score assessments from three to five lesson plans. This study, however, is focused on a parallel edTPA task which only requires the submission of an assessment from one lesson plan (this will be further discussed in Chapter 3). The modified version of Rubric 5 can be found in Table 1 and the original Rubric 5 can be found in Appendix A.

Table 1. Modified Rubric 5: Planning Assessments to Monitor and Support Student Learning

<table>
<thead>
<tr>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
<th>Level 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>The assessment only provides evidence of students’ procedural skills and/or factual knowledge.</td>
<td>The assessment provides evidence to monitor students’ conceptual understanding and procedural fluency related to the learning objectives and standards.</td>
<td>The assessment provides evidence to monitor students’ conceptual understanding related to the learning objectives and standards.</td>
<td>The assessment provides multiple forms of evidence to monitor students’ progress toward developing conceptual understanding, procedural fluency, AND mathematical reasoning and/or problem-solving skills related to the learning objectives and standards.</td>
<td>All requirements from Level 4 are met and the assessment is strategically designed to allow individuals or groups with specific needs to demonstrate their learning.</td>
</tr>
</tbody>
</table>

Note. From edTPA Secondary Mathematics Assessment Handbook (p. 18), by Stanford Center for Assessment, Learning, & Equity, 2016. Copyright 2016 by Board of Trustees of the Leland Stanford Junior University. Adapted with permission (see Appendix G).

In order for an assessment to be considered growth mindset in nature, Boaler (2016) and Sun (2015) assert that the assessment must provide students with opportunities to make sense of mathematics, i.e. to engage in mathematical reasoning or problem solving. In SCALE’s (2016a)
Rubric 5, the first level in which such sense making is evident is Level 3. At this level, the submitted assessment “monitor[s] students’ conceptual understanding, procedural fluency, AND mathematical reasoning and/or problem-solving skills” (p. 18). A Level 4 assessment goes even further by monitoring these areas in “multiple forms.” In a document released by SCALE (2016b), titled Understanding the Rubric Level Progressions (URLP), the Level 4 description of “multiple forms” is further explained to mean “that different types of evidence are used – e.g. description, explanation, sketch, problem steps, generalization to another context and not that there is only one type of evidence on homework, exit slips, and the final test” (p. 13). Providing multiple ways in which students may demonstrate their understanding and reasoning is aligned with Boaler’s (2016) description of multidimensional, growth mindset mathematics, where teachers try to incorporate many “ways to be mathematical” (p. 121). Finally, a Level 5 assessment monitors all the criteria described at Level 4, but also has been designed in a strategic manner, “allow[ing] individuals or groups with specific needs to demonstrate their learning without oversimplifying the content” (SCALE, 2016b, pp. 13-14). Such targeted, strategic design draws upon a second growth mindset practice described by Boaler (2016) as the creating of problems, tasks, or assessments that are “accessible to a wide range of students and…extend to high levels” (p. 84). She refers to such problems, tasks, and assessments as “low floor and high ceiling” (p. 84).

The remaining levels of Rubric 5, Levels 1 and 2 may be seen as relating to fixed mindset practices because they describe mathematics assessments that are more one dimensional in nature. A Level 1 assessment indicates that students are entirely focused on reproducing learned facts or procedures. Such an assessment conveys fixed mindset messages about mathematics (Sun, 2015). A Level 2 assessment goes beyond monitoring simple facts and procedures, also
providing evidence of the students’ procedural fluency and conceptual understanding of the topic(s). In such assessments students are required to make connections, but there is no element of sense making or reasoning, an element both Boaler (2016) and Sun (2015) describe as being important for sending growth mindset messages to students.

**Rubric 12: Providing Feedback to Guide Learning**

SCALE’s (2016a) *Rubric 12: Providing Feedback to Guide Learning* evaluates the feedback pre-service mathematics teachers provide on three assessment samples of student work. The three work samples are of the same assessment task that was evaluated using *Rubric 5.* *Rubric 12* can be found in Table 2.

According to Boaler (2016) formative assessment (or assessment for learning) is a key component of growth mindset assessments. She describes three parts of assessing for learning, “Clearly communicating to students what they have learned, … helping students become aware of where they are in their learning journey and where they need to reach, and… giving students information on ways to close the gap between where they are now and where they need to be” (p. 149). Boaler describes feedback that serves the purpose of formative assessment as diagnostic, and as addressing students’ work in a way through which they will understand how to improve their learning. Level 3 of *Rubric 12* is the first level in which this criterion of diagnostic feedback is met. Level 3 indicates feedback that focuses on specific strengths or needs of the students (but not both). SCALE’s (2016b) *URLP* describes such feedback as “includ[ing] such things as pointing to successful use of a strategy, naming a type of problem successfully solved, pointing to and naming errors, suggesting information that would help solve the problem successfully” (p. 28). The document goes on to provide examples of feedback that provides specific strengths or
needs, stating, “For a learning segment on solving systems of equations, examples of specific feedback are, ‘You were able to choose a variable and show how to multiply the entire equation by a constant to eliminate that variable’ (STRENGTH) OR ‘You multiplied by a constant, but you didn’t eliminate the variables in this problem; what do you need to do for the variable to eliminate?’ (NEED)” (p. 28).

Table 2. Rubric 12: Providing Feedback to Guide Learning

<table>
<thead>
<tr>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
<th>Level 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feedback is unrelated to learning</td>
<td>Feedback is general and addresses needs</td>
<td>Feedback is specific and addresses either needs or strengths related to the learning objectives.</td>
<td>Feedback is specific and addresses both strengths and needs related to the learning objectives.</td>
<td>All requirements from Level 4 are met and feedback for one or more focus students provides a strategy to address an individual learning need OR makes a connection to prior learning or experience to improve learning.</td>
</tr>
<tr>
<td>OR developmentally inappropriate</td>
<td>AND/OR strengths related to the learning objectives.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OR Feedback contains significant content inaccuracies OR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No feedback is provided to one or more focus students.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note. From *edTPA Secondary Mathematics Assessment Handbook* (p. 34), by Stanford Center for Assessment, Learning, & Equity, 2016. Copyright 2016 by Board of Trustees of the Leland Stanford Junior University. Adapted with permission (see Appendix G).*

The specific examples provided in the *URLP* seem to be in line with what de Kraker-Pauw et al. (2017) describe as growth-oriented feedback. In the example addressing a student strength, the feedback is focused on the student’s effective use of a strategy, and in the example addressing a need, the feedback touches on the error and provides cues (in the form of a question) to help the student understand how to improve their results. Such feedback may be considered diagnostic, and thus growth mindset, in nature. Level 4 goes one step further by
providing specific feedback that is specific and addresses both the student’s strengths and needs. For their use of diagnostic comments that will help the student better understand where they are in their learning, where they need to go, and how to get there, Levels 3 and 4 may be considered as indicating more growth mindset feedback.

Level 5 feedback, the highest level on this rubric, indicates feedback that addresses all the criteria of Level 4 feedback, but also goes beyond these comments by providing the student with some strategy to address their learning needs or “mak[ing] connections to prior learning or experience to improve learning” (SCALE, 2016a, p. 34). In SCALE’s (2016b) URLP, the following example is provided, “I want you to visualize the new situation as you did in the problem you solved yesterday, to be able to compare the different scenarios. Then sketch the situation and label all the angles and sides before you work on solving it. This will help you see the problem as you solve it” (p. 30). Level 5 was also considered as indicating feedback that was more growth mindset in nature.

The remaining two levels, Levels 1 and 2, of Rubric 12, describe feedback that was deemed fixed mindset in nature. Level 1 describes feedback that is either unrelated to student learning or learning needs, or that contains significant content errors that may hinder the students learning of the given content. Such feedback cannot be classified as diagnostic; therefore, Level 1 was considered a fixed mindset level on this rubric. At Level 2 the rubric describes feedback as “general and addresses needs AND/OR strengths related to the learning objectives” (SCALE, 2016a, p. 34). The use of the word “general” seems unclear here, so it may serve to clarify the type of feedback that might be scored at a Level 2. SCALE’s (2016b) URLP document provides greater detail about the feedback classified at this level, stating, “At a Level 2, although feedback is related to the learning objectives, it is vague and does not identify specific strengths or needs
for improvement. At Level 2, general feedback includes identifying what each focus student did or did not do successfully with little detail, e.g., checkmarks for correct responses, points deducted, and comments such as, ‘Watch out for negative signs!’ that are not linked to a specific strength or need. General feedback does not address the specific error or correct solution (e.g., ‘Check your work’ or ‘Yes!’)” (p. 29).

Though the descriptors provided here are shorter than those provided for Level 3, length should not be taken into consideration when scoring between a Level 2 or Level 3. Instead, pointing to specific strengths or needs should be the determining factor of scoring feedback at a Level 3. With this description, the researcher did not feel Level 2 feedback could be classified as growth mindset feedback, because it does not provide student with enough information about what the student knows, needs to know, or how to “close the gap between where they are now and where they need to be” (Boaler, 2016, p. 149). Thus, Level 2 was also considered a fixed mindset level on Rubric 12.

Rubric 15: Using Assessment to Inform Instruction

SCALE’s (2016a) Rubric 15: Using Assessment to Inform Instruction evaluates the next instructional steps that pre-service teachers propose after analyzing whole class performance on the submitted assessment task. Rubric 15 can be found in Table 3.
<table>
<thead>
<tr>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
<th>Level 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Next steps do not follow from the analysis.</td>
<td>Next steps primarily focus on changes to teaching practice that are superficially related to student learning needs, for example, repeating instruction, repeating pacing, or classroom management issues.</td>
<td>Next steps propose general support that improve student learning related to assessed learning objectives.</td>
<td>Next steps provide targeted support to individuals or groups to improve their learning relative to conceptual understanding, procedural fluency, AND/OR mathematical reasoning and/or problem-solving skills.</td>
<td>Next steps provide targeted support to individuals AND groups to improve their learning relative to conceptual understanding, procedural fluency, AND/OR mathematical reasoning and/or problem-solving skills.</td>
</tr>
<tr>
<td>OR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Next steps are not relevant to the learning objectives assessed.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Next steps are not described in sufficient detail to understand them.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. From *edTPA Secondary Mathematics Assessment Handbook* (p. 37), by Stanford Center for Assessment, Learning, & Equity, 2016. Copyright 2016 by Board of Trustees of the Leland Stanford Junior University. Adapted with permission (see Appendix G).

As discussed previously, using assessment formatively is key component of assessments that convey growth mindsets (Boaler, 2016). In order to use assessment formatively, the assessment is not viewed as a final product, but instead as a tool for the teacher to select next instructional steps to improve student learning, as evaluated on the assessment (Masters, 2013). Levels 3, 4, and 5 of *Rubric 15* describe using assessment formatively by proposing instructional steps that will help to improve student learning, as evidenced in the graded assessment. Should a pre-service teacher score at a Level 3, they will have proposed next instructional steps that support the learning needs of the class as a whole. If, in addition to these general supports, the pre-service teacher describes specific, strategic next instructional steps that would “support specific needs for either individuals (2 or more students) or [emphasis added] groups with similar needs related to one or more of the three areas of mathematical learning,” the pre-service teacher will score a Level 4 on this rubric (SCALE, 2016b, p. 37). In both Levels 3 and 4, the
pre-service teacher is analyzing student work and using the obtained information to guide their next instructional steps, sending a growth message that the assessment does not indicate final learning (Boaler, 2016; Master, 2013). The difference between the two levels, however, is that the at a Level 3 the next steps are geared more towards supporting whole class needs, whereas at a Level 4 the next steps are addressing whole class needs in addition to the needs of either “individuals or [smaller] groups” within the class (SCALE, 2016a, p. 37).

Finally, if the pre-service teacher provides next steps that fulfill the requirements of a Level 3 and proposes specific, strategic next instructional steps that would “support individuals and [emphasis added] groups needs in relation to the areas of mathematical learning,” the pre-service teacher will score a Level 5 on this rubric (SCALE, 2016b, p. 37). As was the case with Levels 3 and 4, Level 5 describes a process of assessment where “evidence about student achievement [has been] elicited, interpreted, and used by teachers…to make decisions about the next steps in instruction” (Wiliam, 2011, p. 43). In other words, if a pre-service teacher has scored at Levels 3, 4, or 5, this is an indication that the teacher has indeed engaged in the process of formative assessment. Using assessment in this way (formatively) conveys growth mindset messages about the assessment and learning process (Boaler, 2016).

In contrast, Levels 1 and 2 of Rubric 15 describe next instructional steps that do not satisfy the criteria of using assessment formatively. At these levels, next instructional steps that do not take student needs into account or do not provide targeted support to improve student learning. Wiliam (2011) has described this process of using assessment to inform future instruction as a central purpose of formative assessment. He states, “evidence that is collected with the intent of being used but never actually used is unhelpful” (p. 44). Examples of next instructional steps that may score at these levels include moving on without considering needs,
providing students with more practice (with no specific detail as to what that practice will entail), repeating the instruction of the lesson, or improving “pacing or classroom management, with no clear connections to how changes address...student learning needs” (SCALE, 2016b, p. 37). If a teacher moves on without considering the needs of the class, or simply engages in repeated instruction without a focus on specific needs, a fixed mindset message may be conveyed to students. The former practice may convey a message that learning is not the true focus of the classroom, whereas the latter may convey that it is up to the teacher to convey understanding, rather than for the learner to make sense of mathematics and develop their own understanding. Focusing on learning and sense making are important principles of growth mindset assessment (Boaler, 2016).

Further Discussion about edTPA

Although this study makes use of the aforementioned edTPA rubrics to help answer the research questions, the researcher felt it important to note that this study is not advocating for the use of edTPA to assess growth or fixed mindset teaching practices. The choice of using the three rubrics was made because the specified rubrics present a classification that mirrors many of the tenants set forth in Boaler’s (2016) described framework of teaching and assessing for a growth mindset. The rubrics also provided a greater structure for that framework.

While many states have adopted the use of edTPA as a requirement for teacher licensure, and SCALE (2015a; 215b) has released extensive literature describing the research that was used in creating the performance assessment and the reliability and validity of edTPA in ensuring that teachers enter the profession ready to teach, a growing number of teacher educators have expressed concerns regarding the use of edTPA as a high stakes performance assessment and the
unnecessary stress it places on teacher educators, pre-service teachers, and other members of teacher education programs (Aydarova & Berliner, 2018). As mentioned previously, various scholars have questioned SCALE’s (2015a) reporting of the reliability and validity of the assessment; much of the research supporting its use was conducted “in a different context where stakes were lower for candidates” (Clayton, 2018, p. 4). At least one analysis has reported that edTPA scores are predictive of teaching effectiveness in reading but have not been found to be significantly predictive of teaching effectiveness in mathematics (Goldhaber, Cowan, & Theobald, 2017).

In addition, many social justice-oriented teacher educators have raised concerns that the high stakes nature of edTPA has constrained the curriculum in their teaching methods courses and shifted the focus of teacher education programs away from addressing important issues related to social justice and equity, and more towards the tools needed to pass edTPA (Henning, Dover, Dotson, & Agarwal-Rangath, 2018). These teacher educators also pose concerns about the anonymous third-party scorers that are hired to evaluate edTPA portfolios. In relation to these scorers, one teacher educator writes,

They [do] not know our candidates, or our local schools. As an applied linguist, I [wonder] if our students would…be evaluated fairly because in their videotaped segments they speak with southern accents and/or use other varieties of English, albeit in culturally and pedagogically appropriate ways with their students. Knowing that my university’s service area is primarily comprised of Title I schools in under resourced, underserved and marginalized communities, I [wonder] how SCALE [can] ensure that scorers [will] be [impartial]…in the evaluation of our candidates if videotaped segments [capture] mostly black and brown students who are not sitting quietly in neat rows (Henning, Dover, Dotson, & Agarwal-Rangath, 2018, p. 20).

This teacher educator goes on to discuss the importance of teacher educators having contextual, local knowledge about the communities and students in which the pre-service teacher has been placed (Henning, Dover, Dotson, & Agarwal-Rangath, 2018)
Scholars also caution that the cost of edTPA, which adds an additional $300 to the cost of licensure, adds a financial burden on teacher candidates that are non-traditional or from marginalized groups (Henning, Dover, Dotson, & Agarwal-Rangath, 2018). Such a burden may reinforce the “systems of exclusion that could result in reduced access to the teaching profession for prospective teachers of color” (Donovan & Cannon, 2018, p. 19). While members of SCALE have crafted a response to address many of the aforementioned concerns, and to defend edTPA as an “educative”, rather than “subtractive” experience for pre-service teachers (Whittaker, Pecheone, & Stansbury, 2018), the use of edTPA as a performance assessment remains controversial throughout the field of education.
This study used a mixed-methods approach to explore the relationship between a pre-service mathematics teacher’s beliefs about mathematics and intelligence (mindset), and the mindset messages conveyed in their assessments, their feedback on those assessments, and the next instructional steps they propose after analyzing student performance on the assessments. This chapter provides a description of the participants, data collection, and methods for analysis.

Participants

The pre-service teachers in this study were all enrolled in an Initial Certification Master’s Program, which required admitted students to have completed at least 24 mathematics credits in their undergraduate studies. Before they were assigned to their first student teaching placement, pre-service teachers were also required to complete a teaching methods course in which they were exposed to research-based, constructivist methods for teaching mathematics. Upon completing this teaching methods course, pre-service teachers were enrolled in a student teaching seminar in which they were assigned to a public school in a large Northeastern city of the United States to complete at least 100 hours of student teaching and 50 hours of observations. Following their first placement, the pre-service teachers were required to complete a second teaching placement with the same hour requirements. One of these placements was to take place in a public middle school and one in a public high school.
During each of their two student teaching placements, the pre-service teachers were required to compile a three-part portfolio in which they submitted lesson plans, video clips showing their instruction from those lessons, and student samples of an assessment administered during those lessons. Along with their lessons, video clips, and assessment samples, the pre-service teachers were required to respond to a series of prompts that had them reflect and comment on various aspects of their planning, instruction, and student performance on the submitted assessment. These prompts were identical to those that students would submit for their commentaries on the educative Teacher Preparation Assessment (edTPA), which they were required to pass for teacher licensure. That is, students ultimately submitted two edTPA-type portfolios: what will be referred to as Assessment 5, which was a parallel edTPA portfolio submitted during their first placement; and the final edTPA portfolio, created from their second placement, which was the one submitted for teacher licensure to the state. During the pre-service teachers’ first student teaching placement, their created parallel edTPA portfolio (Assessment 5) was submitted as a formative assessment. The researcher scored Assessment 5 (in its entirety) using the 15 edTPA rubrics created by SCALE (2016a) and provided the pre-service teachers with extensive feedback explaining their performance on each rubric. The researcher also provided pre-service teachers with extensive feedback on their lesson plans, video submission, student work samples, and all commentary responses. The final edTPA portfolio compiled during their second student teaching placement was instead used summatively, as their edTPA submission. The edTPA portfolios were submitted directly to Pearson for teacher licensure and thus, the final portfolios had higher stakes. Aside from using the first student teaching portfolio formatively and the second summatively, the two portfolios were essentially identical assignments, with the exception that Assessment 5 required pre-service teachers to focus on a
segment of one to three lessons, whereas the final edTPA portfolio required a segment of three to five lessons.

In preparing the pre-service teachers to compile their Assessment 5 portfolios and their final edTPA portfolios, the program dedicated three sessions per semester of the student teaching seminar to edTPA workshops in which pre-service teachers were introduced to edTPA requirements. These workshops were created and facilitated by the researcher. During the workshops, pre-service teachers were provided with copies of the *Secondary Mathematics Assessment Handbook* (2016a) and *Understanding the Rubric Level Progressions* (2016b), both developed by the Stanford Center for Assessment, Learning, & Equity (SCALE). While the *Secondary Mathematics Assessment Handbook* (SCALE, 2016a) described the requirements of edTPA, the *Understanding the Rubric Level Progressions* (SCALE, 2016b) document delved more deeply into the various rubric levels introduced in the *Secondary Mathematics Assessment Handbook* (SCALE, 2016a). During the workshops, pre-service teachers were also tasked with using the *Secondary Mathematics Assessment Handbook* (SCALE, 2016a) and *Understanding the Rubric Level Progressions* (SCALE, 2016b) to score a sample portfolio. Rationales for the assigned scores, as well as any questions stemming from those scores, were discussed throughout these three workshop sessions.

The pre-service teachers’ cooperating teachers and supervisors were also made familiar with Assessment 5 and edTPA requirements and agreed to allow their student teachers to submit portfolio items that were an accurate reflection of the pre-service teacher’s own style and philosophy, rather than that of the cooperating teacher. The workshops and scoring of the portfolios all took place before the researcher attempted to recruit participants for this study.
To recruit participants, the researcher emailed 16 pre-service teachers who had recently completed their first student teaching placement (see Appendix B for original recruitment email). The main criterion used to include pre-service teachers in the recruitment pool was that the teacher must have completed their first student teaching placement in one of the two semesters preceding the recruitment period. The researcher chose to only include pre-service teachers completing their first placement in the two preceding semesters because at the time of this study, these were the two semesters that had completed identical workshops (implemented by the researcher) introducing them to and preparing them for their submissions for Assessment 5 and the final edTPA portfolio (these workshops were those described previously). In preceding semesters, the state’s implementation of edTPA as a requirement for licensure was in its infancy and many teacher preparation programs were still in the process of fine-tuning their supports for pre-service teachers in this area. The preceding two semesters were also two subsequent semesters in which SCALE, the organization that develops the edTPA, had not made any changes to the rubrics in its Secondary Mathematics Assessment Handbook (2016a). The researcher also chose to include only pre-service teachers in their first student teaching placements because it was felt that the pre-service teachers’ Assessment 5 submissions may be more congruent with their beliefs than their final edTPA submissions. Assessment 5 (compiled during their first placement) was used as a formative assessment in the seminar, whereas their final edTPA portfolio was submitted to Pearson as a summative assessment to evaluate their qualifications for state licensure. Such high stakes assessments may encourage students to “sacrifice one’s authentic self in order to play the game” of edTPA and state licensure (Clayton, 2018).
Eight pre-service teachers volunteered for the study and completed a survey to determine their mindset and beliefs about mathematics (this survey will be described in greater detail in a later section of this chapter). The researcher chose final participants by selecting the three volunteers with the highest mindset survey scores, indicating more of a growth mindset, and the three volunteers with the lowest mindset survey scores indicating more of a fixed mindset. The researcher made the decision to choose participants based on mindset, rather than beliefs about mathematics, in order to better compare final observations to those of Sun’s (2015) study, which found that teaching practices may not be in line with teacher mindset.

**Determining Mindset and Beliefs about Mathematics**

To identify pre-service teachers with growth and fixed mindsets, a mindset survey was administered to study volunteers. Initially, this study only sought to address the alignment of teacher practices and mindset, so the researcher administered a survey which consisted of eight questions, created by Dweck (2000; see Appendix C), to nine volunteers. Data from this initial survey showed that all nine volunteers had a growth mindset. To address this problem and to address some of the findings of Sun’s (2015) newly published dissertation, the researcher recruited a new pool of pre-service teachers and administered a longer, more general Beliefs Survey (see Appendix D), containing the eight mindset questions from the original survey and other items from a survey used in Sun’s study. This longer mindset survey consisted of 35 Likert items. Of those 35 items, 11 measured pre-service teacher mindsets, and were nested among questions measuring pre-service teacher beliefs in the areas of expectations, nature of mathematics, and providing all students access to more rigorous mathematics. Survey items
measuring mindset are outlined in Table 4. Eight of these items, items 7, 10, 13, 16, 19, 22, 25, and 29, were those created by Dweck (2000) and used in the original mindset survey. The remaining three items were obtained from the survey administered for Sun’s (2015) study.

Table 4. Mindset Items from the Beliefs Survey

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Statement</th>
<th>Reverse Coded (Y/N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>A person has a certain amount of intelligence, and they can’t really do much to change it.</td>
<td>Yes</td>
</tr>
<tr>
<td>10</td>
<td>A person’s intelligence is something about them that they can’t change very much.</td>
<td>Yes</td>
</tr>
<tr>
<td>13</td>
<td>No matter who they are, a person can significantly change their intelligence level.</td>
<td>No</td>
</tr>
<tr>
<td>16</td>
<td>To be honest, a person can’t really change how intelligent they are.</td>
<td>Yes</td>
</tr>
<tr>
<td>17</td>
<td>There are limits to how much people can improve their basic math ability.</td>
<td>Yes</td>
</tr>
<tr>
<td>19</td>
<td>A person can always substantially change how intelligent they are.</td>
<td>No</td>
</tr>
<tr>
<td>22</td>
<td>A person can learn new things, but they can’t really change their basic intelligence.</td>
<td>Yes</td>
</tr>
<tr>
<td>25</td>
<td>No matter how much intelligence they have, a person can always change it quite a bit.</td>
<td>No</td>
</tr>
<tr>
<td>26</td>
<td>You have a certain amount of math intelligence, and you can’t really do much to change it.</td>
<td>Yes</td>
</tr>
<tr>
<td>28</td>
<td>Some students have a knack for mathematics and some just don’t.</td>
<td>Yes</td>
</tr>
<tr>
<td>29</td>
<td>A person can change even their basic intelligence level considerably.</td>
<td>No</td>
</tr>
</tbody>
</table>

Survey items measuring beliefs about the nature of mathematics were also obtained from the survey used in Sun’s (2015) study. These items, items 12, 15, 20, and 21, are outlined in Table 5.

Table 5. Beliefs about Mathematics Items from Beliefs Survey

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Statement</th>
<th>Reverse Coded (Y/N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>Mathematics involves mostly facts and procedures that have to be learned.</td>
<td>Yes</td>
</tr>
<tr>
<td>15</td>
<td>There is usually only one way to solve a math problem.</td>
<td>Yes</td>
</tr>
<tr>
<td>20</td>
<td>In mathematics, answers are either right or wrong.</td>
<td>Yes</td>
</tr>
<tr>
<td>21</td>
<td>Discussing students’ errors with the class is a good strategy for enhancing students’ understanding.</td>
<td>No</td>
</tr>
</tbody>
</table>
As previously mentioned, survey items assessing pre-service teacher mindset and beliefs about mathematics were nested among questions measuring teacher’s beliefs in the areas of expectations and providing all students access to more rigorous mathematics. Sun (2016) refers to the latter views as “access views.” Survey questions addressing expectations are outlined in Table 6 and those addressing access views in Table 7.

Table 6. Expectation Items from Beliefs Survey

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Statement</th>
<th>Reverse Coded (Y/N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>In math class there will always be some students who simply won't &quot;get it.&quot;</td>
<td>Yes</td>
</tr>
<tr>
<td>18</td>
<td>Some students are not going to make a lot of progress this year, no matter what I do.</td>
<td>Yes</td>
</tr>
<tr>
<td>23</td>
<td>In my class(es), students who start the year low performing tend to stay relatively low performing at the end of the year.</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Table 7. Access View Items from Beliefs Survey

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Statement</th>
<th>Reverse Coded (Y/N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>How important is it for students to acquire basic math skills before engaging in complex conceptual math problems?</td>
<td>Yes</td>
</tr>
<tr>
<td>33</td>
<td>When learning math, how important is it that students are placed into math classes according to their math achievement (ability grouping)?</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Survey validity and reliability

Eight of the aforementioned survey items, items 7, 10, 13, 16, 19, 22, 25, and 29, were those created by Dweck (2000) and used in the original mindset survey. In her Self-theories book, Dweck (2000) reports these to be valid and reliable. The remaining survey items were obtained from Sun’s (2015) study on teacher beliefs and student mindset. In her study, Sun assessed the reliability of her survey by calculating a pre-post survey correlation. She states, “the
correlation coefficients between the pre- and post-survey suggest stability for the mindset and nature of math beliefs and a fair degree of stability for expectations and access views. However, the reliability for the mindset and expectations construct dropped in the post-survey” (p. 49). Combining these two surveys, as was done in this study, essentially created a new survey. However, the two factors – and the items assessing these factors – were independently discussed as valid and reliable in the studies of Dweck (2000) and Sun (2015). The sample size in this study was too small to conduct tests of statistical significance. However, in the results section, we can see that there was reasonable alignment for each participant on each of the 11 mindset items, and each of the 4 beliefs items. Thus, this suggests the surveys were reasonable measures for these two constructs.

Case Studies

As described previously, pre-service teachers were required to submit a portfolio, called their Assessment 5 portfolio, at the end of their first student teaching placement. This portfolio was intended to showcase their planning of a lesson, instruction of that lesson, and assessment of student learning. Pre-service teachers were also required to respond to several prompts for each component of this portfolio. The requirements and prompts of this portfolio are virtually identical to those of the edTPA Secondary Mathematics portfolio students must compile and submit as part of their state certification requirements (Stanford Center for Assessment, Learning, & Equity, 2016a), with the exception that (1) students submit one to three lessons for Assessment 5 and three to five lessons for edTPA and (2) Assessment 5 was used as a formative assessment in the program and the final edTPA portfolio was a summative assessment. For this
study, data analysis was limited to the final section of the pre-service teachers’ Assessment 5 portfolios, where they were required to select an assessment within their lesson and analyze student performance on that assessment (See Appendix E).

The final section of Assessment 5 required pre-service teachers to describe their chosen assessment and the learning objectives and standards measured. Following this, pre-service teachers were asked to provide the evaluation criteria used for their assessment, as well as discuss “quantitative and qualitative patterns of learning” based on both their evaluation criteria and on student work (Stanford Center for Assessment, Learning, & Equity, 2016a, p. 7). Next, they were to provide three samples of student work, and use those samples to further illustrate the patterns of learning discussed previously and to consider similarities and differences in learning for groups of students or individual students. The students to whom these samples belonged were referred to as focus students. In addition, pre-service teachers were asked to provide an analysis of students’ “understanding and use of academic language” either by using the focus students’ work samples, or by referring back to the video submitted in a previous section of the Assessment 5 portfolio (Stanford Center for Assessment, Learning, & Equity, 2016a, p. 7).

Following their description of student performance on their assessment, the pre-service teachers were required to document feedback they gave to the three focus students and discuss how that feedback (a) addressed the strengths and weaknesses of each student, with regard to the learning objectives and standards assessed, and (b) how they planned to support these students to understand and use the provided feedback to improve learning. The discussion of their assessment, feedback, and analysis of student performance was then followed by a section in
which pre-service teachers were asked to reflect on student performance and use their analysis to propose next steps for instruction.

**Data Analysis**

The researcher used the above described Belief Surveys and Assessment 5 portfolios to explore the three research questions. Data analysis will be described in greater detail in the sections that follow.

**Mindset**

Mindset items from the Beliefs Survey were scored utilizing the same scale as used by Sun (2015). All survey items were measured using a six-point Likert scale, with responses ranging from “strongly agree” to “strongly disagree.” Mindset items that were worded negatively, items 7, 10, 16, 17, 22, 26, and 28, were reverse coded so that higher scores would indicate participants with more of a growth mindset. In determining pre-service teacher mindset, the researcher calculated an average score for participant responses to the 11 mindset items. Using scales similar to those used in Sun’s (2015) study, average scores falling in the range of 1 to 3.9 were classified as “more fixed” and average scores falling in the range of 4 to 6 were classified as “more growth.” From this point forward, the terms “more fixed” and “more growth” will be simplified to “fixed” and “growth.”
Nature of Mathematics Beliefs

Items of the Beliefs Survey that measured beliefs about mathematics were scored in a similar manner as those measuring mindset. Beliefs about mathematics items 12, 15, and 20 which were worded negatively, were reverse coded so that a higher score would indicate participants with more multidimensional views about the nature of mathematics and a lower score would indicate participants with more one dimensional views about the nature of mathematics. Again, the researcher calculated an average score for a participant’s responses to these four items. Average scores falling between 1 and 3.9 were considered “more one dimensional” and average scores falling between 4 and 6 were considered “more multidimensional.” As was mentioned previously for mindset, “more one dimensional” will henceforth be referred to as “one dimensional” and “more multidimensional” will be described as “multidimensional.”

Assessments

In order to explore research question 1, the relationship between the mindset messages conveyed in the pre-service submitted assessment task and their (a) mindset and (b) beliefs about mathematics, the researcher observed the content of the assessment and the pre-service teacher’s description of the assessment’s evaluation criteria and of how the assessment monitored students’ development of conceptual understanding, procedural fluency, and mathematical reasoning/problem-solving in relation to the stated learning objectives and standards. No bonus, extra credit, challenge, or otherwise optional questions were considered in this analysis, as not all students were required to engage with these problems. The researcher then used a modified version of SCALE’s (2016) Rubric 5: Planning Assessment to Monitor and Support Student
Learning, to score the pre-service teacher’s assessment at the appropriate level. This rubric was modified from its original version because Rubric 5 scores assessments submitted from three to five lesson plans, providing a more holistic score across the lesson assessments. Assessment 5, however, only requires students to submit a one to three lesson plans and their associated assessment(s). The participants in this study all chose to submit a single lesson plan. Rubric 5 was modified to better reflect this use of a single lesson. This modified version of Rubric 5, can be found in Table 8 and SCALE’s (2016) original Rubric 5 can be found in Appendix A. Notably, appended to Rubric 5 in Table 8 is a correspondence to fixed- and growth-mindset teaching practices. This alignment to the rubric came from the researcher’s review of the literature around fixed- and growth-mindset teaching practices for planning assessment. This alignment to fixed- and growth-mindset teaching practices is an approximation (Rubric 5 was not necessarily created for this purpose), and was used as one – but not the only – indicator of fixed- and growth-mindset teaching practices in this study.

Participants’ Rubric 5 scores were recorded to indicate whether their assessment practices were more growth or fixed. As can be viewed in Table 8, scores of three or higher would indicate more growth mindset practices, scores below a three would indicate more fixed mindset practices. These rubric scores were then explored in relation to the pre-service teachers’ self–reported beliefs about mathematics and mindsets (from the Beliefs Survey) in each of the six cases.
Table 8. Modified Rubric 5: Planning Assessments to Monitor and Support Student Learning

<table>
<thead>
<tr>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
<th>Level 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>The assessment only provides evidence of students’ procedural skills and/or factual knowledge.</td>
<td>The assessment provides evidence to monitor students’ conceptual understanding and procedural fluency related to the learning objectives and standards.</td>
<td>The assessment provides evidence to monitor students’ conceptual understanding, procedural fluency, and/or problem-solving skills related to the learning objectives and standards.</td>
<td>The assessment provides evidence to monitor students’ conceptual understanding, procedural fluency, and/or problem-solving skills related to the learning objectives and standards.</td>
<td>All requirements from Level 4 are met and the assessment is strategically designed to allow individuals or groups with specific needs to demonstrate their learning.</td>
</tr>
</tbody>
</table>

**Fixed Mindset Levels**

Both levels are one dimensional, either focusing entirely on reproducing learned facts or procedures, or failing to require students to engage in reasoning.

**Growth Mindset Levels**

At each of these levels, students are required to make connections among concepts/ideas and engage in reasoning (making the assessment more multidimensional). In addition, the higher levels describe assessment that monitor student reasoning in various forms and/or are accessible to all students (those who need greater support, those who need greater challenge, and everyone in between).

*Note.* From *edTPA Secondary Mathematics Assessment Handbook* (p. 18), by Stanford Center for Assessment, Learning, & Equity, 2016. Copyright 2016 by Board of Trustees of the Leland Stanford Junior University. Adapted with permission (see Appendix G).

**Feedback**

In order to explore research question 2, the relationship between a pre-service mathematics teacher’s (a) mindset and (b) beliefs about mathematics and the mindset messages
conveyed in the feedback provided to students, the researcher analyzed the three submitted student work samples, which contained the pre-service teacher’s written feedback. For this study, feedback was defined in a similar fashion as in Hattie and Timperley’s (2007) review of the literature on feedback, where “feedback is conceptualized as information provided by an agent (e.g., teacher, peer, book, parent, self, experience) regarding aspects of one’s performance or understanding” (p. 81). In this study, the only feedback observed is that of the pre-service teacher; therefore, the “agent” providing feedback will refer to the pre-service teacher’s written feedback on the assessment samples.

The researcher began by viewing the feedback provided to each student holistically, noting when the pre-service teacher commented on student strengths or student weaknesses and whether those comments were general (e.g., “Nice job!”) or specific enough to improve the student’s intended learning. The researcher then utilized SCALE’s (2016) Rubric 12: Providing Feedback to Guide Learning, Table 9, to score the pre-service teacher’s feedback at the appropriate level.

Participants’ Rubric 12 scores were recorded to indicate whether their feedback practices were more growth or fixed, as indicated in Table 9. Relationships between participants rubric scores were then explored in relation to the pre-service teachers’ self-reported beliefs about mathematics and mindsets (from the Beliefs Survey) in each of the six cases. Again, appended to Rubric 12 in Table 9 is a correspondence to fixed- and growth-mindset teaching practices, which came from the researcher’s review of the literature and was used as one indicator in this study.
<table>
<thead>
<tr>
<th><strong>Fixed Mindset Levels</strong></th>
<th><strong>Growth Mindset Levels</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Feedback is unrelated to learning objectives OR is developmentally inappropriate OR Feedback contains significant content inaccuracies OR No feedback is provided to one or more focus students.</td>
<td>Feedback is general and addresses needs OR Feedback is specific and addresses needs related to the learning objectives. OR Feedback is specific and addresses strengths related to the learning objectives. OR Feedback is specific and addresses both strengths and needs related to the learning objectives.</td>
</tr>
<tr>
<td>Levels 1 and 2 describe feedback that is not diagnostic and that is either unrelated to student learning, or is not specific enough to provide information about what the student knows, needs to know, or how to reach the desired level of learning.</td>
<td>Level 3 through Level 5 describes feedback that is diagnostic and moves the process of learning forward. This feedback is specific and provides the learner with information about their strengths and/or needs, and at the highest level, proposes a strategy or makes connections to prior learning or experiences to improve learning. At these levels, feedback serves a formative purpose.</td>
</tr>
</tbody>
</table>

*Note.* From *edTPA Secondary Mathematics Assessment Handbook* (p. 34), by Stanford Center for Assessment, Learning, & Equity, 2016. Copyright 2016 by Board of Trustees of the Leland Stanford Junior University. Adapted with permission (see Appendix G).

In addition to viewing feedback holistically, the researcher was interested in exploring the specific types of feedback provided by each participant. To do this, the researcher created a table for each participant, documenting every instance of feedback provided on the samples (with the exception of check marks or x’s), and the context of that feedback. After creating these feedback tables, the researcher used the process of constant comparison (Glaser & Strauss, 1967) to begin sorting the individual feedback instances into categories based on similarities. Each item
was reviewed and compared to the other feedback instances when placed into a category. The initial sorting resulted in 9 feedback categories, but after several cycles of refinement by comparison a total of 14 feedback categories were identified (See Appendix F for participant feedback, context, and categories). These 14 feedback categories will be presented and discussed in greater detail in the next chapter.

Following this process of constant comparison, the researcher recorded the number of each pre-service teacher’s feedback instances that had been classified in each category. Additionally, the researcher calculated the percentage of each pre-service teacher’s feedback instances that had been classified in each category. The researcher then compared the percentages for each feedback category to the participant’s average scores for Beliefs Survey items related to the nature of mathematics and for mindset.

**Next Instructional Steps**

In order to explore research question 3, the relationship between a pre-service mathematics teacher’s (a) mindset (b) beliefs about mathematics and the mindset messages conveyed in the next instructional steps they propose after analyzing student performance on their assessment, the researcher observed the pre-service teachers’ descriptions of their submitted assessments, their analysis of student work in response to prompts three and four of Assessment 5, and the next instructional steps they discuss in response to prompt eight of Assessment 5. The researcher considered the relationship between the proposed next steps and the analysis of student performance, as well as between the learning objectives and analysis of student performance/proposed next steps. The researcher also took note of next steps that were more general, applying to whole-class needs, and next steps that were more targeted, meeting the
needs of individual students or smaller groups of students, such as English Language Learners or students with Individualized Education Programs. Next, the researcher applied SCALE’s (2016a) *Rubric 15: Using Assessment to Inform Instruction*, see Table 10, to score each pre-service teacher’s next instructional steps at the appropriate level. Similarly, appended to *Rubric 15* in Table 10 is an approximate correspondence to fixed- and growth-mindset teaching practices, which came from the researcher’s review of the literature but which should not be used as a definitive characteristic of the rubric.

<table>
<thead>
<tr>
<th>Table 10. Rubric 15: Using Assessment to Inform Instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Level 1</strong></td>
</tr>
<tr>
<td>Next steps do not follow from the analysis.</td>
</tr>
<tr>
<td>OR</td>
</tr>
<tr>
<td>Next steps are not relevant to the learning objectives assessed.</td>
</tr>
<tr>
<td>OR</td>
</tr>
</tbody>
</table>

**Fixed Mindset Levels**

At these levels, assessments are not used formatively. Levels 1 and 2 describe next instructional steps that do not take student needs into account or do not provide targeted support to improve student learning.

**Growth Mindset Levels**

Levels 3, 4, and 5 describe using assessment formatively by proposing instructional steps that will help to improve student learning, as evidenced in the graded assessment.

*Note.* From *edTPA Secondary Mathematics Assessment Handbook* (p. 37), by Stanford Center for Assessment, Learning, & Equity, 2016. Copyright 2016 by Board of Trustees of the Leland Stanford Junior University. Adapted with permission (see Appendix G).
The researcher used participants’ Rubric 15 scores in a similar fashion as that described for the rubrics used for the first and second research questions. Scores were recorded to indicate if the pre-service mathematics teachers’ use of formative assessment was more in line with growth or fixed mindset practices, as indicated by the levels in Table 10, and were then explored in relation to the pre-service teachers’ self-reported beliefs about mathematics and mindsets (from the Beliefs Survey) in each of the six cases.

A Note Regarding Coding

In addition to the researcher, a second coder was enlisted to independently score participant responses using Rubric 5, Rubric 12, and Rubric 15. This coder is a mathematics teacher with several years of teaching experience, and possesses an undergraduate and graduate degree in mathematics, as well as a graduate degree in mathematics education. The researcher and coder met to compare their scores on each of the rubrics and in the case of any discrepancy, engaged in discussion until a consensus was reached. This coder was also involved in the final steps of constant comparison in creating the feedback categories (Glaser & Strauss, 1967). As with the rubric scores, the researcher and coder met to compare their classifications of feedback instances and in the case of any discrepancy, engaged in discussion until a consensus was reached. The coder was never made aware of the participants’ mindsets (growth or fixed) and the researcher completed scoring of Rubric 5, Rubric 12, and Rubric 15 before viewing participants’ responses to the Beliefs Survey administered in this study.
Chapter IV
RESULTS

This chapter will begin with a presentation of the beliefs of the six case study participants, as indicated from their responses on the submitted Beliefs Survey. Next, there will be a presentation of the 14 feedback categories developed through the researcher’s use of grounded theory. These categories, when applicable, will be discussed in the context of what is known about feedback that conveys growth or fixed mindset messages to students. Following the discussion of feedback categories, there will be an in-depth presentation of the six case study participants, giving background information on the pre-service teachers’ student teaching placements and discussing the assessments submitted for their portfolios, the feedback provided on submitted student work samples, and the next instructional steps they propose based on their analysis of student performance. To close the chapter, the researcher will address the three research questions of this study. These research questions will be answered by first presenting quantitative comparisons of rubric scores, then by exploring qualitative relationships.

Participants Reported Beliefs

Pseudonyms with a last name of “G.” are indicative of participants who scored growth mindsets, and those with “F.” of those who scored fixed mindsets. All first-name pseudonyms are female, but these are not necessarily indicative of the gender of the participant; in this small-scale study, this was done to further protect the identity of individual participants. Table 11 shows the coding for participants responses to mindset items on the Beliefs Survey. A score of 1
indicates the participant responded to an item by selecting the most fixed mindset option. In positively worded items, such as item 13 “No matter who they are, a person can significantly change their intelligence level,” this was the “strongly disagree” option. In negatively worded items\(^1\) (which were reverse coded), such as item 17 “There are limits to how much people can improve their basic math ability,” this was the “strongly agree” option. Higher scores for mindset items indicate the participant selected more growth mindset options. For example, a score of 6 on item 13 would indicate the participant selected “strongly agree,” whereas a 6 on item 17 would indicate the participant selected “strongly disagree.”

Table 11 also indicates the mean scale score for each participant, as well as a calculated standard deviation. The three fixed mindset participants, Erin F., Nellie F., and Paige G., all possessed mean scale scores within the 3.6-3.8 range, whereas the three growth mindset participants, Jensen G., Alyssa G., and Tess G., all possessed mean scale scores within the 5.2-5.7 range. When viewing the standard deviation of responses in Table 11, almost all of the participants provided responses to mindset items that possessed a standard deviation of less than 1, indicating there was little variation between their responses from one mindset item to the next. Tess G. is the exception, with a standard deviation of 1.51. In viewing her mindset item responses, Tess G. selected the most growth mindset option on all mindset items except for item 29, in which she selected the most fixed mindset option. This, in turn, resulted in a higher

\(^1\) The mindset items that were “negatively worded” (and thus reverse coded) were items 7, 10, 16, 17, 22, 26, and 28. The coding in Table 11 reflects this reverse coding.
### Table 11. Participant Responses to Mindset Items on the Beliefs Survey

<table>
<thead>
<tr>
<th>Name</th>
<th>Q7</th>
<th>Q10</th>
<th>Q13</th>
<th>Q16</th>
<th>Q17</th>
<th>Q19</th>
<th>Q22</th>
<th>Q25</th>
<th>Q28</th>
<th>Q30</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erin</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>3.8</td>
<td>.60</td>
</tr>
<tr>
<td>Nellie</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>5.5</td>
<td>1.51</td>
</tr>
<tr>
<td>Paige</td>
<td>5</td>
<td>5</td>
<td>6</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>6</td>
<td>5.3</td>
<td>0.5</td>
</tr>
<tr>
<td>Jensen</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Alyssa</td>
<td>6</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>5.7</td>
<td>0.47</td>
</tr>
<tr>
<td>Tess</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>5.5</td>
<td>1.51</td>
</tr>
</tbody>
</table>

### Table 12. Participant Responses to Nature of Mathematics Items on the Beliefs Survey

<table>
<thead>
<tr>
<th>Name</th>
<th>Q12</th>
<th>Q15</th>
<th>Q20</th>
<th>Q21</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erin</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>4.3</td>
<td>.96</td>
</tr>
<tr>
<td>Nellie</td>
<td>3</td>
<td>6</td>
<td>4</td>
<td>5</td>
<td>4.5</td>
<td>1.29</td>
</tr>
<tr>
<td>Paige</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>6</td>
<td>5.3</td>
<td>0.96</td>
</tr>
<tr>
<td>Jensen</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>6</td>
<td>5.3</td>
<td>0.5</td>
</tr>
<tr>
<td>Alyssa</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Tess</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>0</td>
</tr>
</tbody>
</table>

**Note:** The numbers represent scores on the survey items, with higher numbers indicating stronger agreement with the mindset or nature of mathematics items.
standard deviation than the other five participants. Tess G.’s response to item 29 seems unusual, given her responses to the preceding mindset items.

Similarly, participants’ responses to nature of mathematics items on the Beliefs Survey may be viewed in Table 12. Higher scores indicate that the participant selected responses that indicated a more multidimensional view of mathematics (i.e. they view mathematics as a subject of sense making), and lower scores indicate a more one dimensional view of mathematics (i.e. mathematics as the learning of facts and procedures). As was the case for the mindset items, negatively worded items, such as item 12 “Mathematics involves mostly facts and procedures that have to be learned,” were reverse coded². Table 12 indicates that all participants possessed a mean scale score of over 4 with regard to beliefs about the nature of mathematics. This indicates that all participants had somewhat multidimensional views about mathematics. As was true with the mindset items, the majority of participants possess a standard deviation of less than 1 in their responses to nature of mathematics items. The exception is Nellie F., whose standard deviation was 1.29. Nellie F. provided a range of answers which were coded from 3 to 6 on the four nature of mathematic items.

The mean scale scores for participant responses to items regarding mindset and beliefs about the nature of mathematics are depicted in the graph shown in Figure 1. The lower right quadrant of the graph contains participants whose Beliefs Survey responses indicated they had a fixed mindset and multidimensional views about mathematics. For example, the data point indicating Erin F.’s scores (dark blue) is the highest point in that quadrant, indicating she

² The nature of mathematics items that were “negatively worded” (and thus reverse coded) were items 12, 15, and 20. The coding in Table 12 reflects this reverse coding.
possessed the highest mindset score of the fixed mindset participants, but is also the point that is furthest to the left in that quadrant, indicating she held the least multidimensional views of the other two participants shown in that quadrant (Nellie F. and Paige F.). The upper right quadrant of the graph contains participants whose responses indicated they possessed a growth mindset and more multidimensional views about mathematics. The data points indicating Tess G. (red) and Alyssa G. (green) are further to the right than the data point for Jensen G. (purple), indicating they possessed stronger multidimensional views about mathematics than Jensen G. However, Jensen G.’s data point is higher than that of Alyssa G. and Tess G., indicating she possessed a stronger growth mindset.

![Figure 1](image)

Figure 1. Participants' mean scale scores for responses to mindset and beliefs about the nature of mathematics items on the Beliefs Survey.

While none of the participants’ scores fell in the upper or lower left quadrants, the upper left quadrant signifies participants with growth mindsets and one dimensional views about
mathematics and the lower left quadrant signifies participants with fixed mindsets and one dimensional beliefs about mathematics.

Feedback Categories

The use of SCALE’s Rubric 12 allowed the researcher to view comments holistically to determine if, overall, a growth or fixed mindset message had been conveyed to students. In addition to gaining this holistic view, the researcher was interested in exploring any relationships between the specific types of feedback provided by participants and their beliefs. This was accomplished through analyzing every instance of feedback provided on student samples using grounded theory to determine various feedback groups into which the participants feedback could be categorized. The initial sorting of feedback resulted in the following 9 categories:

1. Comments pertaining to the student’s use of a solution method.
2. Comments pertaining to the student’s effort or finding multiple solutions.
3. Comments requesting more information from the student, but not necessarily to further student learning. e.g. “Show the work.”
4. Comments pertaining to technical aspects such as precision, syntax, vocabulary, or organization of work.
5. Comments praising the student (work, grade, etc.).
6. Comments providing elaborated correction in which the teacher writes out the solution method(s) for the student.
7. Comments correcting student errors, with no other information (no solution methods or instructional comments otherwise).
8. Comments in the form of questions, intended to further student learning.

9. Comments that could not be categorized in the preceding 8 categories.

After creating these initial 9 categories, the researcher engaged in several cycles of refinement, which resulted in a few of the initial categories being divided into smaller categories. For example, the “comment in the form of questions” category was divided into five smaller categories (probing questions, guiding questions, factual question, rhetorical questions, and unclear questions), based on the type of question being asked by the teacher. The final 14 feedback categories, as well as their definitions, may be viewed in Table 13. The table has been organized in a hierarchical structure, grouping categories that are seemingly similar, yet distinct, under a “family” heading. For example, correcting student work and providing elaborated correction could be considered as similar teacher behaviors, but feedback in the elaborated correction category goes further than that in the correction category because it provides some comment that is intended to move the student learning forward, rather than simply correct student work. These two feedback categories are therefore represented under the “family” heading of “instructive comments,” but remain separate categories. Similarly, the various question types (unclear questions, rhetorical questions, factual questions, guiding questions, and probing questions) could be grouped in a similar category (as they were originally in the first iteration of the sorting process) because they all pose questions to the students. However, probing questions ask more of the students than do factual questions, thus they were counted as a separate category. In Table 13 the five question categories (unclear questions, rhetorical questions, factual questions, guiding questions, and probing questions) appear under the larger “family” of “posed questions.”
<table>
<thead>
<tr>
<th>Description of Feedback Categories</th>
<th>Instructive Comments</th>
<th>Elaborated Correction</th>
<th>Requesting More Information</th>
<th>Other Technical Feedback</th>
<th>Posed Questions</th>
<th>Praise of Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructive Comments</td>
<td>Correction of work or step by step completion of the problem.</td>
<td>Correction of work or step by step completion of the problem.</td>
<td>Requesting more information</td>
<td>Requesting more information</td>
<td>Requesting more information</td>
<td>Requesting more information</td>
</tr>
<tr>
<td>Elaborated Correction</td>
<td>More than a correction of work or step by step completion of the problem by the teacher; contains some comment that moves the intended learning (from the learning objectives and/or standards) forward. This may also include general suggestions of strategies.</td>
<td>Anything related to the technicalities in mathematics, such as corrections related to using precise mathematical property.</td>
<td>Functional feedback or other technical feedback.</td>
<td>Functional feedback or other technical feedback.</td>
<td>Functional feedback or other technical feedback.</td>
<td>Functional feedback or other technical feedback.</td>
</tr>
<tr>
<td>Requesting More Information</td>
<td>Comments or questions that request more of the student, but do not necessarily further their learning. For example, “explain using key words” or “show the work” are considered.</td>
<td>Comments or questions that request more of the student, but do not necessarily further their learning. For example, “explain using key words” or “show the work” are considered.</td>
<td>Requesting more information</td>
<td>Requesting more information</td>
<td>Requesting more information</td>
<td>Requesting more information</td>
</tr>
<tr>
<td>Other Technical Feedback</td>
<td>Posing questions go beyond having students recall facts and procedures. These questions press students to connect their prior knowledge to “explore and develop new concepts and procedures” (Sahin &amp; Kulm, 2008, p. 224). The purpose of such questions is to extend “students’ knowledge, encourage student explanations, and promote deeper thinking.” Students know when to learn procedures and how to solve problems. “Students know how to use new concepts and procedures to solve problems when provided with the appropriate guidance” (Sahin &amp; Kulm, 2008, p. 223). The purpose of such questions is to connect their prior knowledge to “explore and develop new concepts and procedures.”</td>
<td>Posing questions go beyond having students recall facts and procedures. These questions press students to connect their prior knowledge to “explore and develop new concepts and procedures” (Sahin &amp; Kulm, 2008, p. 224). The purpose of such questions is to extend “students’ knowledge, encourage student explanations, and promote deeper thinking.” Students know when to learn procedures and how to solve problems. “Students know how to use new concepts and procedures to solve problems when provided with the appropriate guidance” (Sahin &amp; Kulm, 2008, p. 223). The purpose of such questions is to connect their prior knowledge to “explore and develop new concepts and procedures.”</td>
<td>Requesting more information</td>
<td>Requesting more information</td>
<td>Requesting more information</td>
<td>Requesting more information</td>
</tr>
<tr>
<td>Posed Questions</td>
<td>Questions about “specific facts,… definitions,… or a next step in a procedure” (Sahin &amp; Kulm, 2008, p. 222).</td>
<td>Questions about “specific facts,… definitions,… or a next step in a procedure” (Sahin &amp; Kulm, 2008, p. 222).</td>
<td>Requesting more information</td>
<td>Requesting more information</td>
<td>Requesting more information</td>
<td>Requesting more information</td>
</tr>
<tr>
<td>Praise of Grade</td>
<td>Praise of grade</td>
<td>Praise of grade</td>
<td>Requesting more information</td>
<td>Requesting more information</td>
<td>Requesting more information</td>
<td>Requesting more information</td>
</tr>
</tbody>
</table>
While not all of the 14 feedback categories in Table 13 can be classified in a binary manner (fixed or growth), there are several for which such a classification can be made, based on the existing mindset literature. For example, feedback classified under the categories of “effort” and “praise of solution method or use of a mathematical property” parallel the effort and process focused praise that the literature on mindset classifies as growth mindset in nature (de Kraker-Pauw et al., 2017; Kamins & Dweck, 1999; Mueller & Dweck, 1998). The mindset literature also supports the inclusion of the feedback categories of “probing questions” and “guiding questions” as growth mindset feedback, for they are included to scaffold student learning or to provide “hints, cues,….prompts, suggestions for improvement, and [to monitor] the process [of learning]” (de Kraker-Pauw et al., 2017, p. 6). In addition, feedback providing students with elaborated corrections might also be considered growth mindset in nature, as it not only provides correction of student work, but also provides some information about “how results…can be improved” (de Kraker-Pauw et al., 2017, p. 6).

There are also categories from Table 13 that may be classified as more fixed mindset, based on the existing mindset literature. For example, de Kraker-Pauw et al. (2017) describe results-oriented feedback as fixed mindset in nature. Results-oriented feedback is feedback that that focuses on “correct or wrong answers, giving the correct answer and indicating what is missing” (p. 6). By this description, the “correction” feedback category in Table 13 may be classified as fixed mindset. Similarly, the “praise of grade” feedback category also falls under fixed mindset feedback. Such feedback that focuses on student outcomes or personal abilities or performance has been documented as fixed mindset in nature (de Kraker-Pauw et al., 2017; Kamins & Dweck, 1999; Mueller & Dweck, 1998).
Case One - Jensen G.

Jensen G. completed her first student teaching placement in an urban public middle school, where she taught a non-accelerated seventh grade mathematics class consisting of 18 students. Two of her students were eighth grade students who had not yet passed the seventh grade mathematics state examination. While teaching this class, Jensen G. had the support of her cooperating teacher as well as a special education teacher, who co-taught the class. Jensen G.’s average scale score on the mindset items of the Beliefs Survey was 5.7, indicating she possessed a growth mindset. Her average scale score for beliefs about the nature of mathematics was 5.3, indicating she possessed more “multidimensional” views.

The Assessment

The assessment Jensen G. submitted for her portfolio, a homework assignment, is stated as addressing Common Core State Standard CCSS.Math.Content.7.G.B.6, “Solve real-world and mathematical problems involving area, volume and surface area of two- and three-dimensional objects composed of triangles, quadrilaterals, polygons, cubes, and right prisms” (National Governors Association Center for Best Practices, 2010). The assessment was administered after a lesson on volume and surface area, which Jensen G. stated addressed the following learning objectives:

1. SWBAT³ roughly compare volume and surface area of two rectangular prisms using mathematics common sense without calculation.

³ The pre-service teacher uses the common acronym SWBAT in place of the phrase “the student will be able to.”
2. SWBAT explain and justify how surface area of an object changes as its volume changes in specific examples.
3. SWBAT explain through calculation that two prisms with the same volume can have different surface areas and elaborate real life examples.
4. SWBAT justify or critique arguments concerning relationships between volume and surface area of a prism.

On the homework assignment, students were asked to measure the dimensions of three pieces of furniture at home and then to calculate the surface area and volume of each of the three objects. Students were instructed to limit their measurements to furniture that was roughly rectangular in shape. This portion of the assessment, assessed little more than the students’ ability to classify objects as a specific prism and apply the formulas associated with that prism, i.e. their procedural fluency.

After taking measurements and calculating volume and surface area, students were to compare the surface area and volume of the three pieces of furniture, determining which measured pieces of furniture had the greatest volume, and which had the greatest surface area. If the object of greatest volume was not the object of greatest surface area, students were asked to consider why that was the case. While having students determine why the object of greatest volume may not have the greatest surface area (or vice versa) required students to engage in mathematical reasoning and to draw from their conceptual understanding of volume and surface area, students were only required to answer this question if the object of greatest surface area and object of greatest volume were not the same piece of furniture. In fact, none of the students for whom Jensen G. submitted work samples answered this question, because both the object of greatest volume and of greatest surface area were the same piece of furniture. For this reason, the researcher did not classify Jensen G.’s assessment as having truly engaged students in mathematical reasoning or conceptual understanding.
In addition to measuring the three pieces of furniture and answering the above questions, the assignment stated that prizes would be given to students who measured “furniture with the greatest volume, smallest volume, greatest surface area, and smallest surface area.” The assignment also stated, “To win a prize, you must show and do the calculation correctly.” To complete the challenge of measuring a piece of furniture that will have the greatest volume, smallest volume, greatest surface area, or smallest surface area, the students needed to develop a plan before measuring pieces of furniture. The creation of such a plan would have required the student to engage in what the National Research Council (2001) calls strategic competence, “the ability to formulate mathematical problems, represent them, and solve them” (p. 124). According to the National Research Council (2001), strategic competence “is similar to what has been called problem solving and problem formulation in the literature of mathematics education” (p. 124). However, Jensen G. provided no way to enforce student participation in this competition, so it is unclear if students engaged in the above stated problem solving processes. The inclusion of a prize (as well as placing such emphasis on correct calculations) could be deemed as an instructional move that conveyed a fixed mindset to students, as it could shift the focus of the activity from learning to winning or outperforming classmates (Ames, 1992; Sun, 2015).

To grade this assessment, Jensen G. used a rubric which attempted to employ a more holistic approach but was somewhat vague. The rubric assessed the level at which students demonstrated essential understandings (procedural fluency, conceptual understanding, mathematical reasoning, and problem solving) but offered no insight as to how those varying levels may be demonstrated, especially given that the assignment appeared to only address
procedural fluency and not the other stated essential understandings. The rubric is shown in Figure 2.

<table>
<thead>
<tr>
<th>4 (2/2)</th>
<th>3 (2/2)</th>
<th>2 (1/2)</th>
<th>1 (1/2)</th>
<th>0 (0/2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student demonstrates conceptual understanding, procedural fluency and/or mathematical reasoning/problem solving skills. Students use proper language function with mathematical precision.</td>
<td>Student demonstrates conceptual understanding, procedural fluency and/or mathematical reasoning/problem solving skills with minor mistakes. Students use proper language function with minor errors in calculation, vocabulary and syntax.</td>
<td>Students demonstrate emergent conceptual understanding, emergent procedural fluency and emergent mathematical reasoning/problem solving skills. Student does not use language function and attend to mathematical precision at all times.</td>
<td>Students demonstrate emergent to little conceptual understanding, emergent procedural fluency and emergent mathematical reasoning/problem solving skills. Student does not attend to language function or mathematical precision.</td>
<td>Student demonstrates no conceptual understanding, procedural fluency, or mathematical reasoning/problem solving skills.</td>
</tr>
</tbody>
</table>

Figure 2. Jensen G.'s assessment scoring rubric

**Feedback Provided to Students**

Jensen G.'s feedback fell under five of 14 feedback categories in this study. The percentages and number of comments that fell under each category are outlined in Table 14.
Table 14. Jensen G. Feedback Categories

<table>
<thead>
<tr>
<th>Feedback category</th>
<th>Number of Feedback Instances</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correction</td>
<td>7</td>
<td>50%</td>
</tr>
<tr>
<td>Precision, syntax, mathematical vocabulary, or organization</td>
<td>3</td>
<td>21.4%</td>
</tr>
<tr>
<td>Elaborated correction</td>
<td>2</td>
<td>14.3%</td>
</tr>
<tr>
<td>Praise of a grade</td>
<td>1</td>
<td>7.1%</td>
</tr>
<tr>
<td>Praise of a solution method or use of a mathematical property</td>
<td>1</td>
<td>7.1%</td>
</tr>
</tbody>
</table>

Jensen G. provided little feedback outside of check marks and x’s, with most of her written feedback (50%) focused on correcting student work unrelated to the standards assessed on the assignment. In several of her corrections, Jensen G. provided step-by-step processes using the standard multiplication algorithm or addressing other arithmetic mistakes. For example, one student measured a dresser with a length of 5.5 feet, width of 1.5 feet, and height of 4 feet. To calculate the volume, the student presented the work shown in Figure 3.

![Figure 3](image)

Figure 3. Student calculations for the volume of a dresser

In response, Jensen G. placed an x over the work on the left and wrote the comments shown in Figure 4.

![Figure 4](image)

Figure 4. Jensen G.’s feedback to students' miscalculation of dresser volume
In other instances, Jensen G. corrected the student’s work with no further comment. For example, another student measured a bed with dimensions of 105 inches, 14.5 inches, and 45 inches. When calculating the volume, the student provided the work shown in Figure 5.

\[
\begin{array}{c}
105 \\
14.5 \\
977.5
\end{array}
\]

Figure 5. Student calculations for the volume of a bed

Jensen G. circled 977.5 and wrote 1522.5; however, no comments were provided.

Jensen G. also provided students with comments relating to precision, syntax, mathematical vocabulary, or organization (21.4%) and elaborated correction (14.3%). One example, categorized both as feedback about precision, syntax, mathematical vocabulary, or organization and as elaborated correction, addressed the calculation of a table’s volume. The student recorded the table’s length as 152 centimeters, width as 42 centimeters, and height as 73 centimeters. For volume, the student wrote, “42 \times 73 = 3,066 \times 152 = 466,032 \text{ cm}^3.” In response, Jensen G. drew parenthesis around “152 = 466,032 \text{ cm}^3” and wrote “Make sure you start from the next line when you do a new operation.” She then demonstrated this, writing, “3,066 \times 152 = 466,032.”

While Jensen G.’s feedback heavily addressed student’s arithmetic mistakes, the feedback often did not address conceptual errors related to the learning objectives of the assessment. Throughout the analysis, the researcher noticed that Jensen G. marked many student responses correct that in reality were not. As mentioned previously, one student measured a table for their assignment. The student provided a drawing of the table, which can be seen in Figure 6, showing a standard table with a rectangular top and four legs.
The student recorded the table’s length as 152 centimeters, width as 42 centimeters, and height as 73 centimeters. The student then calculated the volume and surface area of the table as if it were a solid rectangular prism, failing to take into account the negative space under the table top and between the legs of the table. Jensen G. marked the student’s solutions correct, rather than addressing the student’s conceptual errors. Instances such as this were found throughout Jensen G.’s grading of the three student samples and could possibly lead to significant content and conceptual inaccuracies.

Next Instructional Steps

Jensen G. framed her analysis of student performance by using the rubric she created to evaluate the homework assignment. She noted that 14 of her 18 students scored a three or four on the assessment, indicating they were able to “[demonstrate] conceptual understanding, procedural fluency and mathematical reasoning/problem solving skills with minor or no mistakes.” Of those 14 students, she noticed that four of them were able to correctly make “[use of] the surface area formula to calculate surface area.” Of the remaining four students, one did not submit the homework assignment and three demonstrated “emergent or little conceptual understanding on surface area and volume” (two scoring at level two and one scoring at level
one). Aside from this description, Jensen G. provided no further analysis of specific student strengths or needs.

As stated previously, Jensen G. stated she felt most students had “acquired procedural fluency in calculating surface area and volume.” In order to push her students further she stated that in subsequent lessons students may “benefit from exploring the surface area and volume of different polyhedrons.” She also asserted that in future lessons she would provide “more open-ended questions and multistep word problems that require integration of different math disciplines.” She did not provide any examples following either of the aforementioned statements, so it was unclear which polyhedrons students would be encouraged to explore, nor the type of open-ended or multistep problems that would be included in future lessons.

In her portfolio, Jensen G. also provided a number of next steps with a focus on repeating instruction or providing more practice. For example, she felt that two of the students for whom she submitted samples had weak “basic mathematics skills.” She stated that these students will need more one-on-one help or tutoring to improve their skills. She also stated that as their teacher, she could provide them with additional weekly assignments designed to “focus on their misconceptions” and with reminders to take their time to complete assignments and to “check their work and format.” Again, no examples were provided to clarify what types of additional assignments would be given to these students, or specific strategies to build their arithmetic skills.

In the above described next steps, Jensen G. focused many of her efforts on improving students’ arithmetic skills by asking more open-ended questions and providing more multistep problems. Such suggestions were not directly tied to the learning objectives and standards of the lesson and assessment, and did not address the incorrect answers and larger misconceptions the
researcher noticed throughout the analysis of Jensen G.’s student work samples and feedback. The only next instructional step that Jensen G. provided that was directly tied to the learning objectives and standards was to have students explore “the surface area and volume of different polyhedrons.” This suggestion, however was not described in sufficient detail, with no examples provided.

Case Two - Alyssa G.

Alyssa G.’s first student teaching placement was in an urban public middle school where she taught a non-accelerated eighth grade mathematics class. The class consisted of 25 eighth grade students, 18 of whom were English Language Learners. Alyssa G.’s average scale score on the mindset items of the Beliefs Survey was 5.2, indicating she possessed a growth mindset. Her average scale score for beliefs about the nature of mathematics was 6, indicating she possessed very strong “multidimensional” views about mathematics.

The Assessment

Alyssa G.’s submitted assessment was a three-part exit ticket, which she stated assessed the following Common Core State Standards:

1. CCSS.Math.Content.8.EE.B.6: Use similar triangles to explain why the slope m is the same between any two distinct points on a non-vertical line in the coordinate plane; derive the equation $y = mx$ for a line through the origin and the equation $y = mx + b$ for a line intercepting the vertical axis at $b^4$.

---

4 Alyssa G. only cited the last part of this standard “derive the equation $y = mx$ for a line through the origin and the equation $y = mx + b$ for a line intercepting the vertical axis at $b$.”
2. CCSS.Math.Content.8.F.A.2: Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or verbal descriptions).

3. CCSS.Math.Content.8.F.B.4: Construct a function to model a linear relationship between two quantities. Determine the rate of change and initial value of the function from a description of a relationship or from two \((x, y)\) values, including reading these from a table or from a graph. Interpret the rate of change and initial value of a linear function in terms of the situation it models, and in terms of its graph or a table of values \(^5\) (National Governors Association Center for Best Practices, 2010).

The exit ticket was designed to assess student learning following a lesson on “recognizing proportional and non-proportional relationships in graphs, equations, and tables.” Alyssa G. stated that the objective of her lesson was for students to be able to “Determine proportionality of given graphs, equations, and tables and explain their [reasoning]” and “Connect different representations of the same data to confirm their answers regarding proportionality.” In the first section of the exit ticket, students were presented with a scenario in which a classmate noticed that the fare of his taxi cab could be modeled by the linear function \(y = 0.50x + 2.50\), with \(y\) representing total cab fare, \(x\) representing “the number of clicks on the taxi’s meter,” $2.50 representing the starting fare, and $0.50 representing the “additional fee per click of the meter\(^6\).” Following the cab scenario, students were asked to determine if the classmate’s observed function represented a proportional or non-proportional relationship, and to explain their reasoning.

In the second portion of the exit ticket, students were provided with a table, Table 15.

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\(^5\) Alyssa G. only cited the last part of this standard, “Interpret the rate of change and initial value of a linear function in terms of the situation it models, and in terms of its graph or a table of values.”

\(^6\) In her commentary on the assessment, Alyssa G. acknowledged that in reality this scenario is best modeled by a step-function.
Table 15. Tabular Representation of Cab Fare Problem

<table>
<thead>
<tr>
<th>Number of “Clicks”</th>
<th>0</th>
<th>5</th>
<th>10</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Cab Fare ($)</td>
<td>$2.50</td>
<td>$4.50</td>
<td>$6.50</td>
<td>$8.50</td>
</tr>
</tbody>
</table>

Students were tasked with analyzing the table and determining if it represented the same cab scenario from part one of the exit ticket, supporting their answers with reasoning. In addition, students were asked if they would describe the table as representing a proportional or non-proportional relationship and to explain their reasoning.

The third, and final, portion of the assessment presented students with a graph, shown in Figure 7.

![Graphical representation of the cab fare problem](image)

Figure 7. Graphical representation of the cab fare problem

Students were asked to determine if the graph represented the cab scenario from part one of the exit ticket, and if the graph represented a proportional or non-proportional relationship. As in parts one and two of the exit ticket, students were required to provide explanations for their answers. The rubric Alyssa G. used to score this assessment may be found in Figure 8.
Through her requirement that students make connections between multiple representations, Alyssa G. was able to evaluate students’ conceptual understanding, as well as procedural fluency, related to linear functions and proportional relationships. Elements of mathematical reasoning were also evident in the requirement that students explain their reasoning throughout the assessment (National Research Council, 2001). It may be important to note, that while each part of the exit ticket dealt with a different representation, the questions were all structured in a similar manner (is this the cab scenario, is it proportional, explain why), and therefore were not considered as providing “multiple forms of evidence” of assessing students’ procedural fluency, mathematical reasoning, and conceptual understanding.

**Feedback Provided to Students**

Alyssa G.’s feedback to students followed a specific format; it first acknowledged something the student did correctly (by highlighting his or her strategy or reasoning) and then posed either guiding or probing questions to push the student’s intended learning further. To illustrate this, we observe a student response for the first portion of the exit ticket, which asked...
whether the cab fare scenario represented a proportional or non-proportional relationship and why. The student wrote, “This doesn’t represent a proportional relationship because the equation also includes the y-intercept. If we were to graph this equation it wouldn’t pass through the [origin]. And we know that if a [straight] line doesn’t go through the [origin] that is a non-[ ] proportional relationship.” In response, Alyssa G. wrote, “I like your clear explanation. You explained why a y-intercept ≠ 0 shows us that the relationship is non-proportional. Consider: does a proportional relationship have a y-intercept? If yes, what is it? And why do we ‘ignore’ it?” This format allowed Alyssa G. to effectively address both student strengths and needs on every student work sample.

Alyssa G.’s feedback fell under five of 14 feedback categories in this study. The percentages and number of feedback instances under each category are outlined in Table 16.

<table>
<thead>
<tr>
<th>Feedback category</th>
<th>Number of Feedback Instances</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probing questions</td>
<td>7</td>
<td>43.8%</td>
</tr>
<tr>
<td>Guiding questions</td>
<td>5</td>
<td>31.3%</td>
</tr>
<tr>
<td>Praise of a solution method or use of a mathematical property</td>
<td>2</td>
<td>12.5%</td>
</tr>
<tr>
<td>Non-specific praise</td>
<td>1</td>
<td>6.3%</td>
</tr>
<tr>
<td>Uncategorized</td>
<td>1</td>
<td>6.3%</td>
</tr>
</tbody>
</table>

The largest percentage of feedback provided by Alyssa G. came in the form of probing questions (43.8%) and guiding questions (31.3%). One probing questions was asked in response to a student’s solution for the initial cab scenario (using the equation). The student wrote, “It [is] not proportional because it [is] not going [through] the [origin].” Alyssa G. responded to this comment with, “That’s right! How do you know? What would the equation look like if it did go through the origin?” On another student’s assignment, the student was determining if the table
representing the cab fare situation was proportional and wrote, “Yes this table represent[s] the cab fares correctly because it has constant rate of change. This [is] not proportional because the table [should] be started from 0/0.” In an effort to guide her student, Alyssa G. responded with the following series of questions, “You’re right that it represents the cab fares correctly, but how does the ‘constant rate of change’ tell you this? Instead can we check the table with the equation? How? What do the, ‘number of clicks’ represent? X or y values? What does the ‘total cab fare’ represent? The x or y values? How can we check them in our original equation?”

**Next Instructional Steps**

In Alyssa G.’s analysis of student performance, she first discussed overall student performance, then highlighted the performance of two specific groups of learners – students with Individualized Education Plans (IEPs) and English Language Learners (ELLs) – in an attempt to address how to better support these groups in the future. Alyssa G. began by stating that a large portion of the class scored at a level 3 on the exit ticket (no students earned a score of 4). These students were able to correctly identify the first scenario, with the equation, as a non-proportional relationship and support their conclusion by stating, “the b term, or the y-intercept, is 2.50, or not 0, which means that the line will not pass through the origin.” For problem 2 and problem 3, many students scoring at this level correctly identified (and explained) the representations as

7 This discussion was provided in response to prompt 8 of Assessment 5, which asked students to “explain how their analysis of student learning informed their instruction in subsequent lessons.” The prompt also specifically asked students to include next steps not only for the whole class, but also for students with special needs, such as students with IEPs or ELLs.
non-proportional, but either skipped the question asking if the table (problem 2) or graph (problem 3) represented the same cab fare scenario as the equation (problem 1) or answered the question incorrectly “based on some small misconception.” As an example of the “small misconceptions” made by students, Alyssa G. referenced a solution on one of the submitted student samples. She wrote, “Student 1 answered it was not the same scenario because the fare increased by 2.00 instead of 0.40. This common misconception was that she did not notice that the ‘Number of clicks’ increased by 5, thus the slope simplified to 0.40.”

Next, Alyssa G. provided a description of how students with IEPs performed on the assessment. She stated that many students in this group scored either a 1 or 2 on the assessment and that these students “were guided (or instructed what to write) by their Special Education teacher or paraprofessional.” In this group, many students failed to support their reasoning in their explanations. She included an example from one student’s sample in which the student wrote “it is not proportional because it doesn’t go through the origin,” with no explanation of why they knew it would not pass through the origin. She stated that many of these students also attempted to find the constant of proportionality but were unable to finish or explain their solutions.

Finally, Alyssa G. provided a description of the overall performance of the English Language Learners in her class, most of whom earned either a 1 or 2 on the assessment. Many of these students had difficulty using mathematical language to explain why the three representations depicted non-proportional relationships and why the equation, table, and graph all represented the same cab fare scenario. Alyssa G. stated that many of these difficulties may have stemmed from “incomplete idea[s] from the lesson.” For example, in explaining why the equation represented a non-proportional relationship, many of these students justified their
response by stating the equation had a y-intercept, so it could not be proportional. Alyssa G. explained, “they should have understood that there is always a y-intercept but in proportional relationships, the y-intercept is 0, and therefore is not evident in the equation representation for the information.” As another example, she referenced a student sample which stated, “Yes this table represent[s] the cab fares correctly because it has constant rate of change. This [is] not proportional because the table [should] be started from 0/0.” Alyssa G. stated, “I believe he was touching on the fact that in a proportional relationship, the line starts from the origin, will have a y-intercept, or b term, of 0, and in a table will have y = 0 when x = 0.” She also noted that many students in this group used some of the terms learned in class, such as “constant rate of change,” but did not connect these terms to the representations, showing they did not fully understand how to use the terms in relation to the problem and would need future support in this regard.

Based on her analysis of student performance on the exit ticket, Alyssa G. proposed several suggestions to address student misunderstandings in her next lessons. She noticed that while most students were able to successfully identify that the cab-fare scenario was non-proportional, several struggled to explain why, using precise language. As an example, she referenced the first problem on the exit ticket, in which students were asked to determine if the equation $y = 0.50x + 2.50$ is proportional or non-proportional. To justify their conclusions, many students stated the relationship was non-proportional because there was a y-intercept, so the line would not pass through the origin, a requirement for proportional relationships. Alyssa G. interpreted this lack of precision as an error on her part, stating she may not have been as precise as she should have been during her lesson. She explained that in her next lesson, she reviewed the definitions of proportional and non-proportional relationships, taking care to define both terms using precise mathematical language. In addition, she planned to write the equation
\[ y = mx + b \] and have students explain the meaning of \( m \) and \( b \), using precise mathematical language. She does not, however, provide the definitions she will use. Following this activity, she stated that she planned to be more attentive to her precision of language in future lessons.

In her discussion of next steps, Alyssa G. also touched on her students’ struggle to see connections between various representations of linear functions. In order to provide more practice with creating representations, she stated that she planned to create a Do Now for her next lesson in which she would ask students to create an equation from a table, graph a given equation, and create a table from a graph. After working independently, students would “compare their methods with a partner to determine if they make sense,” before going over the problems as a class. In addition to the above described next steps, Alyssa G. also stated she intended to allow students to “pair up during class time the next day and discuss the feedback that they’ve received. The students will then be required to write follow-up answers on a separate sheet of paper.”

Alyssa G. described next instruction in more detail than did Jensen G., but she lacked specificity in the definitions she intended to create with students and in the problems she intended to include on her described Do Now. In addition, while she did mention that her planned next instructional steps would help the ELLs and students with IEPs in her classroom, the supports did not seem targeted enough to address the needs she identified for students in these groups, specifically their difficulty in constructing mathematical explanations of why the cab fare scenario represented a non-proportional relationship.

**Case Three - Tess G.**
Tess G.’s first student teaching placement took place in a suburban public middle school, where she taught an eighth grade Integrated Algebra course. The eighth grade class was the second half of a two-year Algebra 1 course in which the majority of seventh and eighth grade students were enrolled. The remaining students were enrolled in a similar algebra course, which moved at a slower pace and focused more on fundamentals. Tess G.’s average scale score on the mindset items of the Beliefs Survey was 5.5, indicating she possessed a growth mindset. Her average scale score for beliefs about the nature of mathematics was 6, indicating she possessed very strong “multidimensional” views about mathematics.

The Assessment

Tess G. submitted a graphic organizer designed to assess student understanding of solving and graphing linear inequalities. This graphic organizer was assigned during a lesson, which Tess G. cites as addressing the following learning objectives:

1. Given a graphic organizer, students will be able to use the arithmetic form of the inequality to generalize an algebraic solution.
2. Given an inequality, students will be able to explain the solution in their own words.
3. Given an inequality, students will be able to label and graph the solutions.

In reality, the assessment itself was what addressed the first objective in this standard, as Tess. G. stated that the lesson preceding this assignment only engaged students in graphing and interpreting simple inequalities such as $2 > x$. The graphic organizer was the students’ first attempt at applying their knowledge of solving linear equations, to their new skills of graphing and interpreting the solution of simple inequalities. She stated that the graphic organizer assessed each of the following Common Core State Standards:
1. CCSS.Math.Content.7.EE.B.4: Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities.

2. CCSS.Math.Content.7.EE.B.4.b: Solve word problems leading to inequalities of the form \( px + q > r \) or \( px + q < r \), where \( p \), \( q \), and \( r \) are specific rational numbers. Graph the solution set of the inequality and interpret it in the context of the problem (National Governors Association Center for Best Practices, 2010).

The researcher felt that the graphic organizer did not assess all aspects of the second standard, CCSS.Math.Content.7.EE.B.4.b, because no word problems were present on the assignment. However, students were required to graph their solution sets and describe their solution in words. This addressed the second sentence of the standard, “Graph the solution set of the inequality and interpret it in the context of the problem” (National Governors Association Center for Best Practices, 2010).

To complete the graphic organizer, students were pre-assigned to groups of four with each group assigned a different inequality. The graphic organizer contained four sections, with one group member responsible for the completion of each section. The top left portion of the graphic organizer asked students to “copy and solve” their given inequality, making sure to show their work. The top right section of the graphic organizer provided space for students to “label and graph the solutions” to their inequality and the bottom left portion required students to “choose a number from the solutions on the graph to substitute and check.” The bottom right section of the graphic organizer asked students to verbally explain the meaning of their solution. Above the graphic organizer, students were provided spaces to “describe the meaning” of each of the four inequality symbols (\(<\), \(\ge\)), and below the graphic organizer, students were provided with an example of a completed assignment, which can be seen in Figure 9.
In describing how the assessment was enacted, Tess G stated:

The group member seated in seat #1 at the table [was] the student responsible for labeling and graphing solutions. The group member seated in seat #2 at the table [was] the student responsible for describing the solution in his or her own words. The group member seated in seat #3 at the table [was] the student responsible for rewriting the groups’ answers on the final hard copy they…submit[ed] to me. The group member seated in seat #4 at the table [was] the student responsible for substituting in the correct value for x and checking the groups’ work. I [did] not accept the final hard copy until each student [had] the graphic organizer completed in his or her notes.

The rubric Tess G. used to score the graphic organizers can be seen in Figure 10.
<table>
<thead>
<tr>
<th>Level</th>
<th>Procedural Fluency</th>
<th>Conceptual Understanding</th>
<th>Mathematical Reasoning</th>
<th>Communication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beginner</td>
<td>The student does not demonstrate a procedure needed to solve the given problem</td>
<td>The inequality is not solved and the students’ answer is not consistent with the given prompt.</td>
<td>There is no evidence of mathematical reasoning. Student provides an inaccurate explanation leading to an incorrect solution.</td>
<td>There is no evidence of formal academic language or any explanation that would lead to a possible solution.</td>
</tr>
<tr>
<td>Apprentice</td>
<td>Outlines a procedure that includes the given information but does not lead to the correct solution.</td>
<td>Partial demonstration of students building on prior knowledge to develop concepts.</td>
<td>Nominal reasoning is provided without incorporating the mathematical language incorporated in the unit.</td>
<td>Partial use of mathematical language is used when collaborating with group members and illustrating ideas on the graphic organizer.</td>
</tr>
<tr>
<td>Knight</td>
<td>Writes an inequality that outlines the given information but is not solved using the correct procedure</td>
<td>Proof that student utilizes prior knowledge when deconstructing the problem but makes a computational error when carrying out the steps to solve the inequality.</td>
<td>A methodical approach is well-ordered and student’s justification is supported.</td>
<td>Formal academic language is represented in both student’s interaction with group members and illustrated response on their graphic organizer.</td>
</tr>
<tr>
<td>Master</td>
<td>Outlines a well-organized procedure that is executed with 100 percent accuracy.</td>
<td>The student accurately devises the correct solution to this word problem by building off of their prior knowledge. No computational errors are made.</td>
<td>Student illustrates a thorough plan incorporating precise academic language acquired throughout this unit and past units. The student then supports their justification by explaining what the solution means with 100 percent accuracy.</td>
<td>Precise academic language is mastered throughout student’s interactions in class, in groups, and in writing. It is evident the student understands the meaning behind both mathematical symbols and vocabulary in context.</td>
</tr>
</tbody>
</table>

Figure 10. Tess G.’s assessment scoring rubric

The top portion of the graphic organizer, in which students were asked to provide the meaning of the inequality symbols (<, >, ≤, and ≥), was no more than an assessment of students’ factual knowledge. Students’ conceptual understanding and procedural fluency of solving linear inequalities were assessed by requiring students to solve their given inequality and represent their solutions graphically. In addition, because Tess G. stated that students had not yet learned how to graph or solve more than simple inequalities, the researcher felt that this portion
of the exit ticket required students to engage in mathematical reasoning. Students had not yet learned to solve inequalities, so they would have been required to recognize the analogous relationship between solving linear equations and solving linear inequalities. According to the National Research Council (2001), identifying and using such analogous relationships are evidence of students engaging in mathematical reasoning. They state, “the human ability to find analogical correspondences is a powerful reasoning mechanism” (p. 129).

The remaining two portions of the graphic organizer, in which students were asked to explain their solution verbally and to choose a number to check their solution, were also assessments of students’ procedural fluency (National Research Council, 2001). At first glance, the requirement that students explain their solution verbally appeared to assess mathematical reasoning, but there was little real explanation required of students for this task. Instead this portion of the graphic organizer was more of a verbal representation of the solution, requiring little more than conceptual understanding of the inequalities solution.

Each of the sections of the graphic organizer required students to engage with a different representation of the inequality they have been assigned. In this sense, Tess G. created an assessment that contained multiple representations. However, the students were never required to provide any explanation or engage in reasoning as to how those representations were connected, leaving this use of multiple representations at a cursory level.

Feedback Provided to Students

Tess G.’s feedback fell under nine of the 14 feedback categories in this study. The percentages and number of feedback instances that fell under each category are outlined in Table 17.
Tess G. Feedback Categories

<table>
<thead>
<tr>
<th>Feedback category</th>
<th>Number of Feedback Instances</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correction</td>
<td>4</td>
<td>21.1%</td>
</tr>
<tr>
<td>Elaborated correction</td>
<td>3</td>
<td>15.8%</td>
</tr>
<tr>
<td>Effort</td>
<td>2</td>
<td>10.5%</td>
</tr>
<tr>
<td>Factual questions</td>
<td>2</td>
<td>10.5%</td>
</tr>
<tr>
<td>Precision, syntax, mathematical vocabulary, and organization</td>
<td>2</td>
<td>10.5%</td>
</tr>
<tr>
<td>Praise of a solution method or use of a mathematical property</td>
<td>2</td>
<td>10.5%</td>
</tr>
<tr>
<td>Rhetorical questions</td>
<td>2</td>
<td>10.5%</td>
</tr>
<tr>
<td>Non-specific praise</td>
<td>1</td>
<td>5.3%</td>
</tr>
<tr>
<td>Uncategorized</td>
<td>1</td>
<td>5.3%</td>
</tr>
</tbody>
</table>

Tess G. provided students with a wider variety of feedback than the other growth mindset participants (Alyssa G. and Jensen G.). Much of Tess G.’s feedback required little cognitive demand, with the largest percentage of feedback falling under the correction and elaborated correction categories. To illustrate this, we view an example of a comment which was classified as an elaborated correction, left on the graphic organizer of the group assigned the inequality \(-10 \leq \frac{2}{3}x + 5\). To solve this inequality, the students began by subtracting 5 from both sides of the inequality to obtain \(-15 \leq \frac{2}{3}x\). Immediately following this step, the students wrote “\(-0.\overline{44} \leq \frac{2}{3}\),” losing their \(x\) variable. The students provided no other work to indicate how the \(-0.\overline{44}\) was obtained. Tess G. drew a horizontal line under -15 and under 2/3. Under that horizontal line she wrote 2/3, indicating that the students needed to divide by 2/3. She then drew an arrow below the graphic organizer and included the work shown in Figure 11.

Next to this feedback, she also wrote, “Great job subtracting 5 from both sides. In order to solve for \(x\), we must divide 2/3 from both sides!” In these comments, Tess G. corrected the students work, which provided the student with the correct process and answer and also
mentioned that if they want to “solve for \( x \)”, the intended goal, they must go further and divide by 2/3 on each side of the inequality.

![Graph showing the solution process for an inequality](image)

Figure 11. Feedback left by Tess G.

Regarding the overall feedback provided to groups, throughout each work sample, as well as through general, holistic comments at the bottom of the assessment, Tess G. attempted to address both the strengths and the needs of each group. This was accomplished through a consistent structure of first addressing what students did well on the assessment, then addressing student needs, either in the holistic comments at the bottom of their graphic organizer, or by referring them back to the comments she had made throughout their organizer. However, there were many instances in which Tess G.’s comments addressing student strengths were unrelated to the learning objectives. For example, on one graphic organizer, Tess G. wrote, “Great job group #15. You were given a challenging inequality and did an incredible job [persevering] and solving it without my help. I am happy to see that you were able to utilize your prior knowledge and correctly subtract a positive number from a negative number without the use of a calculator!” While subtracting positive and negative numbers may be something that was covered earlier in the year, this was a concept that would have been revisited several times throughout the curriculum, especially when solving linear equations. This strength told the students little about the strategies utilized during their solution process. The first sentence did
comment on the student’s effort and perseverance, a decidedly growth mindset comment (Boaler, 2016; Dweck, 2006; Mueller & Dweck, 1998; Sun, 2015), but did little to address the student's strengths as related to the mathematics of the learning objectives.

Next Instructional Steps

In her analysis of student performance on the graphic organizer, Tess G. explained that most students were able to check their solutions by choosing a value to substitute for $x$ and seeing if the inequality was satisfied. However, when asked to explain their solutions, many groups were unable to provide a description using precise mathematical language. She stated, that in some groups, this may have been caused by a group “not know[ing] [for] what they are solving.” For example, one group was assigned the inequality $-10 \leq \frac{2}{3}x + 5$ and correctly subtracted 5 from both sides to obtain $-15 \leq \frac{2}{3}x$. The group’s final step was to write the inequality $-15.044 \leq \frac{2}{3}$, losing the variable entirely. This error may have made it difficult for the group to write an explanation for their solution. Similarly, in another group, assigned the inequality $12 < 3x - 6$, students correctly added 6 to both sides of the inequality and then divided throughout by 3. However, the group did not write their solution as an inequality, instead only wrote the number 6. This lead the group to explain their solution as follows: “The solution is positive 6.” Tess G. highlighted these two instances to support that some students did not yet understand the goal of solving linear inequalities.

To address students’ inability to “incorporate precise mathematical language” on their graphic organizers, Tess G. stated that in Mathematics Workshop, an additional support class in which students were enrolled, she planned to have students resubmit their assignments. During
workshop hours, she would also meet with each group to implement “small group instruction and one-on-one conferences [for] reviewing the feedback written on their first submitted graphic organizer.” No information was provided about the content or structure of this “small group instruction” or the “one-on-one conferences.” Additionally, Tess G. stated, “To address the needs of the three focus students, I plan on providing the scaffolding and feedback students need to practice and succeed.” Again, this vague statement was not developed any further.

Tess G.’s aforementioned next instructional steps were not supported by specific examples or details. The proposed next steps were not tied to the learning objectives or standards of the assessment, but instead could have been applied to any learning objective or standards. In addition, aside from her reference to student use of precise language, it does not appear that Tess G. used her analysis of student performance to provide targeted support for student weaknesses. For example, she noted that many students failed to understand for what they were solving in their inequalities, but she suggested no instructional strategy to support students in this area.

**Case Four - Nellie F.**

Nellie F. completed her first student teaching placement at an urban public middle school, where she taught an eighth grade Algebra 1 course. This class was considered the more advanced track at her teaching placement, and students in this class were to take the state’s Algebra 1 standardized examination at the end of the academic year. Nellie F.’s average scale score on the mindset items of the Beliefs Survey was 3.6, indicating she possessed a fixed mindset. Her average scale score for beliefs about the nature of mathematics was 4.5, indicating she possessed more “multidimensional” views about mathematics.
The Assessment

Nellie F.’s portfolio submission contained an exit ticket which assessed students’ ability to solve a quadratic equation presented in the context of a word problem. The exit ticket was administered following a lesson addressing three learning objectives:

1. Students will be able to identify the number of solutions to a quadratic equation from the discriminant and understand the connection between the discriminant and the graph of a parabola.
2. Students will be able to identify the solutions of a quadratic equation on a graph.
3. Students will be able to generate and solve a quadratic equation from an application problem.

He stated that the exit ticket assessed the following Common Core State Standards:

1. CCSS.Math.Content.HSA.REI.B.4.b: Solve quadratic equations by inspection (e.g., for \(x^2 = 49\)), taking square roots, completing the square, the quadratic formula and factoring, as appropriate to the initial form of the equation. Recognize when the quadratic formula gives complex solutions and write them as \(a \pm bi\) for real numbers \(a\) and \(b\).
2. CCSS.Math.Content.HSA.CED.A.3: Create equations and inequalities in one variable and use them to solve problems. Include equations arising from linear and quadratic functions, and simple rational and exponential functions.
3. CCSS.Math.Content.HSA.SSE.A: Interpret expressions that represent a quantity in terms of its context.
4. CCSS.Math.Content.HSA.SSE.B: Write expressions in equivalent forms to solve problems (National Governors Association Center for Best Practices, 2010).

In viewing the assessment, the researcher felt the last standard, CCSS.Math.Content.HSA.SSE.B, did not apply because students were using the quadratic formula, not delving into its derivation.

On the exit ticket, students were given the following scenario, “During World War I, trench mortars were fired from trenches 3 feet below ground. The mortars had an initial velocity of 150 ft/s. Determine how long it will take for the mortar shell to hit the ground, assuming it misses its target.” In an attempt to scaffold this problem, Nellie F. created three sections for the exit ticket, the first of which stated, “explain what method you will use to solve your quadratic
equation. (It may help to write the equation first!),” the second provided space for student work, and the third space for student solutions. In order to score this assessment, Nellie F. used the evaluation criteria shown in Figure 12.

![Figure 12. Nellie F.'s assessment evaluation criteria.](image)

Nellie F.’s assessment structure appeared to have been constructed in an “I do, you do” model, because she described students as having already seen a similar problem relating to the path of a basketball. In this assessment students appeared to be repeating that process in a different context. This required little more than knowledge of procedural skills. The exit ticket asked students to explain the method they planned to use to solve the quadratic equation they created. It’s possible to describe such an explanation as an attempt to assess student conceptual understanding and mathematical reasoning of when to use the quadratic formula versus the method of factoring. However, in each of the work samples submitted, students did little more than state they were using the quadratic method, leaving this portion of the exit ticket at a cursory level. If, instead, students had been encouraged to explain why they were using the identified method, and thus showing that students “understand why a mathematical idea is important and the kinds of contexts in which it is useful” (National Research Council, 2001,
Feedback Provided to Students

Nellie F.’s feedback fell under 10 of 14 feedback categories in this study. Percentages and number of feedback instances that fell under each category are outlined in Table 18.

Table 18. Nellie F. Feedback Categories

<table>
<thead>
<tr>
<th>Feedback category</th>
<th>Number of Feedback Instances</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precision, syntax, mathematical vocabulary, and organization</td>
<td>8</td>
<td>30.8%</td>
</tr>
<tr>
<td>Elaborated correction</td>
<td>7</td>
<td>26.9%</td>
</tr>
<tr>
<td>Correction</td>
<td>2</td>
<td>7.7%</td>
</tr>
<tr>
<td>Rhetorical questions</td>
<td>2</td>
<td>7.7%</td>
</tr>
<tr>
<td>Guiding questions</td>
<td>2</td>
<td>7.7%</td>
</tr>
<tr>
<td>Praise of a solution method or use of a mathematical property</td>
<td>1</td>
<td>3.8%</td>
</tr>
<tr>
<td>Praise of a grade</td>
<td>1</td>
<td>3.8%</td>
</tr>
<tr>
<td>Probing questions</td>
<td>1</td>
<td>3.8%</td>
</tr>
<tr>
<td>Requesting more information</td>
<td>1</td>
<td>3.8%</td>
</tr>
<tr>
<td>Unclear questions</td>
<td>1</td>
<td>3.8%</td>
</tr>
</tbody>
</table>

On student exit tickets, Nellie F. provided more feedback (30.8%) related to the precision, syntax, mathematical vocabulary, or organization than any of the other feedback types. For example, on all three samples, at some point the "t = " was dropped (or never included) in the students’ solution process while using the quadratic formula. In response to this, Nellie F. wrote "t = " in front of the student’s expression and on one sample she additionally wrote, “Remember that we are solving an equation not an expression.” Another comment, which highlighted Nellie F.’s emphasis on precision and syntax appeared when a student attempted to include an approximate value in their calculations. The student wrote, “$\frac{-150 \pm \sqrt{22.308}}{-32} =$
In response, Nellie F. wrote, “Normally we don’t put words in expressions.” She then wrote, “you write it like this $x = \frac{-150 \pm \sqrt{22308}}{-32} \approx \frac{-150 \pm 149.36}{-32}$.” This comment was also classified under the elaborated correction feedback category. In addition to comments regarding precision and elaborated correction, Nellie F. provided a variety of other, less cognitively demanding comments. She also, however, included a few guiding and probing questions on student samples.

Overall, Nellie F.’s feedback was more focused on addressing students’ areas of weakness, rather than strengths. Any comments provided about student strengths were tangentially related to the learning objectives and standards. For example, on one sample Nellie F. wrote “Well articulated” in response to the students’ answer to the bonus question. On another she wrote “Good context” next to the student’s final answer of “it will take 4.4 seconds for the mortar shell to hit the ground.”

Next Instructional Steps

On her exit ticket, Nellie F. noticed that the majority of the class was able to write the correct equation from the problem and all students correctly recognized they needed to use the quadratic formula. While many students were able to correctly input the values of $a$, $b$, and $c$ into the quadratic formula, many struggled to complete their calculations due to algebraic errors. She also stated that there were several students “who, instead of solving the formula for a variable, either left it as an expression or set the formula equal to 0.” After arriving at their final solution, about 75% of students were able to eliminate the negative solution as a possible result and to write their final answer in the context of the problem. The other 25% “either neglected to round
the solution (as required in the directions), put it into context, or [to] write only one solution.” Nellie F. felt this was the area in which she should focus her next steps, because “[i]t is imperative that the students recognize why only one solution makes sense in this setting.” She also felt it was imperative that students understand why the use of appropriate units is important in a problem such as that presented on the exit ticket.

Based on her analysis, Nellie F. felt her students needed more support in solving application problems. She stated that she planned to provide this support by asking students more scaffolding and open-ended questions. To illustrate this she explained, “[I]nstead of asking the students to ‘solve’ or ‘find the time when the ball hits the ground,’ I can mix in questions like ‘How many solutions does the discriminant to this application problem guarantee us?’ or ‘Write a new application problem with the same initial height but a different initial vertical velocity.’” She went on to justify the inclusion of more scaffolding questions, stating, “Including these more specific questions will help the students that are struggling with application problems since there is just ‘too much’ to focus on at once. Now, the students would be able to only pay attention to the relevant parts of the problem, which will help them develop the skills they need to solve the entire problem. This will also help the students that make algebraic errors, as they will have less overall work to do at one time.” She also asserted that asking more open-ended questions would provide greater challenge to the students that had demonstrated mastery on application problems such as the problem from the exit ticket. She stated that such open-ended problems would “challenge [these students] as they see fit by coming up with new problems, related to their own interests or of a caliber they are more excited to solve.”

Nellie F.’s above described next instructional steps appeared to follow a thoughtful analysis of student performance on the exit ticket and were described in enough detail to show
they were directly tied to the learning objectives and standards assessed. The inclusion of scaffolding and open-ended questions were supports that should improve intended learning for the whole class. While Nellie F. did discuss the inclusion of open-ended questions such as “Write a new application problem with the same initial height but a different initial vertical velocity,” as a targeted support for a smaller group of her students (those who attained mastery on her exit ticket), the researcher did not feel this example would promote the deeper thinking (related to the learning objectives) necessary to push these students learning any further.

Case Five - Erin F.

Erin F. completed her first student teaching placement at an urban public middle school, where she taught a sixth grade mathematics class. The class consisted of 25 students, who were considered to be on the “honors” track. Erin F.’s average scale score on the mindset items of the Beliefs Survey was 3.8, indicating she possessed a fixed mindset. Her average scale score for beliefs about the nature of mathematics was 4.3, indicating she possessed more “multidimensional” views about mathematics.

The Assessment

For her portfolio, Erin F. chose a homework quiz to submit as her assessment. The homework quiz assessed student understanding of the commutative, associative and distributive properties, of evaluating expressions, and of constructing and simplifying mathematical expressions. The quiz followed a lesson with the stated learning objective, “Students will be able to define, explain, and apply the *distributive property* to simplify algebraic expressions.”
Erin F. identified the following Common Core State Standards as being assessed:

1. CCSS.Math.Content.6.EE.A.1: Write and evaluate numerical expressions involving whole-number exponents.
2. CCSS.Math.Content.6.EE.A.2: Write, read, and evaluate expressions in which letters stand for numbers.
3. CCSS.Math.Content.6.EE.A.3: Apply the properties of operations to generate equivalent expressions.
4. CCSS.Math.Content.6.EE.A.4: Identify when two expressions are equivalent. (i.e., when the two expressions name the same number regardless of which value is substituted into them) (National Governors Association Center for Best Practices, 2010).

The first two problems on the quiz asked students to state which property (commutative, associative, or distributive) was illustrated. These problems are shown below:

1. \(6 + (4 + x) = (6 + 4) + x\)
2. \(5 \cdot (3 \cdot z) = (5 \cdot 3) \cdot z\)

The next six problems on the quiz assessed students’ ability to simplify various expressions, with problem 3 and problem 4 requiring that students “explain each step” and problem 5 and problem 6 requiring that students “use the Distributive Property” when simplifying the given expressions. These problems are shown below:

3. \(3 + (x + 12)\)
4. \((8 \cdot k) \cdot 4\)
5. \(5(x + 8)\)
6. \(4(2x - 1)\)
7. \(2(6 + 3n) - 4\)
8. \(5a + 7 - 3a - 2\)

Problems 9 and 10, shown below, presented students with an expression and asked them to “Factor the expression using the GCF.”
9. \(24 - 9\)

10. \(14x + 63\)

Problem 11 provided the image of the trapezoid shown in Figure 13, asking students to find the perimeter “as a simplified expression.”

![Trapezoid Image](image)

Figure 13. Problem 11 trapezoid from Erin F.’s assessment

The final two problems on the homework quiz were word problems. The first, problem 12, appeared to assess students’ ability to evaluate an equation at a given value. The problem provided students with the formula to convert temperatures from Celsius to Fahrenheit, \(F = (C \cdot 1.8) + 32\), and asked students “What is the temperature (in degrees Fahrenheit) of water that is 10 degrees Celsius?” The final question, problem 13, consisted of two parts based on the following scenario, “You and three friends go to a baseball game. You each pay $2 for a drink and \(x\) dollars for nachos.” Part (a) of the question asked students to make use of the Distributive Property and to write a simplified expression for the group’s total cost. Part (b) assessed students’ ability to evaluate an expression at a given value of \(x\), asking students to calculate the group’s total cost if the price of nachos is $3.

To score this assessment, Erin F. awarded the student 1 point for every correct answer, with a possible total of 14 points. She stated, “Students needed to show all work to receive credit, regardless of whether or not the student recorded the right answer.” Her statement was unclear as to whether the student received a point if they showed all of their work or only if they had the correct answer to accompany that work, but from observing the student samples, it appeared the
students only received a point if they had both the correct answer and had shown their work in obtaining that answer.

The first 12 problems on the quiz were exercises that Erin F. described as being similar to those seen in class lessons. For this reason, they assessed little more than procedural skills. According to Erin F., however, students had not been presented a word problem such as problem 13. This problem asked students to recognize that the problem is describing four groups of $2 drinks and four groups of $x$ dollar nachos, i.e. $4(2) + 4(x)$, then to make the connection between that representation and $4(2 + x)$. In writing such a representation, students were required to engage in both conceptual understanding and mathematical reasoning (National Research Council, 2001).

Feedback Provided to Students

Erin F. provided the largest variety of feedback of the six case study participants, falling under 12 of the 14 feedback categories, as can be seen in Table 19.

<table>
<thead>
<tr>
<th>Feedback category</th>
<th>Number of Feedback Instances</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precision, syntax, mathematical vocabulary, and organization</td>
<td>5</td>
<td>15.6%</td>
</tr>
<tr>
<td>Guiding questions</td>
<td>5</td>
<td>15.6%</td>
</tr>
<tr>
<td>Correction</td>
<td>4</td>
<td>12.5%</td>
</tr>
<tr>
<td>Non-specific praise</td>
<td>4</td>
<td>12.5%</td>
</tr>
<tr>
<td>Unclear questions</td>
<td>3</td>
<td>9.4%</td>
</tr>
<tr>
<td>Praise of a solution method or use of a mathematical property</td>
<td>2</td>
<td>6.3%</td>
</tr>
<tr>
<td>Praise of a grade</td>
<td>2</td>
<td>6.3%</td>
</tr>
<tr>
<td>Requesting more information</td>
<td>2</td>
<td>6.3%</td>
</tr>
<tr>
<td>Elaborated correction</td>
<td>2</td>
<td>6.3%</td>
</tr>
<tr>
<td>Factual questions</td>
<td>1</td>
<td>3.1%</td>
</tr>
<tr>
<td>Probing questions</td>
<td>1</td>
<td>3.1%</td>
</tr>
<tr>
<td>Uncategorized</td>
<td>1</td>
<td>3.1%</td>
</tr>
</tbody>
</table>
The highest percentage of Erin F.’s comments were categorized as addressing precision, syntax, mathematical vocabulary, or organization (15.6%), or as guiding questions (15.6%). The majority of Erin F.’s comments addressing precision were left to students’ solutions of problems 1 and 2, which asked students to determine the illustrated property (commutative, associative, or distributive). On all three student work samples, students identified the associative property, but did not reference the problem’s operation. On the first two student samples, Erin F. addressed this lack of specificity by writing “property of addition,” “property of multiplication,” or “property of …. what?” following the students’ response of “associative property.”

As stated previously, Erin F. also asked several questions that were classified as guiding questions. Most of these questions were structured as a series of factual questions, sequenced to scaffold student learning. For example, in response to problem 13, the baseball game problem, one student wrote a solution of “2x” under part (a) and “3x” under part (b), with no work to accompany these solutions. Erin F. responded to this student’s solution by providing the following list of questions:

1. How many people go to the game?
2. What are they buying?
3. Can we create an algebraic expression to show what we buy?
4. Can we use a special property to show that each person buys the same thing?

In addition to feedback about precision and guiding questions, Erin F. left several comments that were classified as non-specific praise (12.5%) or as corrections (12.5%). The previously mentioned comments in which Erin F. corrected student work by writing “property of addition” or “property of multiplication,” are examples of comments that were classified as corrections. One example of non-specific praise was left in reference to a student solution to problem 12 or problem 13a (it was unclear, given the context and position of the feedback).
both problems, the student showed their work for each step and provided the correct solution for the problem. Below the student’s response to 12, but next to the prompt for problem 13a, Erin F. simply wrote “Beautiful work.” What was beautiful about the work was left to the interpretation of the student.

Erin F. also wrote three questions that were categorized as unclear questions. This is a larger number than the previous participants, so some context may be needed. The first unclear question was left in response to a student’s work for problems 9 and 10, which asked students to factor two expressions using the greatest common factor. For problem 9, the student factored the expression $24 - 9$ as $3(8 - 3)$ and for problem 10 the student factored the provided expression, $14x + 63$, as $7(2x + 9)$. Next to these student responses, Erin F. wrote, “How can you use the GCF to find these answers?” It seemed unclear what she was asking for here, given the student used the greatest common factor in their solution. On another student sample, to simplify the expression $5a + 7 - 3a - 2$ (problem 8), the student wrote “$9 - 2a$,” with no other work. In response to this solution, Erin F. wrote, “can we combine the $5a$ and 2? Why or why not?” It was unclear why she referenced the $5a$ and the 2, since the student’s errors appeared to be that they added 7 and 2, rather than subtracting 2 from 7, and provided an incorrect sign preceding the $2a$. The final unclear question was asked in response to a student’s solution to problem 10. An image of the student’s work can be seen in Figure 14. Beside the student’s work, Erin F. wrote “what would $x \cdot x$ give us? What would, say, $9 \cdot 9$ mean?” It was not entirely clear how this is related to the student’s solution. While the $x \cdot x$ may have referred to the student’s factoring of $14x$ as $7x \cdot 2x$, it was unclear why the $9 \cdot 9$ was included or what Erin F. intended for the student to take away from this question.
Next Instructional Steps

Erin F. stated that the majority of her students struggled to combine like terms and to factor using greatest common factor (GCF). She stated, “Though some students did correctly combine the like terms in the expression $5a + 7 – 3a – 2$ to obtain $2a + 5$, many added $5a$ and $3a$ instead of subtract[ing]. Others attempted to combine terms with $a$ with terms without $a$.” She noticed a similar struggle related to students’ use of the distributive property. In an expression such as $3 + (x + 12)$, several students confused the commutative property of addition with the distributive property and distributed the 3 to both $x$ and 12. A large number of students also failed to fully distribute in expressions such as $5(x + 8)$, distributing to the first term ($x$), but not the second term (8). The final struggle noticed by Erin F. related to problem 13a, in which many students forgot to count themselves when writing their expressions.

To address student needs, Erin F. first stated she intended to have students address questions or comments from the feedback she left on their assessments and submit them as a homework assignment the next day. In subsequent lessons, she asserted that she would further differentiate her homework assignments to meet the needs of gifted and struggling students. She wrote, “The homework assignments will be differentiated for all students by using a rating
system on the questions. Easier, more procedural questions will be rated with fewer stars (typically only one), while the most challenging questions (ones that test both conceptual understanding and mathematical reasoning at a very high level) will be rated with more stars (typically five to six stars). Moderately difficult questions that test conceptual understanding will be rated with anywhere from two to four stars. Students can answer any questions they want, but they must answer a total of, say, fourteen stars.” No examples accompanied this description of differentiated homework tasks. She did, however, go on to state that she would use these homework assignments to provide “highly individualized” feedback to students. She stated that if students continued to make the same mistakes, then she would examine their explanations “in order to use other methods that a student may understand better instead of repeated methods we have learned in class that the student is still not understanding.” She would also “make a concerted effort to use feedback garnered from more advanced students’ work to inform ways to differentiate for struggling students using fresh, more student-friendly methods.” It was not clear what she meant in either of these statements, as no further examples or explanations were included.

Another next step Erin F. suggested was in relation to an individual student for which she submitted a homework sample. The student, an English Language Learner, struggled to use precise mathematical language. For example, on problems 1 and 2 the student correctly identified the use of the associative property but failed to include “of addition” in her response to problem 1 and “of multiplication” in problem 2. This student also struggled with problems 12 and 13, both word problems. For problem 13 the student simply wrote “2x” for part a and “3x” for part b, with no additional work, and for problem 12, the student wrote “10 + (C · 1.8) + 32” with no additional work. For this student, Erin F. attributed all struggles to language difficulties.
Her proposed next step was to provide more direct translations for the student. She stated, “I need to make even more of an effort translating directions and/or prompts for my ELL student. In subsequent lessons, I have created documents and handouts specifically translated for her, with several parts in both English and Chinese to make sure she understands fully the directions and begins to learn the associated English vocabulary.”

Overall, the next instructional steps provided by Erin F. were very general, lacking sufficient detail pertaining to the learning objectives and standards assessed in the homework assignment. In addition, the next steps did not appear to be grounded in Erin F.’s analysis of student performance on the assessment. She did not suggest any supports to aid students in exploring their errors related to the distributive property, combining like terms, factoring using greatest common factor, or writing expression from word problem such as the one in problem 13.

Case Six - Paige F.

Paige F. completed her first student teaching placement at an urban public middle school in an eighth grade “pre-honors” mathematics class. The pre-honors designation implied that the students in this group were on grade level. Paige F. had 31 students in her course. The researcher felt that it was important to note that Paige F. was the only pre-service teacher in this study that had any previous teaching experience. Before enrolling in her current Master’s program, Paige F. taught mathematics abroad for one year. Paige F.’s average scale score on the mindset items of the Beliefs Survey was 3.7, indicating she possessed a fixed mindset. Her average scale score for beliefs about the nature of mathematics was 5.3, indicating she possessed more “multidimensional” views about mathematics.
The Assessment

Paige F. submitted an exit ticket in which the focus was solving linear equations in one variable and which she stated followed a lesson addressing three learning objectives:

2. Students will determine the number of solutions to an equation (one solution, no solution, or infinitely many solutions).
3. Students will translate a visual representation of an equation into an algebraic expression.

Paige F. stated that her exit ticket assessed the following content standards:

1. CCSS.MATH.CONTENT.8.EE.C.7: Solve linear equations in one variable.
2. CCSS.MATH.CONTENT.8.EE.C.7.a: Give examples of linear equations in one variable with one solution, infinitely many solutions, or no solutions. Show which of these possibilities is the case by successively transforming the given equation into simpler forms, until an equivalent equation of the form x=a, a=a, or a=b results (where a and b are different numbers).
3. CCSS.MATH.CONTENT.8.EE.7.C.b: Solve linear equations with rational number coefficients, including equations whose solutions require expanding expressions using the distributive property and collecting like terms (National Governors Association Center for Best Practices, 2010).

On Paige F.’s exit ticket, question 1 contained a balance scale and asked students to express the situation as an algebraic equation, as well as solve the equation. On the left side of the balance scale there was a 5 pound block and two blocks of unknown weight (these blocks were labeled with a question mark, as shown in Figure 15). On the right side, there were two 3 pound blocks, one 9 pound block, and four blocks of unknown weight.

![Balance scale from Paige F.’s exit ticket](image)

Figure 15. Balance scale from Paige F.’s exit ticket
The second question asked students to “change the coefficient or constant of the equation above [in question 1] so that there is (a) no solution or (b) infinitely many solutions.” After making a selection and writing their new equation, students were instructed to “explain using key words.” The word “explain” here seemed to refer to an explanation of why the equation they had written fit the selected criterion. The final question of the exit ticket asked students to find the area of a rectangle, shown in Figure 16, and to include all of their work in the solution process.

![Rectangle from Paige F.'s exit ticket](image)

Figure 16. Rectangle from Paige F.'s exit ticket

Paige F. stated that no partial credit was awarded on the exit ticket because any points earned on this assessment would be counted as extra credit points for an upcoming quiz. Points were awarded based on the evaluation criteria shown in Figure 17.

```
<table>
<thead>
<tr>
<th>Problem 1 (1 point if meets Criteria A AND B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Criteria A: Correctly translates and sets up equation (Conceptual Understanding)</td>
</tr>
<tr>
<td>- Criteria B: Carries out calculations accurately to find solution (Procedural Fluency)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Problem 2 (1 point if meets Criteria A AND B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Criteria A: Able to provide appropriate example (Conceptual understanding)</td>
</tr>
<tr>
<td>- Criteria B: Able to explain using key words (Problem Solving/Mathematical Reasoning)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Problem 3 (1 point if meets Criteria A AND B AND C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Criteria A: Correctly sets up equation using the property of a rectangle (Problem Solving)</td>
</tr>
<tr>
<td>- Criteria B: Recalls the area formula for a rectangle to solve (Problem Solving)</td>
</tr>
<tr>
<td>- Criteria C: Carries out calculations accurately to find solution (Procedural Fluency)</td>
</tr>
</tbody>
</table>
```

Figure 17. Paige F.'s assessment evaluation criteria

The first question of the exit ticket assessed conceptual understanding by requiring students to make connections between two representations – the visual representation of the scale...
and the more abstract algebraic representation of an equation. This question also assessed procedural fluency by requiring students to find the solutions to their equation. The second question, which had students modify their original equation (from question 1) to create an equation that had either no solution or infinitely many solutions, assessed students’ conceptual understanding by requiring them to generate their own example of an equation that would have a specific type of solution. Generating such an example and explaining why the example meets the selected criteria required an understanding of why these types of solutions (no solution and infinitely many solutions) occur and in what contexts. In addition, the second question addressed mathematical reasoning by having students explain why the change they made to the equation from question 1 resulted in the selected criterion (National Research Council, 2001).

In order to solve the third, and final, question on the exit ticket students were required to engage in mathematical problem solving. To solve this problem, students may have been tempted to move directly to the familiar area formula of \( A = lw = (4x - 1)(6x + 9) \) or \( A = lw = (4x - 1)(2x + 17) \). However, from this point determining the next step in the solution process was less straightforward. Because this problem was one for which “the solution method [was] not known in advance,” it falls under mathematical problem solving as described by the National Council of Teachers of Mathematics (2000, p. 52). In order to take this problem any further the student needed to activate prior knowledge of the properties of a rectangle, specifically the knowledge that opposite sides of the rectangle are equal in measure, and connect that to their new knowledge of solving linear equations by setting the measures of the sides labeled \( 2x + 17 \) and \( 6x + 9 \) equal to one another to find the value of \( x \). This process of making connections between concepts and solving for \( x \) assessed both conceptual understanding and procedural fluency of students.
Feedback Provided to Students

Paige F.’s feedback fell under 10 of 14 feedback categories in this study. The percentages and number of feedback instances that fell under each category are outlined in Table 20.

Table 20. Paige F. Feedback Categories

<table>
<thead>
<tr>
<th>Feedback category</th>
<th>Number of Feedback Instances</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precision, syntax, mathematical vocabulary, and organization</td>
<td>10</td>
<td>37%</td>
</tr>
<tr>
<td>Elaborated correction</td>
<td>4</td>
<td>14.8%</td>
</tr>
<tr>
<td>Unclear questions</td>
<td>3</td>
<td>11.1%</td>
</tr>
<tr>
<td>Probing questions</td>
<td>2</td>
<td>7.4%</td>
</tr>
<tr>
<td>Guiding questions</td>
<td>2</td>
<td>7.4%</td>
</tr>
<tr>
<td>Praise of a solution method or use of a mathematical property</td>
<td>2</td>
<td>7.4%</td>
</tr>
<tr>
<td>Non-specific praise</td>
<td>1</td>
<td>3.7%</td>
</tr>
<tr>
<td>Factual questions</td>
<td>1</td>
<td>3.7%</td>
</tr>
<tr>
<td>Requesting more information</td>
<td>1</td>
<td>3.7%</td>
</tr>
<tr>
<td>Uncategorized</td>
<td>1</td>
<td>3.7%</td>
</tr>
</tbody>
</table>

Paige F. provided a variety of feedback on students’ exit tickets, with a large percentage (37%) being categorized as precision, syntax, mathematical vocabulary, or organization. On one student’s exit ticket, the student indicated that s/he had written an equation that did not have a solution, then included the work shown in Figure 18.

Figure 18. Student work for problem 2 of Paige F.’s exit ticket

To the right of this, the student also wrote “insert two more ? ? on the left.” Paige F. left several comments on this problem. Next to the solution she wrote “Great example,” which was categorized as non-specific praise, as it was unclear why the example was great. Below, where
the student wrote, “insert two more ?? on the left,” Paige F. wrote, “Is there a math term that you can use to describe ‘?’” This comment was categorized under precision, syntax, mathematical vocabulary, or organization, as well as a factual question. Below the work shown in Figure 18, Paige F. also wrote, “What are some other key words or math terms you can use to accurately describe the changes you were making to the original equation?” This comment was also categorized as addressing precision, syntax, mathematical vocabulary, or organization. In addition, Paige F. underlined the sentence “Explain using key words” in the statement of the problem, which was categorized as precision, syntax, mathematical vocabulary, or organization, as well as feedback that requests more information from the student. A more complete breakdown of the feedback provided by Paige F. can be found in Table 20.

As did Erin F., Paige F. provided three questions that were categorized as unclear questions. The first unclear question was left on a student sample in response to the student’s solution to problem 1, the balance scale problem. The student began by writing the equation “5 + 2x = 3 + 3 + 9 + 4x,” before combining like terms to obtain “5 + 2x = 15 + 4x.” Next the student subtracted 2x from both sides of the equation, which resulted in 5 = 15 + 2x. After this, the student subtracted 15 from both sides of the equation, then divided the equation by 2 on both sides, resulting in a correct solution of −5 = x. Paige F. wrote, “Great! Is there another way to express the right-hand side of the equation? What if you grouped the blocks together? Any multiple groups of blocks that can use the same expression?” While it seemed that she was trying to push the student’s learning further with this comment, it was unclear that the student would know for what Paige F. was asking, so the comment was categorized under unclear questions. Paige F. left another comment similar to this one on a different student work sample. On that sample, the student also obtained −5 as a solution, after correctly showing their work. Paige F.
wrote, “Great! Is there another way to express the right-hand side of the equation? Can we use parenthesis? Any grouping ideas?”

Paige F. left the third, and final, question that was categorized as unclear next to a student’s response to problem 3, where students were asked to find the area of the provided rectangle (see Figure 16). For this question, the student provided the work shown in Figure 19.

![Figure 19. Student work for problem 3 of Paige F.’s exit ticket](image)

Paige F. provided several comments to address the work shown on the left of Figure 19, but the comment that was categorized as an unclear question was pertaining to the student’s work on the right side of the figure. Paige F. drew an arrow pointing to where the student wrote “3.25 \cdot 4x - 1” and left the question, “what does this expression represent?” To the researcher, it seemed that this comment may have been addressing the student’s lack of parenthesis, but it was unclear if the student would recognize this or if that was indeed what Paige F. was trying to draw the student’s attention towards.

Overall, the comments left by Paige F. on the student samples attempted to focus on both strengths and needs. In fact, Paige F. left holistic comments at the end of each student sample in which she attempted to address both student strengths and needs. However, in the first two student samples when Paige F. addressed student strengths for problem 1, she asked an unclear question to try and push that students’ learning further. In addition, the third student sample contained no feedback about student strengths. The student in the last sample did appear to
struggle with the three exit ticket questions, but she was able to correctly write equations for problems 1 and 2 and complete some of the solution process correctly, which Paige F. did not acknowledge.

**Next Instructional Steps**

In her analysis of student work on the exit ticket, Paige F. found that most students were successful (or mostly successful) in completing problems 1 and 3. All students in the class were able to construct an equation from the balance scale provided in problem 1 and only four students made minor errors in solving for the missing weight. Similarly, for problem 3 a large majority (83%) of students were able to correctly set up an equation by setting the expressions on opposite sides of the rectangle equal to one another. After solving for $x$, 70% of students correctly recalled the necessary area formula. However, Paige F. stated that only 60% of students were able to find the correct solution because they either “did not realize they [could] find the actual side lengths of the rectangle by substituting in the value of $x$” or they “failed to carry out the series of calculations accurately until the end because either they ran out of time or lacked the procedural fluency.”

Students were not as successful in solving problem 2 of the exit ticket, with less than half able to construct an equation with either no solution or infinitely many solutions. In addition, less than a fourth of her students were able to explain why the equation had the indicated solution using precise mathematical language. In order to address this, Paige F. stated that in her next lesson she planned to use student samples to create an error analysis task for the class. The error analysis task would require students to view their classmates work and discuss “the error[s] in mathematical reasoning.” For this task, Paige F. stated she would “group students together with
the same misconception, needs, or weakness” and would “circulate and visit the different groups and make sure the specific issues are resolved.” In addition, Paige F. stated that she felt it important she stress “the importance of mathematical precision in showing work or steps for another person to view,” while students completed the error analysis task. She went on to say, “by showing [students] parts of the student mathematical work that does not accurately present the intentions of the writer, students will be able to understand how important it is to use the standard conventions to properly show work as it conveys different information.” After completing this error analysis task in class, Paige F. wrote she intended to have students reflect upon and “re-attempt questions they got wrong” on their exit ticket. Such a move, allowing students to resubmit or re-attempt work, has been deemed growth mindset in nature by the existing mindset literature (Sun, 2015).

Paige F.’s suggestion of an error analysis task was a targeted next step, grounded in her analysis of students’ performance on the exit ticket. The focus of this error analysis (on the number of solutions) was directly tied to her assessed learning objectives and standards and provided support to her students as a whole.

**Research Question 1**

The cases described above will now be used to address the first research question of the study, exploring the relationship between a pre-service mathematics teacher’s (a) mindset and (b) beliefs about mathematics and the assessment task submitted for his/her portfolio.
**Mindset and the Created Assessment**

Two of the three growth mindset participants, Tess G. and Alyssa G., scored at growth mindset levels on *Rubric 5*, both scoring at a Level 3. The remaining growth mindset participant, Jensen G., did not score at a growth mindset level on *Rubric 5*. In fact, she scored at a Level 1, the lowest possible fixed mindset score. The three fixed mindset participants all scored at varying levels on *Rubric 5*, with Nellie F. at a Level 1, Erin F. at a Level 2, and Paige F. at a Level 4. Table 21 and Table 22 indicate that only the assessments of Alyssa G., Tess G., and Paige F. conveyed growth mindset messages to their students. These tables indicate that, in this study, the pre-service mathematics teachers’ mindsets were not always aligned with the mindset messages conveyed in their planned assessments. This is especially true of Jensen G., who had the strongest growth mindset but scored at the most fixed mindset level for her assessment, and Paige F., who possessed a fixed mindset, yet submitted an assessment that was considered at a higher growth mindset level than any of the growth mindset participants. However, it is true that the majority (two of three) of growth mindset participants submitted growth mindset assessments for their portfolio and the majority of fixed mindset participants submitted fixed mindset assessments.

<table>
<thead>
<tr>
<th>Fixed Mindset Participant</th>
<th>Average Mindset Score</th>
<th><em>Rubric 5</em> Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nellie F.</td>
<td>3.6</td>
<td>1</td>
</tr>
<tr>
<td>Paige F.</td>
<td>3.7</td>
<td>4</td>
</tr>
<tr>
<td>Erin F.</td>
<td>3.8</td>
<td>2</td>
</tr>
</tbody>
</table>

*Note.* Highlighted entries indicate participants who scored at growth mindset levels of *Rubric 5*.

<table>
<thead>
<tr>
<th>Growth Mindset Participant</th>
<th>Average Mindset Score</th>
<th><em>Rubric 5</em> Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alyssa G.</td>
<td>5.2</td>
<td>3</td>
</tr>
<tr>
<td>Tess G.</td>
<td>5.5</td>
<td>3</td>
</tr>
<tr>
<td>Jensen G.</td>
<td>5.7</td>
<td>1</td>
</tr>
</tbody>
</table>

*Note.* Highlighted entries indicate participants who scored at growth mindset levels of *Rubric 5*. 116
As stated, Table 21 and Table 22 indicate that only Alyssa G., Tess G., and Paige F. submitted assessment that scored at growth mindset levels of *Rubric 5*. In their assessments, these three pre-service teachers included questions that examined students conceptual understanding, procedural fluency, and mathematical reasoning (and/or problem-solving) of the learning objectives. The National Research Council (2001), identifies these strands, called strands of mathematical proficiency⁸, as “capturing what … it means for anyone to learn mathematics successfully” (p. 5). The National Research Council identifies a key element in this successful learning of mathematics as providing assessments that “gauge the development of proficiency” in each of the presented strands (National Research Council, 2001, p. 13). The key differences between the exit tickets submitted by Alyssa G. and Tess G. (who both scored at a Level 3), and Paige F. (Level 4) are that only Paige F.’s exit ticket furthered the assessment of the strands of mathematical proficiency by providing a variety of different question types that examined students’ understanding in these areas.

The remaining three participants’ assessments were scored at fixed mindsets levels of *Rubric 5*. One growth mindset participant, Jensen G., and one fixed mindset participant, Nellie F., scored at a Level 1 (the lowest score on this rubric) indicating assessments that conveyed fixed mindset messages. In the submitted assessments Jensen G. asked students to calculate volume and surface area of rectangular prisms and Nellie F. had students apply the quadratic formula to a given word problem. Both pre-service teachers’ assessments required students to recreate the procedural skills or factual knowledge learned in class, rather than to engage in any

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⁸ “Productive disposition” is the fifth and final strand included in NRC’s (2001) model of mathematical proficiency.
elements of conceptual understanding or mathematical reasoning (elements needed to score higher on this rubric).

The final participant, Erin F., submitted a Level 2 assessment. Erin F. submitted an assessment that mainly assessed students’ procedural fluency of the lesson content. Erin F. included a large number of questions on her homework assignment that assessed students’ procedural fluency. Only her final question, question 13, engaged students in conceptual understanding and mathematical reasoning. The inclusion of one such problem was not enough to carry Erin F.’s assessment to a Level 3 score, because a Level 3 requires a “pattern of evidence” of engaging students in mathematical reasoning.

With regard to a qualitative pattern observed by the researcher, it was noticed at all three participants that scored at growth mindset levels on Rubric 5, included opportunities for students to engage with multiple mathematical representations on their submitted assessments.

Providing students with opportunities to explore connections between various representations is one method that Boaler (2016) identifies in creating a growth mindset task. Alyssa G.’s assessment required that students compare three representations (an equation, graph, and table) to determine if they each represented the cab fare scenario of the exit ticket, and then determine whether or not the relationship presented was proportional. In Tess G.’s graphic organizer, she encouraged students to interpret their solutions using multiple representations (verbal, graphical, and algebraic). However, there was no real attempt at having students explore how the representations were connected. The only fixed mindset participant that required students to engage in exploring connections between representations was Paige F., who asked students to connect the balance scale representation to the associated algebraic equation.
In addition, three of the six participants submitted mathematics assessments that provided students opportunities (of varying degrees) to repeat the mathematics learned in class. From their descriptions of the assessments and the lessons that proceeded those assessments, Jensen G.’s and Nellie F.’s assessments provided little more than opportunities to recreate the mathematics learned in class. Erin F. did provide one problem, problem 13, that had students attempt to extend the learning from class, but the remainder of the assessment was described by Erin F. as similar to the problems seen in class, providing students with additional practice. In her book *Mathematical Mindsets*, Boaler (2016) discusses this notion of providing students with extra practice of mathematical ideas in assessments and other class activities. She writes, “We know that when learning happens a synapse fires, and in order for structural brain change to happen we need to revisit ideas and learn them deeply. But what does that mean? It is important to revisit mathematical ideas, but the ‘practice’ of methods over and over again is unhelpful. When you learn a new idea in mathematics, it is helpful to reinforce that idea, and the best way to do this is by using it in different ways” (p. 42). Boaler goes on to describe this approach of repeating “methods over and over again” as turning students away from mathematics and contributing to their fixed mindset views of the subject (p. 42). By Boaler’s description, the assessments of Jensen G. and Nellie F. may be seen as reinforcing fixed mindset views of mathematics because (by their descriptions) they only required students to reproduce the mathematics learned in class. Erin F.’s assessment, however, did not fully fall under this category, because problem 13 of her quiz required students to recognize the distributive property in a context with which they have never had exposure. So, while the majority of the questions (1-12) on Erin F.’s assessment may be deemed as fixed mindset, in that they required little more than practice of learned material, the
final question may be seen as an indication that there was at least one growth mindset element included in Erin F.’s assessment.

**Beliefs About Mathematics and the Created Assessment**

With regard to beliefs about mathematics, Table 23 indicates that all six participants scored over a 4 in the area of beliefs, meaning all participants viewed mathematics as more multidimensional, to some degree. This may be a reflection of the teacher certification program in which the students were enrolled at the time of this study, which subscribes to a multidimensional, constructivist view of teaching mathematics. If we view the assessment scores in relation to these beliefs, we see that Paige F., Alyssa G., and Tess G. (who scored at levels indicating a growth mindset assessment) had some of the strongest multidimensional views about mathematics, so it may be that this belief construct is more strongly related to the mindset messages conveyed in the pre-service teachers’ planned assessments. Jensen G., however, stands out as a possible contradiction to this statement. Though she had strong multidimensional views of mathematics and had the same mean scale score for this belief as did Paige F., her assessment was not scored as conveying growth mindset messages to students.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Average Nature of Mathematics</th>
<th>Rubric 5 Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erin F.</td>
<td>4.3</td>
<td>2</td>
</tr>
<tr>
<td>Nellie F.</td>
<td>4.5</td>
<td>1</td>
</tr>
<tr>
<td>Jensen G.</td>
<td>5.3</td>
<td>1</td>
</tr>
<tr>
<td>Paige F.</td>
<td>5.3</td>
<td>4</td>
</tr>
<tr>
<td>Tess G</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Alyssa G.</td>
<td>6</td>
<td>3</td>
</tr>
</tbody>
</table>

*Note.* Higher nature of mathematics scores (4-6) indicated a view of mathematics that goes beyond facts and procedures, a view of mathematics as multidimensional, as described by Boaler (2016). Entries highlighted in green indicate a participant who scored at growth mindset levels of Rubric 5.
In relation to the qualitative patterns of the assessment (described previously), participants with the strongest multidimensional views of mathematics (Tess G., Alyssa G., and Paige F.) were those that included multiple representation in their assessments and provided students with opportunities to engage with the mathematics learned in class in different ways (i.e. not simply reproducing learned materials). These are features that are considered more growth mindset in nature (Boaler, 2016). Participants with weaker multidimensional views of mathematics were those that dedicated most or all of their assessments to the reproduction of memorized or learned facts or procedures. Such practice conveys and reinforces fixed mindset messages to students (Boaler, 2016). However, beliefs about mathematics alone cannot be seen as the only factor influencing these growth or fixed mindset elements of the teachers’ assessment practices. For example, Erin F. possessed the most fixed mindset views of the participants, yet she incorporated at least one question in her assessment that extended student learning to a new context (and was thus growth mindset in nature). Jensen G. and Nellie F., who had slightly stronger multidimensional views than Erin F., did not include any such questions to extend student learning in their assessments. Similarly, Jensen G. possessed the same mean scale score for her beliefs about mathematics as did Paige F. However, Paige F. included the use of multiple representations, as well as opportunities to extend their understanding of the mathematics learned in class. In addition, Jensen G. is the only participant that included a competitive element to her assessment (winning a prize), something that the literature on growth mindset deems as fixed mindset (or performance oriented) in nature (Ames, 1992; Sun, 2015).
Research Question 2

Next, the researcher will explore the second research question, the relationship between a pre-service mathematics teacher’s (a) mindset and (b) beliefs about mathematics and the feedback they provided to students.

Mindset and Feedback

Regarding participants’ scores on SCALE’s (2016a) Rubric 12, all three fixed mindset participants scored at a Level 3, indicating that they provided feedback that was specific and addressed either student strengths or student needs with regard to the learning objectives (see Table 24). Using the classification set forth in Chapter 2, a score of Level 3 also indicates the three pre-service teachers conveyed growth mindset messages in the feedback provided to their students. The scores of the growth mindset participants, however, were much more variable (see Table 25). Jensen G. did not provide much feedback, but of the feedback she did provide, most was unrelated to the learning objectives assessed in her homework and in many cases did not address some of the significant misconceptions of her students (as demonstrated on their work samples). Her score of Level 1 indicates that her feedback conveyed fixed mindset messages to her students. Tess G. and Alyssa G. both scored at levels indicating they conveyed growth mindset messages in their feedback. Tess G. scored at a Level 3 because she provided specific feedback to address either student strengths or student needs in relation to the learning objectives, whereas Alyssa G. scored at a Level 4 because she provided specific feedback to address student strengths and student needs in relation to the learning objectives.
Table 24. Feedback Scores and Average Mindset Scores for Fixed Mindset Participants

<table>
<thead>
<tr>
<th>Participant</th>
<th>Average Mindset Score</th>
<th>Rubric 12 Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nellie F.</td>
<td>3.6</td>
<td>3</td>
</tr>
<tr>
<td>Paige F.</td>
<td>3.7</td>
<td>3</td>
</tr>
<tr>
<td>Erin F.</td>
<td>3.8</td>
<td>3</td>
</tr>
</tbody>
</table>

*Note.* Highlighted entries indicate participants who scored at growth mindset levels of *Rubric 12.*

Table 25. Feedback Scores and Average Mindset Scores for Growth Mindset Participants

<table>
<thead>
<tr>
<th>Participant</th>
<th>Average Mindset Score</th>
<th>Rubric 12 Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alyssa G.</td>
<td>5.2</td>
<td>4</td>
</tr>
<tr>
<td>Tess G.</td>
<td>5.5</td>
<td>3</td>
</tr>
<tr>
<td>Jensen G.</td>
<td>5.7</td>
<td>1</td>
</tr>
</tbody>
</table>

*Note.* Highlighted entries indicate participants who scored at growth mindset levels of *Rubric 12.*

With regard to alignment of teacher mindset and feedback, the researcher concluded that the pre-service teachers’ self-identified mindset was not always aligned with the overall mindset messages conveyed in the written feedback provided to students (as determined by *Rubric 12*).

As can be seen in Table 24, all three participants possessing fixed mindsets provided feedback that conveyed an overall growth mindset message to their students, whereas all but one of the participants possessing growth mindsets provided such feedback to their students (see Table 25). This may indicate that a teachers’ personal mindset may not strongly align to the overall mindset messages conveyed in the feedback provided to students.

In exploring the individual feedback instances of the pre-service teachers, the analysis showed that pre-service teachers with fixed mindsets provided more feedback related to precision, syntax, mathematical vocabulary, or organization. In fact, this category of feedback was the highest percentage of feedback provided by each of the three fixed mindset participants. Of the fixed mindset participants, Erin F. left the fewest comments in this area, with the majority of her feedback asking students to specify the operation of the property they identified in problems 1 and 2. Paige F. and Nellie F. provided the most feedback (of the six participants) falling under this category, as can be seen in Table 26.
Table 26. Percentage of Feedback Provided by Participants in Each Category by Mindset

<table>
<thead>
<tr>
<th>Family</th>
<th>Feedback category</th>
<th>Nellie F.</th>
<th>Paige F.</th>
<th>Erin F.</th>
<th>Alyssa G.</th>
<th>Tess G.</th>
<th>Jensen G.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructive Comments</td>
<td>Correction</td>
<td>7.7%</td>
<td>0%</td>
<td>12.5%</td>
<td>0%</td>
<td>21.1%</td>
<td>50%</td>
</tr>
<tr>
<td></td>
<td>Elaborated correction</td>
<td>26.9%</td>
<td>14.8%</td>
<td>6.3%</td>
<td>0%</td>
<td>15.8%</td>
<td>14.3%</td>
</tr>
<tr>
<td>Posed Questions</td>
<td>Unclear questions</td>
<td>3.8%</td>
<td>11.1%</td>
<td>9.4%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Rhetorical questions</td>
<td>7.7%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>10.5%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Factual questions</td>
<td>0%</td>
<td>3.7%</td>
<td>3.1%</td>
<td>0%</td>
<td>10.5%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Guiding questions</td>
<td>7.7%</td>
<td>7.4%</td>
<td>15.6%</td>
<td>31.3%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Probing questions</td>
<td>3.8%</td>
<td>7.4%</td>
<td>3.1%</td>
<td>43.8%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Praise</td>
<td>Praise of grade</td>
<td>3.8%</td>
<td>0%</td>
<td>6.3%</td>
<td>0%</td>
<td>0%</td>
<td>7.1%</td>
</tr>
<tr>
<td></td>
<td>Non-specific praise</td>
<td>0%</td>
<td>3.7%</td>
<td>12.5%</td>
<td>6.3%</td>
<td>5.3%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Praise of solution method</td>
<td>3.8%</td>
<td>7.4%</td>
<td>6.3%</td>
<td>12.5%</td>
<td>10.5%</td>
<td>7.1%</td>
</tr>
<tr>
<td></td>
<td>or use of a mathematical</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>property</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Precision, syntax,</td>
<td>Precision, syntax,</td>
<td>30.8%</td>
<td>37%</td>
<td>15.6%</td>
<td>0%</td>
<td>10.5%</td>
<td>21.4%</td>
</tr>
<tr>
<td>mathematical vocabulary, or</td>
<td>mathematical vocabulary,</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>organization</td>
<td>or organization</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Requesting more information</td>
<td>Requesting more</td>
<td>3.8%</td>
<td>3.7%</td>
<td>6.3%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>information</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effort</td>
<td>Effort</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>10.5%</td>
<td>0%</td>
</tr>
<tr>
<td>Uncategorized</td>
<td>Uncategorized</td>
<td>0%</td>
<td>3.7%</td>
<td>3.1%</td>
<td>6.3%</td>
<td>5.3%</td>
<td>0%</td>
</tr>
</tbody>
</table>

*Note. The organization of these tables reflect participants’ average mindset scores from the Beliefs Survey. As you move from left to right in the table, participant average mindset scores are arranged in increasing order, with Nellie F. having the lowest, most fixed, mindset score (3.6) and Jensen G. having the highest, most growth, mindset scores (5.7).*

The majority of Paige F.’s comments relating to precision, syntax, mathematical vocabulary, or organization can be seen as falling under two themes – pushing students to use
more precise mathematical language in their explanations to problem 2 or encouraging students to use proper syntax in their area calculations for problem 3. As an example of the first theme, in trying to change the equation from problem 1 to a problem with no solution, one student wrote $5 + 2x = 5 + 2x$, and then subtracted 5 from both sides to obtain $2x = 2x$. Following this step, the student divided both sides of the equation by $2x$ and indicated that their final answer is $x$, shown in Figure 20. Paige F. posed several questions to address the students’ error in the final steps of the problem, but she also encouraged the student to use more precise mathematical language by stating, “What math terms can you use to describe the changes you made to the original equation?” She also underlined the phrase “Explain using key words” in the directions of the problem.

![Figure 20. Second example of student work for problem 2 of Paige F.’s exit ticket](image)

Illustrating the second theme (focusing on syntax), in attempting to find the area of the rectangle in problem 3, one student provided the work shown in Figure 21, forgetting the parentheses around the expression for length and around the expression for width (an error made by every student for which Paige F. submitted a sample).

\[
A = l \cdot w \\
A = 4(2) - 1 \cdot 6(2) + 9 \\
A = 8 - 1 \cdot 12 + 9 \\
A = 7 \cdot 21 \\
A = 147
\]

Figure 21. Student error on problem 3 of Paige F.’s exit ticket
In response, Paige F. wrote, “Is this an accurate way to express the length and width? What numerical answer would you get if you followed the PEMDAS rule here?” In a separate comment, next to this one, she wrote, “Great job using the equals sign appropriately throughout your work! Next time, check to see if the work you show is accurately expressing your actual mathematical intentions. Remember that the reader of your math work may not fully understand your logic unless you accurately express [it] using standard conventions.”

The majority of Nellie F.’s feedback pertaining to precision, syntax, mathematical vocabulary, or organization also addressed two major themes – writing the quadratic equation as an equation (rather than an expression) and writing that equation using correct mathematical symbols throughout. One example that illustrates both of these themes comes from a previously described sample on which a student wrote the expression “$-16x^2 + 150x - 3.$” Next, the student wrote the expression “$\frac{-150 \pm \sqrt{22308}}{-32}$” to find the solutions of the quadratic. After finding the square root of 22,308 the student wrote, “$\frac{-150 \pm \sqrt{22308}}{-32} = \frac{-150 \pm \text{around 149.36}}{-32}.$” Nellie F. first addressed the student’s expression of $-16x^2 + 150x - 3$ by writing, “Remember that we are solving an equation not an expression” and adding “$h(x) =$” in front of the expression $-16x^2 + 150x - 3$ and an “$x =$” in front of the expression $\frac{-150 \pm \sqrt{22308}}{-32}$. She also drew an arrow to where the student wrote “around 149.36” in the expression and added the comment “normally we don’t put words in expressions,” after which she displayed the correct way of writing the expression.

Of the growth mindset participants, Jensen G. provided the most feedback relating to precision, syntax, mathematical vocabulary, or organization. Three comments left by Jensen G. were classified in this category, one of which addressed a student forgetting to include units (in²) after one of their surface area calculations and two that addressed students’ errors in incorrectly
writing their calculations in a single equation. One such example was previously discussed, in which the student recorded the length of a table as 152 centimeters, width as 42 centimeters, and height as 73 centimeters and to calculate volume, the student wrote, “$42 \times 73 = 3,066 \times 152 = 466,032 \text{ cm}^3.$” In response, Jensen G. drew parenthesis around “$152 = 466,032 \text{ cm}^3$” and wrote “Make sure you start from the next line when you do a new operation.” She then demonstrated below her comment, writing, “$3,066 \times 152 = 466,032.$”

The remaining two growth mindset participants, Tess G. and Alyssa G., left very few or no comments related to precision, syntax, mathematical vocabulary, or organization. Tess G. left two comments classified in this category; one comment addressing a student losing their inequality sign when solving and instead writing a single solution, 6, as their answer and another comment correcting a group’s description of their solution. For the second comment, the students obtained an inequality of $x < 3$, which they interpreted as “a number is less than 3” and Tess G. corrected to “Any number less than 3 will satisfy the inequality.” Alyssa G. left no comments classified as relating to precision, syntax, mathematical vocabulary, or organization.

Another observation made by the researcher was that the fixed mindset participants’ feedback contained more variety than did that of the growth mindset participants. This is evidenced in Table 26. The feedback Jensen G., Alyssa G., and Tess G. provided to students was sorted into five, five, and nine categories respectively, whereas the feedback Nellie F., Erin F., and Paige F. provided to students was sorted into 10, 12, and 10 categories, respectively. In addition, two of the growth mindset participants, Alyssa G. and Tess G., left several general (more holistic) comments at either the end of each section or at the end of the students’ assignments, which clearly attempted to focus on at least one student strength, followed by a student need or needs. For example, at the bottom of one group’s graphic organizer, Tess G.
provided the following note to students: “Group #16, great job checking your work and substituting 7 in for x. I see that you originally substituted in 6 and discovered that 6 wouldn’t work. If that’s the case, how can the solution be 6? Please take a look at the given inequality symbol to determine where the error exists. If you resubmit the question boxed in red by tomorrow, you will receive full credit for that portion of the graphic organizer.” The “question boxed in red” asked students if the solution could be 6, because the group lost their inequality sign in solving their inequality, $12 < 3x − 6$. Instead of obtaining the correct solution set of $6 < x$, the students came to the conclusion that “the solution is positive 6.”

One fixed mindset participant, Paige F., also attempted to leave general (more holistic) comments at the end of each student’s assignment, but only one of these comments addressed a strength on one of the student samples, with the other two samples receiving general comments that focus on student needs and were worded more critically. For example, the following comment was left at the end of one student sample: “You need to review and remember the mistakes you made while working with equations. I see the same type of errors you made on your previous work. Before you copy down the different expressions given, why don’t you take time to clarify the end goal of the word problem? This will help you plan the steps more logically.”

Two fixed mindset participants provided comments that were classified as praising a student’s grade by writing “Nice!” (Nellie F.), “You did nice work on this quiz!” (Erin F.), and drawing a smiling face (Erin F.) next to a student’s overall score on the assignment. Only one growth mindset participant, Jensen G., provided such a comment, writing “Great work!” next to a student’s overall score on one of the samples. Much of the research on praise and mindset, has found that praising a students’ grade sends fixed mindset message to students, whereas focusing
on effort or process sends a growth mindset message (Kamins & Dweck, 1999; Mueller & Dweck, 1998). Only one participant, Tess G., provided a comment about student effort. In her overall comments at the end of the sample, she wrote, “You were given a challenging inequality and did an incredible job persevering and solving it without my help. I am happy to see that you were able to utilize your prior knowledge and correctly subtract a positive number from a negative number without the use of your calculator! Please read my comments carefully so that you will master the next inequality organizer in workshop!” The fact that Tess G., a growth mindset participant, is the only pre-service teacher that provided such effort feedback may indicate that a growth mindset is a necessary, but not sufficient, condition for providing such feedback.

As can be seen in Table 26, two growth mindset participants, Jensen G. and Tess G., provided more feedback than any other participants that simply corrected student work, by showing the student how to complete the problem, step-by-step, with no further comment. One such example was described previously in the case of Jensen G. Two other participants, Nellie F. and Erin F., provided such corrections in their feedback to students, but much fewer than Jensen G. and Tess G. Based on the existing mindset literature, such feedback may be considered fixed mindset in nature because such comments are results-oriented and provide students with little insight as to how to move their learning forward (de Kraker-Pauw et al., 2017). While Jensen G. and Tess G. both possessed the strongest growth mindsets of all six participants, they provided more of this fixed mindset feedback than did Erin F. and Nellie F., the only other two participants that provided this type of feedback and both of whom had fixed mindsets.

All three fixed mindset participants posed at least one unclear question on a student sample (described earlier under the individual case studies). These three participants also
provided feedback that requested more information from the student, with statements such as “show the work,” “explain using key words,” or “context?” No growth mindset participants posed unclear questions or requested this type of information in their feedback.

**Beliefs About Mathematics and Feedback**

Regarding beliefs about mathematics, most of the participants provided feedback conveying growth mindset messages to their students, with the exception of Jensen G., who (relative to the other participants) had neither the strongest nor weakest multidimensional views of mathematics (see Table 27). Because all six preservice teachers possessed multidimensional views about mathematics, this may indicate that, in most cases, a multidimensional view of mathematics lends itself to providing more growth mindset feedback overall. Of course, Jensen G.’s score for beliefs about mathematics and *Rubric 12* score may be seen as an indication that this belief construct alone is not sufficient in conveying overall growth mindset messages in feedback.

Table 27. Pre-Service Teacher Beliefs about Mathematics and Feedback Scores

<table>
<thead>
<tr>
<th>Participant</th>
<th>Average Nature of Mathematics</th>
<th>Rubric 12 Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erin F.</td>
<td>4.3</td>
<td>3</td>
</tr>
<tr>
<td>Nellie F.</td>
<td>4.5</td>
<td>3</td>
</tr>
<tr>
<td>Jensen G.</td>
<td>5.3</td>
<td>1</td>
</tr>
<tr>
<td>Paige F.</td>
<td>5.3</td>
<td>3</td>
</tr>
<tr>
<td>Tess G</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Alyssa G.</td>
<td>6</td>
<td>4</td>
</tr>
</tbody>
</table>

*Note.* Highlighted entries indicate participants who scored at growth mindset levels of *Rubric 12.*

Table 28 shows the feedback provided by each participant in relation to their self-reported beliefs about mathematics.
Table 28. Percentage of Feedback Provided by Participants in Each Category by Beliefs about Mathematics

<table>
<thead>
<tr>
<th>Feedback category</th>
<th>Erin F.</th>
<th>Nellie F.</th>
<th>Jensen G.</th>
<th>Paige F.</th>
<th>Tess G.</th>
<th>Alyssa G.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructive</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comments</td>
<td>Correction</td>
<td>12.5%</td>
<td>7.7%</td>
<td>50%</td>
<td>0%</td>
<td>21.1%</td>
</tr>
<tr>
<td></td>
<td>Elaborated Correction</td>
<td>6.3%</td>
<td>26.9%</td>
<td>14.3%</td>
<td>14.8%</td>
<td>15.8%</td>
</tr>
<tr>
<td>Posed Questions</td>
<td>Unclear questions</td>
<td>9.4%</td>
<td>3.8%</td>
<td>0%</td>
<td>11.1%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Rhetorical questions</td>
<td>0%</td>
<td>7.7%</td>
<td>0%</td>
<td>0%</td>
<td>10.5%</td>
</tr>
<tr>
<td></td>
<td>Factual questions</td>
<td>3.1%</td>
<td>0%</td>
<td>0%</td>
<td>3.7%</td>
<td>10.5%</td>
</tr>
<tr>
<td></td>
<td>Guiding questions</td>
<td>15.6%</td>
<td>7.7%</td>
<td>0%</td>
<td>7.4%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Probing questions</td>
<td>3.1%</td>
<td>3.8%</td>
<td>0%</td>
<td>7.4%</td>
<td>0%</td>
</tr>
<tr>
<td>Praise</td>
<td>Praise of grade</td>
<td>6.3%</td>
<td>3.8%</td>
<td>7.1%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Non-specific praise</td>
<td>12.5%</td>
<td>0%</td>
<td>0%</td>
<td>3.7%</td>
<td>5.3%</td>
</tr>
<tr>
<td></td>
<td>Praise of solution method or use of a mathematical property</td>
<td>6.3%</td>
<td>3.8%</td>
<td>7.1%</td>
<td>7.4%</td>
<td>10.5%</td>
</tr>
<tr>
<td>Precision, syntax, mathematical vocabulary, or organization</td>
<td>Precision, syntax, mathematical vocabulary, or organization</td>
<td>15.6%</td>
<td>30.8%</td>
<td>21.4%</td>
<td>37%</td>
<td>10.5%</td>
</tr>
<tr>
<td>Requesting more information</td>
<td>Requesting more information</td>
<td>6.3%</td>
<td>3.8%</td>
<td>0%</td>
<td>3.7%</td>
<td>0%</td>
</tr>
<tr>
<td>Effort</td>
<td>Effort</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>10.5%</td>
</tr>
<tr>
<td>Uncategorized</td>
<td>Uncategorized</td>
<td>3.1%</td>
<td>0%</td>
<td>0%</td>
<td>3.7%</td>
<td>5.3%</td>
</tr>
</tbody>
</table>

*Note.* The organization of the table reflects participants average beliefs about mathematics scores from the Beliefs Survey. As you move from left to right in the table, participant beliefs about mathematics scores are arranged in increasing order, with Erin F. having the lowest score (4.3) for her beliefs in this area and Tess G. and Alyssa G. having the highest possible scores (6) for their beliefs in this area.
As can be seen in Table 28, Tess G. and Alyssa G. provided the least amount of feedback falling under the category of precision, syntax, mathematical vocabulary, or organization (10.5% and 0%, respectively or 2 comments and 0 comments, respectively). Examples of their specific comments falling under these categories were discussed previously in this chapter. Both of these participants also had the highest possible score (6) for beliefs about mathematics on the Beliefs Survey, indicating they had very strong multidimensional views of mathematics. The participants with the next strongest multidimensional views were Paige F. and Jensen G., both of whom scored a 5.3 for their nature of mathematics beliefs on the administered Beliefs Survey. Jensen G. also provided relatively few comments (the third least) falling into the category of precision, syntax, mathematical vocabulary, or organization. Paige G., however, was the participant to provide the most feedback falling under this category.

Another trend related to beliefs about mathematics can be viewed in participant feedback falling under the “praise of grade” category. Alyssa G. and Tess G, both of whom had the strongest possible multidimensional views of mathematics, provided no feedback that could be interpreted as praising a student’s grade. Of the participants who reported having the next strongest multidimensional views of mathematics, Jensen G. and Paige F., only one (Jensen G.) left a comment that could be viewed as praising a student’s grade. In her comment, she wrote “Great work” next to one student’s overall grade on the homework assignment. Paige F. left no such comments. In addition, the participant with the weakest multidimensional views of mathematics, Erin F., left the most comments classified in this category. Erin F. provided such comments on two student samples where she wrote “You did nice work on this quiz!” next to one student’s final grade and drew a smiling face next to another student’s final grade. This may
indicate that weaker multidimensional views have some relationship to the pre-service teachers providing such fixed mindset comments on their students work.

Finally, most participants with stronger multidimensional views of mathematics also left more feedback that praised a student’s solution method or use of a mathematical property. Such comments are growth mindset in nature (de Kraker-Pauw, 2017; Kamins & Dweck, 1999; Mueller & Dweck, 1998). Alyssa G., Tess G., and Paige F. all left two comments that fell under this category (this comprised of 12.5%, 10.5%, and 7.4%, respectively, of their overall feedback to students). An example of such feedback, taken from Alyssa G.’s feedback samples, dealt with a student’s response to the second cab fare scenario (with the table). Though the student did not answer this question, he/she wrote “x” beside the row labeled “number of ‘clicks’” entry and “y” next to the row labeled “total cab fare.” To the right of the table, the student also wrote, \( \frac{0.50}{10} = 0.05 \) and \( \frac{0.50}{15} = 0.033 \). In her feedback, Alyssa G. praised the student for creating “\( \frac{y}{x} \) ratios” and wrote, “(What does it [the ratio] show?) Are they the same (constant)?”

Jensen G. only left one such comment on the submitted student work samples. Since she provided so little feedback overall, however, this comprised of 7.1% of the overall feedback she left for students. Nellie F., who had weaker multidimensional views about mathematics than did Jensen G. and Paige F., also left a single comment that was categorized as praising a student’s solution method or use of mathematical property. This comment comprised 3.8% of the overall feedback Nellie F.’s provided to her students. From the above described percentages (and number of individual comments) it may be interpreted that those with stronger multidimensional views about mathematics were also more likely to engage in the growth mindset practice of praising a student’s solution method or use of a property. However, Erin F. can be seen as
contradicting this statement, as she had the weakest multidimensional views about mathematics but provided two comments falling under this feedback category (making up 6.3% of her overall feedback to students).

**Research Question 3**

The case studies described above will now be used to address the final research question, exploring the relationship between a pre-service mathematics teacher’s (a) mindset and (b) beliefs about mathematics, and the mindset messages conveyed in the next instructional steps they proposed after analyzing student performance on the assessment from their portfolio.

**Mindset and Next Instructional Steps**

Three participants, Erin F., Jensen G., and Tess G., scored at a Level 1 on SCALE’s (2016a) *Rubric 15*. Such scores indicated that the next instructional steps proposed by these pre-service teachers were likely to convey fixed mindset messages to students. The remaining three participants, Alyssa G., Nellie F., and Paige F., all scored at a Level 3 on SCALE’s (2016a) *Rubric 15*, indicating that their next instructional steps were likely to convey growth mindset messages to their students.

Of the participants that could be seen as conveying fixed mindset messages in their proposed next steps, two self-reported as having the strongest growth mindsets of the group on the Beliefs Survey (Tess G. and Jensen G.). The third participant, Erin F., self-reported as having a fixed mindset on the Beliefs Survey. The remaining participants, Nellie F., Paige F., and Alyssa G., all could be seen as conveying growth mindset messages in their proposed next
instructional steps. Of these participants, only Alyssa G. self-reported as having a growth mindset on the Beliefs Survey. Participant scores for *Rubric 15*, as well as their mindset scores from the Beliefs Survey, can be viewed in Table 29 and Table 30. The tables may indicate that mindset was not strongly related to the mindset messages conveyed in the pre-service teachers’ planned next instructional steps and that fixed mindset participants were more likely to convey growth mindset messages in their next steps than were growth mindset participants.

Table 29. Next Steps Scores and Average Mindset Scores for Fixed Mindset Participants

<table>
<thead>
<tr>
<th>Participant</th>
<th>Average Mindset Score</th>
<th><em>Rubric 15</em> Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nellie F.</td>
<td>3.6</td>
<td>3</td>
</tr>
<tr>
<td>Paige F.</td>
<td>3.7</td>
<td>3</td>
</tr>
<tr>
<td>Erin F.</td>
<td>3.8</td>
<td>1</td>
</tr>
</tbody>
</table>

*Note.* Highlighted entries indicate participants who scored at growth mindset levels of *Rubric 15*.

Table 30. Next Steps Scores and Average Mindset Scores for Growth Mindset Participants

<table>
<thead>
<tr>
<th>Participant</th>
<th>Average Mindset Score</th>
<th><em>Rubric 15</em> Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alyssa G.</td>
<td>5.2</td>
<td>3</td>
</tr>
<tr>
<td>Tess G.</td>
<td>5.5</td>
<td>1</td>
</tr>
<tr>
<td>Jensen G.</td>
<td>5.7</td>
<td>1</td>
</tr>
</tbody>
</table>

*Note.* Highlighted entries indicate participants who scored at growth mindset levels of *Rubric 15*.

All three pre-service teachers who scored at fixed mindset levels on these rubrics provided general (and sometimes vague) statements about how they used their analyses of student performance to shape their instruction in subsequent lessons. In the case of Jensen G., her suggested next steps were not related to the learning objectives, but rather focused students’ arithmetic skills and asking more open-ended questions drawing from other fields of mathematics. Her next steps also did not address the misconceptions students demonstrated on their submitted assessments. Similarly, Tess G. and Erin F.’s suggested next steps did not appear to follow from their analysis of student performance. Tess G.’s suggested next steps consisted of vague statements such as “providing the scaffolding and feedback students need to practice and succeed,” rather than addressing her observation that students had not yet obtained an
understanding of the goal of solving linear inequalities. Erin F.’s steps focus on general statements of creating differentiated assignments and providing more translations for English Language Learners rather than addressing the areas in which she observed that her students struggled, namely combining like terms, factoring using greatest common factor, and knowing when and how to apply the distributive property. By engaging in next steps that did not address student needs, these pre-service teachers failed to use their assessments formatively. Using assessments formatively to move student learning forward is a key component of growth mindset assessment practice (Boaler, 2016). In this study, it appears that a growth mindset was not sufficient in using assessments in this manner, as two of the three growth mindset participants failed to use the assessment formatively.

All three of the pre-service teachers who scored at growth mindset levels on Rubric 15 proposed specific changes, based on their analyses of student performance that would improve student learning with regard to the learning objectives, and that were “not specifically targeted for individual students” (SCALE, 2016b, p. 36). In the case of Alyssa G., her proposed next steps of reviewing definitions related to linear functions using precise language, and creating a “Do Now” to allow students to make connections between various representations of linear functions, were grounded in her observations that students struggled to use mathematical language in their explanations and to connect the tabular and graphical representations to the linear equation of the cab fare scenario. In the case of Nellie F., her proposed next steps focused on providing more scaffolding and open-ended questions (of which she provides specific examples) and were grounded in her observation that students struggled with the broader focus of the application problem. She stated that the questions would help students attack the problem by narrowing their focus and scaffolding the problem. Like Alyssa G. and Nellie F., Paige F. also provided specific
details about her proposed next steps. She stated that in her next lesson, she would provide an error analysis problem addressing students’ struggles with problem 2, dealing with writing equations with no or infinitely many solutions. During this activity, students would be provided with the opportunity to view classmates’ work and discuss what error was made on the assignment. She also provided details as to how she planned to group students based on similar misconceptions. The next steps proposed by Nellie F., Paige F., and Alyssa G. were all grounded in the analysis of student performance on the submitted assessments. Such next steps help to address the needs of their students, possibly sending a growth mindset message that new learning could still be acquired in this area.

In addition to the rubric measures, the author noticed that four of the six participants provided some opportunity for students to resubmit their work on the submitted assessment, a practice that has been found be growth mindset in nature (Sun, 2015). Two of these participants, Erin F. and Paige F., reported as having fixed mindsets on the Beliefs Survey; the other two, Alyssa G. and Tess G., possessed a growth mindset.

**Beliefs About Mathematics and Next Instructional Steps**

Participants beliefs about mathematics scores and Rubric 15 scores may be viewed in in Table 31. The table indicates that only two participants (Alyssa G. and Paige F.) that were scored at levels indicating their next steps conveyed growth mindset messages possessed strong multidimensional views about mathematics. The final participant conveying growth mindset messages in her next steps was Nellie F., who possessed the second weakest multidimensional views about mathematics.
In contrast, Tess G., who also scored as having the strongest possible multidimensional views (6), proposed next steps that were seen as conveying fixed mindset messages to students. Similarly, Jensen G. (who scored as having the same strength of multidimensional views as Paige F.), also proposed next steps conveying fixed mindset messages to students. The final participant to convey a fixed mindset message in her next instructional steps was Erin F., who also had the weakest multidimensional views of mathematics. This may indicate, as was true for mindset beliefs, that beliefs about mathematics were not strongly related to the mindset messages conveyed in the pre-service teachers’ planned next instructional steps.

Table 31. Pre-Service Teacher Beliefs about Mathematics and Next Steps Scores

<table>
<thead>
<tr>
<th>Participant</th>
<th>Average Nature of Mathematics</th>
<th>Rubric 15 Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erin F.</td>
<td>4.3</td>
<td>1</td>
</tr>
<tr>
<td>Nellie F.</td>
<td>4.5</td>
<td>3</td>
</tr>
<tr>
<td>Jensen G.</td>
<td>5.3</td>
<td>1</td>
</tr>
<tr>
<td>Paige F.</td>
<td>5.3</td>
<td>3</td>
</tr>
<tr>
<td>Tess G</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Alyssa G.</td>
<td>6</td>
<td>3</td>
</tr>
</tbody>
</table>

*Note. Highlighted entries indicate participants who scored at growth mindset levels of Rubric 15.*

In relation to the growth mindset practice of allowing students to resubmit work, three of the four participants that provided such opportunities (Paige F., Tess G., and Alyssa G.) possessed very strong multidimensional beliefs about mathematics. This may indicate some relationship between the pre-service teachers’ beliefs about mathematics as influencing their willingness to allow students to resubmit work. Erin F., however, may be seen as a contradiction to this statement, because she was the participant containing the least multidimensional views of the participants and also provided students with an opportunity to resubmit work.
Chapter V
SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

This study sought to explore two belief constructs (mindset and beliefs about mathematics) of pre-service mathematics teachers and the relationship between those beliefs and the mindset messages teachers conveyed to their students in three facets of their assessment practice: (a) planning of an assessment, (b) feedback provided to students on that assessment, and (c) use of student performance on the assessment to inform future instruction. To explore these relationships, eight pre-service teachers completed a Beliefs Survey to determine their mindsets and beliefs about mathematics. Of the initial eight participants, six were selected as the focus of this study. They were selected due to their having the most fixed or most growth mindset views on the Beliefs Survey. All six selected participants possessed multidimensional beliefs about mathematics, though the strength of those beliefs varied. To explore the relationship between beliefs and assessment practices, the researcher obtained permission from the six participants to review an assignment they submitted in their student teaching seminar. The assignment was a portfolio intended to demonstrate the pre-service teachers’ best instructional and assessment practices in their first student teaching placement. The researcher viewed only the final portion of this portfolio, which focused on an assessment of student learning.

In exploring relationships between teacher beliefs and the three areas of assessment practice, the researcher utilized three rubrics developed by SCALE (2016a): Rubric 5, Rubric 12,
Rubric 15. Rubric 5 assessed the extent to which the pre-service teachers’ submitted assessment monitored students’ development of procedural fluency, conceptual understanding, mathematical reasoning, and problem-solving abilities; Rubric 12 assessed the pre-service teachers’ ability to provide focus students with feedback that was specific, and addressed the students’ strengths and/or needs; and Rubric 15 analyzed the next instructional steps that the pre-service teachers proposed based on their analysis of student assessments. The five levels on these rubrics were compared to practices of growth and fixed mindset assessments (as described in the existing mindset research) to determine whether the pre-service teacher’s assessment practices could be seen as conveying a fixed or growth mindset to students (Boaler, 2016; Dweck, 2000; Dweck 2006; Sun, 2015). Relationships between these assessment practices (and rubric scores) were then explored in relation to the pre-service teachers’ self-reported beliefs about mathematics and mindsets (from the Beliefs Survey) in each of the six cases.

In addition to using the SCALE (2016a) rubrics, this study also made use of grounded theory in exploring the feedback preservice teachers provided to students on the submitted assessment samples. Using the method of constant comparison, 14 feedback categories were created:

1. Correction
2. Elaborated correction
3. Unclear questions
4. Rhetorical questions
5. Factual questions
6. Guiding questions
7. Probing questions
8. Praise of grade  
9. Non-specific praise  
10. Praise of a solution method or use of a mathematical property  
11. Precision, syntax, mathematical vocabulary, or organization of work  
12. Requesting more information  
13. Effort  
14. Uncategorized

Upon establishing these categories, the researcher conducted a more thorough analysis exploring the relationship between the categories and the teachers reported (a) mindset and (b) beliefs about mathematics.

Conclusions

Using a case study methodology, this study sought to answer the three research questions. These questions will be discussed in the following sections:

1. What is the relationship between the mindset messages conveyed in an assessment task created by a pre-service mathematics teacher and his/her (a) mindset and (b) beliefs about mathematics?  
2. What is the relationship between the mindset messages conveyed in the feedback a pre-service mathematics teacher provides to students and his/her (a) mindset and (b) beliefs about mathematics?  
3. What is the relationship between the mindset messages conveyed by the next instructional steps proposed by a pre-service teacher (after analyzing student
performance on the assessment) and his/her (a) mindset and (b) beliefs about mathematics?

**Research Question 1 – Assessment**

Research question 1 sought to explore the relationship between the pre-service teachers’ personal beliefs (about mathematics and their mindset) and the mindset messages conveyed in their submitted assessments. Results indicated that pre-service teachers’ beliefs about mathematics and their mindset may have some bearing on the assessment they created. Pre-service teachers with growth mindsets were more likely to create growth mindset assessments that provided students with opportunities to engage with multiple representations of the mathematics content. Similarly, pre-service teachers with the strongest multidimensional views were those who created growth mindset assessments that provided such opportunities for students to engage with multiple representations.

Three of the six pre-service teachers (Alyssa G., Tess G., and Paige F.) in this study scored at levels of *Rubric 5* that indicated they had created assessments conveying growth mindsets to their students. Of those three participants, two reported having growth mindsets on the Beliefs Survey; whereas the third reported having a fixed mindset. In relation to beliefs about mathematics, the three participants that submitted growth mindset assessments were those who possessed the strongest multidimensional beliefs about mathematics. Such a finding may indicate that pre-service teachers’ beliefs about mathematics had a stronger influence on the mindset messages conveyed through their assessments. Jensen G., however, serves as a possible contradiction to this statement, and as an anomaly in this study. While she possessed the strongest growth mindset beliefs and scored as having the same strength of multidimensional
views as did Paige F., Jensen G. did not plan a growth mindset assessment. In fact, throughout this study Jensen G.’s assessment practices proved to be inconsistent with her mindset beliefs and with her multidimensional views of mathematics. This could indicate that there are some other mitigating factors or beliefs at play in the creation of assessments that convey growth or fixed mindsets.

Sun’s (2015) study of the relationship between student and teacher mindset supports this notion of other influential beliefs in teaching for a growth mindset (though not in creating assessments specifically). While the present study seems to support the notion that pre-service teachers’ mindsets and beliefs about mathematics both have some relationship to the assessments created by the teacher, Sun found that teacher mindset did not predict student mindset, often because teachers’ instructional practices were not aligned with their personal mindset. She also concluded that teachers’ beliefs about mathematics predicted student mindset. In addition, teachers’ beliefs about who should have access to challenging mathematics (i.e. access views) “marginally predicted…student mindset” (p. 82). It may be that the pre-service teachers in this study and in Sun’s (2015) study were teaching in ways that were more aligned with their access views and beliefs about mathematics as connected beliefs that were more central (and thus more influential) to their personal belief systems than their mindset (Pajares, 1992; Rokeach, 1972). Such an interpretation would help to explain why Paige F., who had a fixed mindset, was able to plan a growth mindset assessment. It is possible that Paige F.’s access views and beliefs about the nature of mathematics were more central to her belief system, and thus more influential in her assessment planning. Similarly, this interpretation of access views and beliefs about mathematics as connected, more central, beliefs, may also help to explain why Jensen G. consistently exhibited fixed mindset behaviors throughout her assessment practices. It is possible
that she did not possess strong access views to accompany her growth mindset and multidimensional beliefs, and thus these beliefs (mindset and beliefs about mathematics) were less influential in her assessment planning.

In exploring the planned assessments submitted by the six participants the researcher also observed that only three participants (Tess G., Alyssa G., and Paige F.) attempted to have students engage with multiple representations. Two of the participants (Alyssa G. and Paige F.) were able to successfully engage students in reasoning between representations, while the third (Tess G.) had students engage with representations without requiring students to explore their connectedness. Two of these participants possessed a growth mindset and the third possessed a fixed mindset; however, each of these participants possessed the strongest multidimensional beliefs about mathematics of the six participants. This may indicate that a pre-service teacher’s beliefs about mathematics are more strongly related to their attempts at utilizing representations in their assessments. Utilizing representations to explore connections and sense making has been identified as a tactic in creating growth mindset tasks and assessments (Boaler, 2016). So, it may be that all three teachers with strongest multidimensional beliefs about mathematics attempted to create a growth mindset assessment that explored connections between representations; however, one (Tess G.) fell short in doing so.

Though not explored in this study, a factor that may have contributed to Tess G.’s inability to effectively use representations in her assessment could have been due to weak pedagogical content knowledge. Ball, Thames, and Phelps (2008) discuss the importance of pedagogical content knowledge when selecting representations in instruction. They state, “Some representations are especially powerful; others, although technically correct, do not open the ideas effectively to learners” (p. 392). They go on to state that powerful representations are
“informed by content-specific knowledge of student conceptions” and also misconceptions (p. 392). In the case of Tess G., it is possible that her pedagogical content knowledge was not strong enough to support her selection and use of powerful representations in her assessment.

**Research Question 2 – Feedback**

Research question 2 sought to explore the relationship between the pre-service teachers’ personal beliefs (about mathematics and their mindset) and the mindset messages conveyed in the feedback they provided to their students. It was found that, when viewed holistically, pre-service teachers’ mindsets were not always aligned to the mindset messages conveyed through their feedback. However, some relationships were observed when viewing the individual feedback instances provided by the pre-service teachers. Participants with fixed mindsets were more likely to provide feedback related to precision, syntax, mathematical vocabulary, or organization of work, and they provided a greater quantity of feedback to their students overall.

Pre-service teachers’ multidimensional beliefs about mathematics were also found to have some relation to providing overall growth mindset messages in their feedback. In addition, participants with the strongest multidimensional views about mathematics were the least likely to leave feedback praising a student’s grade, and were the most likely to engage in a specific feedback structure: first addressing a student strength (or strengths), and then addressing a student need (or needs).

When viewed holistically, all but one of the participants provided students with feedback that was scored at growth mindset levels on SCALE’s (2016a) *Rubric 12*. Those who scored at growth mindset levels provided feedback that was specific to students’ strengths and/or needs relative to the learning objectives. Such specific feedback, which can be used to further learning,
has been deemed growth mindset in nature (Boaler, 2016). The only participant who did not provide growth mindset feedback was Jensen G. Her feedback pertained more to errors unrelated to the learning objectives and in many cases, did not correct (or even address) student misunderstandings related to the assessed objectives.

When observing specific feedback instances of the pre-service teachers, the researcher observed that those with fixed mindsets were more likely to provide feedback related to precision, syntax, mathematical vocabulary, or organization. This category of feedback captured the more technical aspects of mathematics. While the National Governors Association’s Common Core State Standards Initiative (2010) has highlighted precision (in mathematical vocabulary, syntax, etc.) as one of their eight core Standards for Mathematical Practice, there is still a need to understand when such attention to technical aspects of mathematics becomes pedantry in the eyes of students (Dedò, 2012). It is possible that such acute attention to precision could be categorized as what de Kraker-Pauw, Van Wesel, Krabbendam, and Van Atteveldt (2017) deem “results-oriented” feedback for its hyper focus on correcting student results, rather than the process of learning. They cite results-oriented feedback as “potentially decreasing the results and motivation of students” and should thus be considered fixed mindset in nature⁹ (2017, p. 9). Because those with fixed mindsets were more likely to focus on this type of feedback, their beliefs and practice may be considered aligned in this regard. Concerning beliefs about

To clarify, the author is not arguing that all feedback related to precision, syntax, mathematical vocabulary, or organization should be considered as fixed mindset in nature. However, growth mindset feedback should be formative, keeping student learning in relation to the assessed objectives at the forefront (Boaler, 2016). Such formative feedback that focuses on the learning process has been found to not only convey growth mindsets, but also to be overall more effective for students (Black & Wiliam, 1998; Boaler, 2016; Hattie & Timperly, 2007; Wiliam, 2011).
mathematics, those with the strongest possible multidimensional views (Tess G. and Alyssa G.) left the least feedback related to precision, syntax, mathematical vocabulary, or organization. One possible explanation for this may be that teachers with very strong multidimensional views of mathematics are more focused on the conceptual understanding and reasoning skills of their students than on the more technical aspects of mathematics.

In addition, those with fixed mindsets provided a wider variety of feedback than did growth mindset participants. The three fixed mindset participants provided feedback that fell under 10 (Paige F. and Nellie F.) and 12 (Erin F.) categories. In contrast, the growth mindset participants provided feedback that fell under five (Alyssa G. and Jensen G.) and nine (Tess G.) categories. This greater variety may be due (in part) to the fact that fixed mindset participants provided more feedback overall than did growth mindset participants. Here, the word “more” indicates number of comments, rather than length. While two of three growth mindset participants (Tess G. and Alyssa G.) provided longer, more holistic comments to students, they provided fewer comments throughout the student assignments than did fixed mindset participants. The third growth mindset participant, Jensen G., did not provide holistic comments but also provided far fewer comments than did the three fixed mindset participants. After removing feedback instances that were categorized in multiple categories, it was observed that Jensen G. and Alyssa G. provided 12 individual instances of feedback on their student samples and Tess G. provided 13 individual instances of feedback. In contrast, Nellie F. provided 18 individual instances of feedback, Erin F. provided 25, and Paige F. provided 21. This finding that growth mindset participants provide less feedback than fixed mindset participants has also been observed in at least one other study. In their study of teacher mindset and oral feedback, Kraker-Pauw et al. (2017) also found that teachers with fixed mindsets provided more feedback overall.
than did those with growth mindsets. Concerning this finding, they state, “one explanation could be that teachers with a growth mindset are less inclined to urge their students to achieve more or better, being more likely to appreciate their students' efforts as such” (p. 10).

In viewing the relationship between feedback categories and beliefs about mathematics, the researcher noticed that the two participants with the strongest multidimensional views (Alyssa G. and Tess G.) also left less feedback that could be interpreted as praising a student’s grade on the assignment. These two participants were also the most likely to leave feedback praising a student’s solution method or use of a mathematical property. Educational researchers have found outcome praise (such as praising a student’s grade) to convey and reinforce fixed mindset messages in students, whereas effort and process praise (such as praising a solution method or use of a mathematical property) have been found to convey and reinforce growth mindset messages in students (Kamins & Dweck, 1999; Mueller & Dweck, 1998).

One final observation growing out of this study was related to the structure of feedback that pre-service teachers provided to students. Three of the six participants attempted to provide more holistic feedback to students either at the end of each section or at the end of the students’ assignments. This holistic feedback attempted to address student strengths, followed by a student need (or needs). One participant, Alyssa G., was able to successfully address student strengths and needs through this format. A second, Tess G., was also able to address students’ strengths and needs through this format, but did not always relate those strengths and needs to the learning objectives at hand. Both of these participants reported having growth mindsets and the strongest possible multidimensional beliefs about mathematics. The third participant (Paige F.) was less successful in her attempts at this feedback structure, with only one sample addressing a student strength. Many of Paige F.'s holistic comments were also worded in a critical manner. Paige F.
possessed a fixed mindset and strong (but not the strongest), multidimensional views about mathematics. Alyssa G. and Tess G.’s strong multidimensional beliefs about mathematics coupled with their strong growth mindset orientations may be related to their success in formatting their feedback to better address strengths and needs in this area.

**Research Question 3 – Next Instructional Steps**

Research question 3 sought to explore the relationship between the pre-service teachers’ personal beliefs (about mathematics and their mindset) and the mindset messages conveyed in their next instructional steps, proposed after analyzing student performance on their submitted assessments. As was the case with feedback, it was found that neither pre-service teachers’ beliefs about mathematics nor their mindset seemed strongly related to the overall mindset messages conveyed through their proposed next instructional steps; however, those with stronger multidimensional beliefs about mathematics were more likely to provide students with opportunities to resubmit their assessments.

Three of the six study participants proposed next instructional steps that scored at fixed mindset levels on *Rubric 15*. The next instructional steps proposed by these participants did not attempt to address areas of student weakness identified in the analysis of student performance on the assessment. In failing to address these areas of weakness, a student’s fixed mindset beliefs (that the student was not meant to understand the content) may have been reinforced. Of the three participants who scored at these levels, two reported having growth mindsets (Tess G. and Jensen G.) and one, a fixed mindset (Erin F.). In relation to beliefs about mathematics, one of these participants (Tess G.) reported having the strongest possible multidimensional beliefs about mathematics and another (Erin F.) having the weakest multidimensional views of mathematics.
The final participant to score at a fixed mindset level (Jensen G.) on this rubric fell in the middle range with regard to beliefs about mathematics. These results may indicate that neither beliefs about mathematics nor mindset are strongly related to a pre-service teacher’s proposed next instructional steps. It may, however, be wise to interpret this result with caution. In the portfolio used for data collection, pre-service teachers are asked to describe their next instructional steps as the very last step in compiling their portfolio. By the time pre-service teachers reach this final requirement, they have likely spent countless hours on this assignment. The fact that half of the participants in this study received 1’s on this rubric may be more an indication of their stamina upon reaching this portion of the portfolio.

Another possible explanation for this finding may be that, in general, teachers struggle to determine next instructional steps based on their own examination of student work. A similar result was obtained in a study by Heritage, Kim, Vendlinski, and Herman (2009). In their study, the authors tasked 118 sixth grade teachers with reviewing student responses to assessment tasks related to solving equations, the distributive property, and rational number equivalence. Following their review of student work, the teachers were asked to identify the content assessed, discuss any inferences that could be drawn about the student’s understanding, provide sample feedback to the student, and plan subsequent instructional steps to move the student’s learning forward. It was found that teachers struggled much more in the area of determining next instructional steps than in any of the other areas of formative assessment. More research and professional development may be needed to better support teachers in this area.

Limitations
A number of limitations to this study should be noted. None of the three fixed mindset participants possessed mean scale scores that indicated they were at the most extreme end of the fixed mindset scale and all six participants indicated having multidimensional beliefs about mathematics. The participants of this study also all self-reported on the survey instrument. It is possible that the pre-service teachers engaged in a practice of selecting answers they felt were socially acceptable, rather than those that reflected their true beliefs (Nederhof, 1985). The six participants of this study were enrolled in a teacher preparation program that placed emphasis on high expectations for all students, as well as constructivist, multidimensional teaching methods. It is possible that the participants engaged in this process of social desirability and selected answers reflecting the multidimensional beliefs (and to some extent, growth mindset views) of their graduate program, rather than their own beliefs. Whatever the case, it would be beneficial to conduct a similar study with a larger sample that includes a broader range of beliefs about mathematics, as well as mindsets. In order to generalize (which was not the intent of this study), it would also be beneficial to include in-service mathematics teachers in such a study. This study’s exclusive use of pre-service teachers may be seen as a further limitation, as pre-service teachers are in a stage of development in which their teaching and assessment practices may still be seen as being in their infancy.

Additionally, this study focused on a single assessment for which pre-service teachers submitted three student samples of their choosing. It is possible that the pre-service teachers selected an assessment in which they provided more or better feedback to students than they typically provide. It is also possible that the pre-service teachers submitted the “best” three feedback samples from the larger assessment, leaving very little feedback on the remaining student assignments. Observing more than a single assessment or, at the very least, examining an
entire class set of student samples for an assessment may be beneficial in obtaining richer (and possibly more realistic) data.

Another limitation relates to use of the edTPA rubrics in this study. When using SCALE’s (2016a) edTPA rubrics, the researcher attempted to use existing research on assessment practices conveying growth and fixed mindset to determine rubric levels that would correspond to either growth or fixed mindset assessment practices. The researcher did this to conduct local research on growth and fixed mindset assessment practices, but has done so with caution and is not advocating that others should use the edTPA rubrics in this way. Imposing the research relating to growth and fixed mindset practices onto the edTPA rubrics may have been too restrictive, as they were not created to be used in this manner. In addition, edTPA as a performance assessment remains controversial in the field of education and it is possible that the use of edTPA rubrics in assessing growth and fixed mindset may be viewed as equally controversial. Future research should explore creating a mindset specific framework for use in categorizing assessment practices as either growth or fixed in nature.

In relation to the rubrics, one conflict felt by the researcher was the question of alignment in the rubrics, especially Rubric 12, which focused on the feedback provided by the pre-service teacher. In order to score at a Level 3 on this rubric, the pre-service teacher must provide feedback that addresses student strengths or needs, in relation to the assessed learning objectives. In order to score at a Level 4, the pre-service teacher must provide feedback that addresses both strengths and needs, in relation to the assessed learning objectives. In these rubric levels, the requirement that feedback is directly tied to the assessed learning objectives, may have been too restrictive. The literature on growth mindset does not specify such a restriction, so in reality, Tess G’s feedback, which did address both strengths and needs (but not always in relation to the
learning objectives), may have been more growth mindset in nature than her score of Level 3 indicated. More research is needed to clarify how necessary or related this condition (alignment with the specified learning objectives) is in conveying more growth or fixed mindset messages to students.

Similarly, when using the final rubric, *Rubric 15* (next instructional steps), there was considerably less research to support the rubric levels than was the case for *Rubric 5* and *Rubric 12*. Scholars have identified that using assessment formatively is a growth mindset use of assessment (Boaler, 2016; Masters, 2013). In order to use assessment formatively, the teacher would need to view the assessment as a tool to provide information to the teacher about student learning so that they may plan their next steps accordingly. By using assessment in this way, and addressing student needs through next instructional steps, Boaler (2016) and Master (2013) contend that a growth mindset message is conveyed to students. Aside from this criteria of using assessment formatively, there has been no parsing between the types of next instructional steps that convey fixed or growth mindsets messages. Further research should help to better separate these two ideas and possibly create a specific framework for use in categorizing next instructional steps as either growth or fixed in nature.

Finally, this study sought to explore pre-service teachers’ assessment practices in relation to their beliefs about mathematics and mindsets; however, there may be other factors that influenced the pre-service teachers’ assessment practices. Teachers’ beliefs about the use and nature of assessments in mathematics may differ from their mindsets and beliefs about mathematics as a subject. Future studies may wish to explore this area of beliefs and its relation to assessment practices. Additionally, Assessment 5 was a written assessment. While not all of the analysis relied on students’ written descriptions of their assessment practices, at least one
facet of this study (next instructional steps), relied heavily on the pre-service teachers written communication of their next instructional steps and analysis of student work. It is possible that this writing component had some influence on the ways in which the participants described their assessment practices. Future studies may wish to explore these areas through observations and interviews, as to eliminate the heavy emphasis on students’ written communication.

**Implications and Recommendations**

This study supports the idea that a pre-service teachers’ mindset and the mindset messages conveyed in their assessment practices may not always be aligned, especially in the area of feedback (overall and specific types) and in the planning of next instructional steps (i.e. using assessments formatively). Such results were also obtained in Sun’s (2015) study of teacher mindset and instructional practices. Though Sun’s study found that teachers’ beliefs about mathematics predicted student mindset, this study found that pre-service teachers with multidimensional views of mathematics did not always engage in assessment practices that conveyed growth mindset messages to students. Such misalignment between teacher beliefs and practice has been observed in past research (Raymond, 1997). In the context of past mindset research, this may indicate that while mindset interventions (orienting individuals towards growth mindsets) have been found to be beneficial to students and to increase student achievement, changing teachers’ mindsets with such interventions may not necessarily result in teachers engaging in growth mindset assessment (or instructional) practices. This statement is best illustrated by the case of Jensen G., who possessed the strongest growth mindset and strong multidimensional beliefs about mathematics but was not found to convey growth mindset
messages in any of her assessment practices. Rather than relying on the mindset interventions that have been found effective in changing student mindsets, it may be more beneficial for professional development and teacher training programs to focus on changing teacher beliefs and practice concurrently and to encourage teachers to reflect on both their beliefs and practice (Philipp, 2007). Such reflection may lead pre-service teachers to a greater awareness of when their beliefs and practice are misaligned. Based on the results of this study, it may be beneficial to have such reflection focus on the alignment between beliefs and the mindset messages conveyed in (a) some aspects of feedback and (b) next instructional steps, as these were the areas in which teacher beliefs seemed less aligned to mindset messages conveyed in assessment practices.

In addition to changing pre-service teachers’ beliefs and practice concurrently, it may be beneficial for programs and professional development to explicitly teach educators how to incorporate growth minded practices in their instruction and assessment. The present study suggests that pre-service teachers may design assessments that are more or less aligned with their beliefs about mathematics and mindsets, but the same cannot be said about the feedback they provide to students nor their planning of next instructional steps. These two areas of assessment also convey mindset messages to students (Boaler, 2016), so providing pre-service teachers with training in how to convey growth mindset messages through these assessment practices would be beneficial. This need for more explicit training in ways to incorporate growth mindset practices is supported by a recent survey administered by the Education Week Research Center (2016) to a sample of over 600 teachers nationwide. On this survey, 98% of respondents agreed that “using growth mindset in the classroom will lead to improved student learning” and the majority reported attempting to use teaching practices consistent with fostering growth mindsets (p. 3).
However, a mere 20% reported feeling confident in their abilities to foster growth mindsets in students and 85% indicated wanting more professional training on how to implement growth mindset principles in their classrooms.

With regard to feedback, it may be beneficial for such professional training to provide teachers with specific examples of feedback from the 14 feedback categories created for this study and discuss how such comments convey growth or fixed mindset messages to students. While there are current, general examples of the types of feedback that convey growth mindset messages (process or effort-based feedback) or fixed mindset messages (outcome or personal feedback), providing more content specific examples, such as those from the 14 feedback categories in this study, may be beneficial to support teachers in their implementation of growth mindset feedback. For example, pre-service teachers may benefit from viewing specific feedback examples from the categories of “correction” and “elaborated correction,” examining the differences between the two categories and exploring why a simple correction may convey a fixed mindset message and how elaborating on that correction (to extend student learning) may convey a growth mindset message. It may also be useful to have pre-service teachers compare how feedback in the “correction” category positions a student versus how the “probing” or “guiding” questions categories position a student. In the “correction” category the learner is positioned as more a receiver of the teachers’ knowledge of facts or procedures (conveying a fixed mindset message) whereas feedback posed as guiding or probing questions position the student as an active participant in their own learning process (conveying a growth mindset message). Pre-service teachers may then find it beneficial to engage in exercises of changing corrective feedback into probing or guiding questions that will move students learning forward.
It may also be helpful to use the feedback categories created in this study to explore how the categories that could not be classified (as growth or fixed) convey growth or fixed mindset messages to students. The categories that were categorized as neither fixed nor growth include: unclear questions, rhetorical questions, factual questions, non-specific praise, technical feedback (related to precision, syntax, mathematical vocabulary, or organization), and requesting more information. It is possible that some of these categories convey more growth or fixed mindset messages to students, even though they could not be classified as such in this study. It is also possible that there is a threshold for certain types of feedback as conveying more growth or fixed mindset messages to students. For example, it was previously mentioned that an acute attention to the technical aspects of a student’s work may be seen as pedantic in the eyes of students, thus conveying a fixed mindset message. Future research may wish to better understand at what point this type of feedback moves from constructive (and maybe more growth mindset in nature) to overly critical (and more fixed mindset in nature). A similar investigation for the other feedback categories may prove useful as well.

Moreover, future research may wish to explore why misalignment between beliefs and practice occurs. It is possible that while teachers possess growth mindsets about their students’ intelligence and abilities, they do not hold the same growth mindset about their own competencies. Such an explanation is plausible, given that individuals have been found to possess different mindsets in relation to various attributes or skills (e.g., you may believe that everyone can develop their mathematics skills, but musical talent is fixed) (Elliot, Dweck, & Yeager, 2017). Another possible explanation is that the pre-service teachers’ content knowledge or pedagogical content knowledge is too weak to engage in some growth mindset assessment practices (as was previously speculated in the case of Tess G. and her use of representations).
Future studies may seek to explore these areas in order to provide a more connected view of the interactions between beliefs, practice, and teacher knowledge. Gaining such insight will aid teacher preparation programs and those organizing professional development with a more holistic picture of supporting the development of both pre- and in-service teachers in teaching for a growth mindset.
REFERENCES


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Appendix A: SCALE’s Rubric 5

### Rubric 5: Planning Assessments to Monitor and Support Student Learning

<table>
<thead>
<tr>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
<th>Level 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>The assessments only provide evidence of students’ procedural skills and/or factual knowledge. OR Candidate does not attend to ANY ASSESSMENT requirements in IEPs and 504 plans.</td>
<td>The assessments provide limited evidence to monitor students’ conceptual understanding, procedural fluency, <strong>AND</strong> mathematical reasoning and/or problem-solving skills during the learning segment.</td>
<td>The assessments provide evidence to monitor students’ conceptual understanding, procedural fluency, <strong>AND</strong> mathematical reasoning and/or problem-solving skills during the learning segment.</td>
<td>The assessments provide multiple forms of evidence to monitor students’ progress toward developing conceptual understanding, procedural fluency, <strong>AND</strong> mathematical reasoning and/or problem-solving skills throughout the learning segment.</td>
<td>Level 4 plus: The assessments are strategically designed to allow individuals or groups with specific needs to demonstrate their learning.</td>
</tr>
</tbody>
</table>
Appendix B: Email Recruiting Participants

Hi [insert name],

I hope this email finds you well. As part of my doctoral dissertation, I am conducting a study to investigate the influence of a pre-service teacher’s mindset on pedagogical practice. I would be very interested in, and greatly appreciate, your participation in this study. If you should decide to participate, I would ask you to complete the attached mindset survey (8 questions) and also to grant me permission to access and use Part 3 of the Assessment 5 bundle you submitted in your first semester of student teaching. As you have already completed your student teaching placements and grades have been submitted and are final, participation or non-participation will in no way impact your grade for Dr. [redacted]’s course. If you are willing to participate in this study, please read over, complete, and return the attached mindset survey, as well as the informed consent/participants right form. If you have any questions or concerns about participating in this study, please feel free to email me at bew2126@tc.columbia.edu.

Best,
Brandie Waid
### Appendix C: Dweck (2000) Mindset Survey

1. A person has a certain amount of intelligence, and they can't really do much to change it.
   - Strongly Agree
   - Mostly Agree
   - Mostly Disagree
   - Strongly Disagree

2. A person’s intelligence is something about them that they can't change very much.
   - Strongly Agree
   - Mostly Agree
   - Mostly Disagree
   - Strongly Disagree

3. No matter who they are, a person can significantly change their intelligence level.
   - Strongly Agree
   - Mostly Agree
   - Mostly Disagree
   - Strongly Disagree

4. To be honest, a person can't really change how intelligent they are.
   - Strongly Agree
   - Mostly Agree
   - Mostly Disagree
   - Strongly Disagree

5. A person can always substantially change how intelligent they are.
   - Strongly Agree
   - Mostly Agree
   - Mostly Disagree
   - Strongly Disagree

6. A person can learn new things, but they can't really change their basic intelligence.
   - Strongly Agree
   - Mostly Agree
   - Mostly Disagree
   - Strongly Disagree

7. No matter how much intelligence they have, a person can always change it quite a bit.
   - Strongly Agree
   - Mostly Agree
   - Mostly Disagree
   - Strongly Disagree

8. A person can change even their basic intelligence level considerably.
   - Strongly Agree
   - Mostly Agree
   - Mostly Disagree
   - Strongly Disagree
Appendix D: Beliefs Survey

1. In your class(es), when grouping students how often do you group students by math skill or ability level?
   
   All of the time  Regularly  Occasionally  Rarely  Never
   (100% of the time) (around 80% of the time) (around 50% of the time) (less than 20% of the time)

2. How often do you allow students to resubmit tests for a regrade?
   
   All of the time  Regularly  Occasionally  Rarely  Never
   (100% of the time) (around 80% of the time) (around 50% of the time) (less than 20% of the time)

3. How often do you allow students to resubmit assignments (e.g., classwork, homework) for a regrade?
   
   All of the time  Regularly  Occasionally  Rarely  Never
   (100% of the time) (around 80% of the time) (around 50% of the time) (less than 20% of the time)

4. How often do you publicly discuss an individual student’s mistakes in front of the whole class?
   
   All of the time  Regularly  Occasionally  Rarely  Never
   (100% of the time) (around 80% of the time) (around 50% of the time) (less than 20% of the time)

5. How often do you give different assignments to different students based on achievement or ability?
   
   All of the time  Regularly  Occasionally  Rarely  Never
   (100% of the time) (around 80% of the time) (around 50% of the time) (less than 20% of the time)

6. Most of my students are ready for the kind and level of math instruction that I am expected to teach.
   
   Strongly Agree  Mostly Agree  Mostly Agree  Mostly Disagree  Strongly Disagree

7. A person has a certain amount of intelligence, and they can’t really do much to change it.
   
   Strongly Agree  Mostly Agree  Mostly Disagree  Strongly Disagree
8. When grading student work, students’ reasoning and process should be given more value (e.g., points) than whether they get the right answer.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Mostly Agree</th>
<th>Mostly Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

1. In math class there will always be some students who simply won’t “get it.”

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Mostly Agree</th>
<th>Mostly Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

2. A person’s intelligence is something about them that they can't change very much.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Mostly Agree</th>
<th>Mostly Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

3. For my students, making mistakes in front of the class is humiliating.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Mostly Agree</th>
<th>Mostly Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

4. Mathematics involves mostly facts and procedures that have to be learned.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Mostly Agree</th>
<th>Mostly Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

5. No matter who they are, a person can significantly change their intelligence level.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Mostly Agree</th>
<th>Mostly Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

6. All of my students would be good at math if they worked hard at it.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Mostly Agree</th>
<th>Mostly Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

7. There is usually only one way to solve a math problem.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Mostly Agree</th>
<th>Mostly Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

8. To be honest, a person can’t really change how intelligent they are.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Mostly Agree</th>
<th>Mostly Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

9. There are limits to how much people can improve their basic math ability.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Mostly Agree</th>
<th>Mostly Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

169
10. Some students are not going to make a lot of progress this year, no matter what I do.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Mostly Agree</th>
<th>Mostly Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

11. A person can always substantially change how intelligent they are.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Mostly Agree</th>
<th>Mostly Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

12. In mathematics, answers are either right or wrong.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Mostly Agree</th>
<th>Mostly Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

13. Discussing students’ errors with the class is a good strategy for enhancing students’ understanding.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Mostly Agree</th>
<th>Mostly Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

14. A person can learn new things, but they can't really change their basic intelligence.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Mostly Agree</th>
<th>Mostly Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

15. In my class(es), students who start the year low performing tend to stay relatively low performing at the end of the year.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Mostly Agree</th>
<th>Mostly Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

16. Students who really understand math will have a solution quickly.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Mostly Agree</th>
<th>Mostly Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

17. No matter how much intelligence they have, a person can always change it quite a bit.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Mostly Agree</th>
<th>Mostly Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

18. You have a certain amount of math intelligence, and you can’t really do much to change it.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Mostly Agree</th>
<th>Mostly Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

19. Mistakes are important when learning math.
<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Mostly Agree</th>
<th>Mostly Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>20. Some students have a knack for mathematics and some just don’t.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strongly Agree</td>
<td>Agree</td>
<td>Mostly Agree</td>
<td>Mostly Disagree</td>
<td>Disagree</td>
<td>Strongly Disagree</td>
</tr>
<tr>
<td>21. A person can change even their basic intelligence level considerably.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strongly Agree</td>
<td>Agree</td>
<td>Mostly Agree</td>
<td>Mostly Disagree</td>
<td>Disagree</td>
<td>Strongly Disagree</td>
</tr>
<tr>
<td>22. How important is it for students to acquire basic math skills before engaging in complex conceptual math problems?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extremely Important</td>
<td>Very Important</td>
<td>Somewhat Important</td>
<td>Of Very Little Importance</td>
<td>Not at All Important</td>
<td></td>
</tr>
<tr>
<td>23. How important is it for students to avoid making mistakes in math class?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extremely Important</td>
<td>Very Important</td>
<td>Somewhat Important</td>
<td>Of Very Little Importance</td>
<td>Not at All Important</td>
<td></td>
</tr>
<tr>
<td>24. How important is it for teachers to use technology when teaching math?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extremely Important</td>
<td>Very Important</td>
<td>Somewhat Important</td>
<td>Of Very Little Importance</td>
<td>Not at All Important</td>
<td></td>
</tr>
<tr>
<td>25. When learning math, how important is it that students are placed into math classes according to their math achievement (ability group)?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extremely Important</td>
<td>Very Important</td>
<td>Somewhat Important</td>
<td>Of Very Little Importance</td>
<td>Not at All Important</td>
<td></td>
</tr>
<tr>
<td>26. In math class, how important is it to get the right answer?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extremely Important</td>
<td>Very Important</td>
<td>Somewhat Important</td>
<td>Of Very Little Importance</td>
<td>Not at All Important</td>
<td></td>
</tr>
<tr>
<td>27. When motivating students in your math class, how important is it to publicly recognize the highest performing student(s)?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extremely Important</td>
<td>Very Important</td>
<td>Somewhat Important</td>
<td>Of Very Little Importance</td>
<td>Not at All Important</td>
<td></td>
</tr>
</tbody>
</table>
1. **Describe an assessment** that you used to evaluate your students’ developing knowledge and skills. Identify the specific standards/objectives from the lesson plans that were measured by the assessment you have identified. [Background info for Rubric 11]

2. **Provide the evaluation criteria** you will use to analyze student learning. Your evaluation criteria should align with and measure the outcomes of the learning segment you selected and address the subject specific emphasis of the segment. [Background info for Rubric 11]

3. Collect and analyze student work to identify quantitative and qualitative patterns of learning with and across learners in the class. **Provide a graphic (table or chart) or narrative summary** of student learning for your whole class based on the evaluation criteria described above. [Rubric 11]

4. Select 3 work samples to illustrate your analysis of the patterns of learning. These students will be your focus students for this task. At least one of the students must have specific learning needs, for example, a student with an IEP (Individualized Education Program) or 504, an English language learner, a struggling reader, an underperforming student or a student with gaps in academic knowledge, and/or a gifted student needing greater support or challenge. Use evidence found in the 3 student work samples and the whole class summary to **analyze the patterns of learning** for the class as a whole and the similarities/differences for groups or individual learners relative to conceptual understanding, procedural fluency, and reasoning and/or problem solving skills. [Rubric 11]

5. **Document the feedback** you gave to each of the 3 focus students either on the work sample itself or via the video clip. Note: For this prompt you simply need include copies (graphic, scanned document, or time stamps from video clip) of the feedback you gave to your three sample students. [Rubric 12]

6. **Describe** how the feedback you provided to the three focus students addresses their individual strengths and needs relative to the standards and objectives that are measured. How will you support each focus student to apply the feedback to guide improvement, either within the learning segment or at a later time? [Rubrics 12 and 13]

7. **Provide** evidence of students’ understanding and use of academic language. Evidence may come from the 15 minute video clip and/or from student work samples. **Explain** the extent to which your students were able to use academic language (those identified in Section 4 of Part I of your bundle) to develop content understandings. [Rubric 14]

---

10 Prompts 7 will not be analyzed for this dissertation
8. **Describe** how your analysis of student learning informed your instruction in subsequent lessons. Your description of instruction should include the next steps in instruction for the whole class, for the 3 focus students, and for other individuals or groups with special needs. Include in your explanation appropriate reference to principles from research or theory that support a standards-based approach to teaching and learning. [Rubric 15]
## Appendix F: Participant Feedback Tables

### Category: Probing Questions

<table>
<thead>
<tr>
<th>Feedback</th>
<th>Name</th>
<th>Mindset (as reported on Beliefs Survey)</th>
<th>Other Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Context:</strong> For the second question, the question with the table, the student wrote “Yes this table represent the cab fares correctly because it has constant rate of change. This not proportional because the table shood [sic] be started from 0/0.”</td>
<td>Alyssa</td>
<td>Growth</td>
<td>None</td>
</tr>
<tr>
<td><strong>Feedback:</strong> In response to the table not being proportional, the teacher wrote “Correct! Why should that tell us that it is a non-proportional relationship?” She also wrote a check mark next to the response.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Context:</strong> For the written scenario, where the equation $y = 0.50x + 2.50$ was given, the student wrote “it not proportional because it not going the oringing.”</td>
<td>Alyssa</td>
<td>Growth</td>
<td>None</td>
</tr>
<tr>
<td><strong>Feedback:</strong> The teacher wrote “That’s right! How do you know? What would the equation look like if it did go through the origin?”</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Context:</strong> For the second scenario (with the table), the student wrote arrows between each entry for “number of ‘clicks’” and wrote +5 above each arrow to show a change of 5 clicks between each entry. The student also drew arrows between each entry for “total cab fare” and wrote +2 to indicate a change of $2 between each entry. The student then included the following response “The table doesn’t represent the cab fares correctly because the cab fares have to increased by $0.40 but on the table the cab fares increased by $2.00. Also the table doesn’t represent a proportional relationship because the number represent ‘x’ and the total cab fares represent ‘y’. The y-intercept is b=2.50 so it doesn’t go through the origin [sic].”</td>
<td>Alyssa</td>
<td>Growth</td>
<td>None</td>
</tr>
<tr>
<td><strong>Feedback:</strong> To address the second portion of the student’s response (about the y-intercept and origin), the teacher wrote “How do you know that the y-intercept is $2.50$ from the table? How does ‘the number represent ‘x’ and the total fare represent ‘y’’ help you?”</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Context:</strong> For the written scenario, where the equation $y = 0.50x + 2.50$ was given, the student wrote “This represent a nonproportional because this not starts from 0/0.”</td>
<td>Alyssa</td>
<td>Growth</td>
<td>None</td>
</tr>
<tr>
<td><strong>Feedback:</strong> The teacher wrote “That’s right! But: 1) How do you know that based on the equation? 2) How does it tell you that the relationship is non-proportional?”</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Context: For the final portion of the exit ticket (the graph), the student wrote “Yes because this shows constant rate of change. No because the line not started from the origin.”

Feedback: In response to the first sentence, the teacher wrote an arrow to what she had written in the last question about rate of change and comparing it to the equation. She also wrote “look at the previous part for same explanation.” In response to the previous part, the teacher had written “You’re right that it represents the cab fares correctly, but how does the ‘constant rate of change’ tell you this? Instead can we check the table with the equation? How? What do the, ‘number of clicks’ represent? X or y values? What does the ‘total cab fare’ represent? The x or y values? How can we check them in our original equation?”

Context: Student originally wrote $-\frac{150+\text{unclear number} -192}{-32} = \frac{-150+8}{-32} = \frac{-142}{-32} = 4.44.$

Feedback: Next to the box provided for the student to put their equation, work, and final answer, the teacher wrote “It looked like you used the formula correctly but then erased part of it. What made you change your mind? Also, consider the discriminant you obtained. How many solutions should that give you, and how many did you get?”

Context: For the second question, the question with the table, the student wrote “Yes this table represent the cab fares correctly because it has constant rate of change. This not proportional because the table should be started from 0/0. “

Feedback: In response to the table correctly representing the cab fare, the teacher wrote “You’re right that it represents the cab fares correctly, but how does the ‘constant rate of change’ tell you this? Instead can we check the table with the equation? How? What do the, ‘number of clicks’ represent? X or y values? What does the ‘total cab fare’ represent? The x or y values? How can we check them in our original equation?”

Context: For the written scenario, where the equation $y = 0.50x + 2.50$ was given, the student wrote “This doesn’t represent a proportional relationship because the equation also includes the y-intercept. If we were to a graph this equation wouldn’t pass through the origin. And we know that if a street line doesn’t go through the orgin that is a non-proportional relationship.”

Feedback: Below the problem, the teacher wrote “I like your clear explanation. You explained well why a y-intercept ≠ 0 shows us that the relationship is non-proportional.” And then below that wrote “Consider: does a proportional relationship have a y-intercept? If yes, what is it? And why do we ‘ignore’ it?”

Context: Problem #11 gives the shape of a trapezoid with top edge having length $w+2$, bottom edge length 6, and left and right edges of length 4. The question asks the student to write the perimeter of the trapezoid as a simplified expression. The student only writes “$w+16$” (shows no work at all) as an answer.
**Feedback:** The teacher wrote “great! How did you know what to simplify? What is the way to find perimeter”

**Context:** For problem 3, the student set the parallel sides equal to each other to obtain the equation $2x + 17 = 6x + 9$ and correctly solved for $x$, then he used his solution of $x=2$ to find the area. He writes $12 + 9 \cdot 8 - 1$. Below that he writes $= 21 \cdot 7$. Below that he writes:

\[
\begin{align*}
\frac{21}{7} \\
147
\end{align*}
\]

He indicates no operations for this.

**Feedback:** The teacher wrote, “Is this an accurate way to express your work? What numerical answer would you get if you used the PEMDAS rule?”

**Context:** For problem 3, the student set the parallel sides equal to each other to obtain the equation $2x + 17 = 6x + 9$ and correctly solved for $x$. The student then wrote $A = l \cdot w$ $A = 4(2) - 1 \cdot 6(2) + 9$

$A = 8 - 1 \cdot 12 + 9$

$A = 7 \cdot 21$

$A = 147$

**Feedback:** In response to the $A = 4(2) - 1 \cdot 6(2) + 9$, the teacher writes “Is this an accurate way to express length and width? What numerical answer would you get if you followed PEMDAS?”

**Category: Guiding Questions**

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<tbody>
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<td>Growth</td>
<td>Praise of a Solution Method</td>
</tr>
<tr>
<td><strong>Feedback:</strong> The teacher wrote “I like your $\frac{y}{x}$ ratios. Nice Work! (what does it show?) Are they the same (constant)?”</td>
<td>Alyssa</td>
<td>Growth</td>
<td>None</td>
</tr>
<tr>
<td><strong>Context:</strong> The student did not answer the third portion of the exit ticket (with the graph).</td>
<td>Alyssa</td>
<td>Growth</td>
<td>None</td>
</tr>
<tr>
<td><strong>Feedback:</strong> The teacher wrote “What would a proportional linear relationship look like on a graph? Is this graph the same? What would that tell you?”</td>
<td>Alyssa</td>
<td>Growth</td>
<td>None</td>
</tr>
<tr>
<td>Context</td>
<td>Alyssa</td>
<td>Growth</td>
<td>Probing Question</td>
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<tr>
<td>Context: For the bonus the student wrote “The discriminant of zero would mean there is one solution because we are using the zpp to get equal to the quadratic”…I’m assuming zpp means zero product property.</td>
<td>Nellie</td>
<td>Fixed</td>
<td>Elaborated Correction</td>
</tr>
<tr>
<td>Feedback: “We use zpp when factoring. Why does this not apply to the quadratic formula?”</td>
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<tr>
<td>Context: For problem 12, the student is given the formula to convert from C to F, ( F = (C \cdot 1.8) + 32 ) and asks the student to find temp, in F, of water that is 10 degrees C. The student only writes a question mark.</td>
<td>Erin</td>
<td>Fixed</td>
<td>Elaborated Correction</td>
</tr>
<tr>
<td>Feedback: The teacher underlines the words “10 degrees Celsius” in the problem and writes “what does this mean?” and “what does the formula tell us to find? What does C mean here? Do we know/are we given a value for C?”</td>
<td></td>
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<tr>
<td>Context: Student originally wrote ( \frac{-150 + \sqrt{150^2 - 4(1)(-192)}}{2(1)} = \frac{-150 + \sqrt{150^2 - 4(-192)}}{-2} = \frac{-150 + 150}{-2} = \frac{0}{-2} = 4.44. )</td>
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<td>Fixed</td>
<td>Probing Question</td>
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<td>Growth</td>
<td>Probing Question</td>
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<td>Context: Problem 13 gives the student the following word problem: “You and three friends go to a baseball game. You each</td>
<td>Erin</td>
<td>Fixed</td>
<td>None</td>
</tr>
</tbody>
</table>
pay $2 for a drink and $x dollars for nachos. A. Use the Distributive Property to write and simplify an expression for the total the group pays. B. How much does the group pay when the nachos cost $3?"

For (a), the student only writes:
\[
3(2 + x) \\
6 + 3x
\]

For (b), the student only writes:
\[
6 + 9 \\
15
\]

**Feedback:** In response to (a), the teacher writes “how many people in total are going to the game? How do we know?”

**Context:** Problem 13 gives the student the following word problem: “You and three friends go to a baseball game. You each pay $2 for a drink and $x dollars for nachos. A. Use the Distributive Property to write and simplify an expression for the total the group pays. B. How much does the group pay when the nachos cost $3?”

For (a), the student only writes “2x” and for (b), the student only writes “3x”

**Feedback:** The teacher wrote the following questions (all direct quotes):
1. How many people go to the game?
2. What are you buying?
3. Can we create an algebraic expression to show what we buy?
4. Can we use a special property to show that each person buys the same thing?

**Context:** For the second scenario (with the table), the student wrote arrows between each entry for “number of ‘clicks’” and wrote +5 above each arrow to show a change of 5 clicks between each entry. The student also drew arrows between each entry for “total cab fare” and wrote +2 to indicate a change of $2 between each entry. The student then included the following response “The table doesn’t represent the cab fares correctly because the cab fares have to increased by $0.40 but on the table the cab fares increased by $2.00. Also the table doesn’t represent a proportional relationship because the number represent ‘x’ and the total cab fares represent ‘y’. The y-intercept is b=2.50 so it doesn’t go through the origin.”

**Feedback:** To address the first part of the student’s response (about it not representing the situation), the teacher wrote “You’re absolutely right that the table is increasing the y-values by 2.00 instead of 0.40 but what is x values increasing by? What is the slope/m? Is it 2.00? or 0.40?”

**Context:** For problem 12, the student is given the formula to convert from C to F, \( F = (C \cdot 1.8) + 32 \) and asks the student to find temp, in F, of water that is 10 degrees C. The student writes “10 + (C \cdot 1.8) + 32” as their answer. This is all that is written.

**Feedback:** “What is the given formula asking us to do? Do we know what C equals? Celsius = C = ? Can we use substitution?”

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<thead>
<tr>
<th>Context</th>
<th>Fixed</th>
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<tbody>
<tr>
<td>Erin</td>
<td>Growth</td>
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<tr>
<td>Alyssa</td>
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<td>Correction</td>
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**Context:** For problem 3, the student wrote $2x + 17 + 6x + 9 = \text{(that’s not a typo, she didn’t set it equal to anything).}$ She then subtracted $2x$ from the $2x$ and $6x$ and wrote $17 + 8x + 9$. Then she added $9$ to $17$ and to $-9$. Below this work she wrote $26 = 8x$. Then she divided both sides by $8$ to get $x = 3.25$. She then tried to check her work by doing $A = l \cdot h$ then wrote $3.25 \cdot 4x - 1$. It looks like she tries to subtract $1$ from $3.25$ and then wrote $2.25$ below $3.25$. Here she stopped.

**Feedback:** At the bottom of the page the teacher wrote “What idea are you using to find the value of $x$? What is the property of a rectangle that you can use to setup an equation? How can you express the area of the rectangle using the algebraic expressions given?”

**Context:** For problem 2, the student wrote “change 5 to 0 and 9, 3, 3” but then crossed it out. Below that the student wrote $5 + 2x = 5 + 2x$, she subtracted $5$ from both sides to obtain $2x = 2x$ and then divided both sides by $2x$ to get and answer of $x$.

**Feedback:** Paige drew an arrow next to the work that shows division by $2x$ and says “What is the result of this operation? If the ‘left hand side’ and ‘right hand side’ are equal to each other, what does this mean for the value of $x$?”

**Context:** Problem 9 asks students to factor the expression $24 - 9$ using the GCF. The student wrote:

**Feedback:** The teacher wrote “once you found $3$ as the GCF, what can you do with it? What does it actually mean, GCF?” She also wrote:

**Category: Factual Questions**

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<tbody>
<tr>
<td><strong>Context:</strong> In the bottom right box, the students wrote “the solution is positive 6”</td>
<td>Tess</td>
<td>Growth</td>
<td>Elaborated Correction</td>
</tr>
<tr>
<td><strong>Feedback:</strong> The teacher wrote “when solving an inequality, we have more than one solution. Since $x &gt; 6$, any number greater than $6$ can satisfy the inequality.” Under this she wrote (boxed in red)“ can the solution be $6$?” and then an arrow to the</td>
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</tbody>
</table>
comment “resubmit the answer to this question by tomorrow to receive credit for this portion”

<table>
<thead>
<tr>
<th><strong>Context:</strong> In the top right box, the students provided the following graph</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Graph Image" /></td>
</tr>
<tr>
<td><strong>Feedback:</strong> Next to the graph the teacher wrote “Good job not shading in the circle. In what direction should we draw a line to represent all possible solutions?”</td>
</tr>
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<td>Tess</td>
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<th><strong>Context:</strong> Problem #11 gives the shape of a trapezoid with top edge having length $w+2$, bottom edge length 6, and left and right edges of length 4. The question asks the student to write the perimeter of the trapezoid as a simplified expression. The student only writes “$w+16$” (shows no work at all) as an answer.</th>
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<td><strong>Feedback:</strong> she wrote “great!” to signal success but then commented on students lack of work by saying “How did you know what to simplify? What is the way to find perimeter”</td>
</tr>
<tr>
<td>Erin</td>
</tr>
</tbody>
</table>

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<tr>
<th><strong>Context:</strong> For problem 2, the student selects “no solution” and writes that $5 + 2x = 15 + 4x$ should be changed to $5 + 4x = 15 + 4x$ by adding two more question mark boxes on the left. The student then crossed out the 4x’s and shows that 5 does not equal 15, so there is no solution.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Feedback:</strong> For the suggestion of “add two more ?? on the left” the teacher writes “is there a math term that you can use to describe ‘?’”</td>
</tr>
<tr>
<td>Paige</td>
</tr>
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<tr>
<td><strong>Context:</strong> In the bottom left box, the students wrote (only black pen is what the student wrote): <img src="image2.png" alt="Equation Image" /></td>
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<tr>
<td>Tess</td>
<td>Growth</td>
<td>None</td>
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<tr>
<td><strong>Feedback:</strong> The teacher circled the equals sign and wrote “what happened to the inequality symbol?”</td>
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<th><strong>Context:</strong> It was unclear where the students solutions were located.</th>
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<tr>
<td><strong>Feedback:</strong> “Where are your solutions?”</td>
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<tr>
<td>Nellie</td>
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<th><strong>Context:</strong> overall note to students</th>
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<td><strong>Feedback:</strong> “Group #16, great job checking your work and substituting 7 in for x. I see that you originally substituted in 6</td>
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<td>Tess</td>
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**Category: Rhetorical Questions**

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<td>Tess</td>
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</table>
and discovered that 6 wouldn’t work. If that’s the case, how can the solution be 6? Please take a look at the given inequality symbol to determine where the error exists. If you resubmit the question boxed in red by tomorrow, you will receive full credit for that portion of the graphic organizer.”

**Context:** Problem 7 asks the student to simplify the expression $2(6 + 3n) - 4$. The student writes:

$$
26 + 13n - 4 \\
12 + 13n - 4
$$

**Feedback:** The teacher writes “where does 13n come from?”

<table>
<thead>
<tr>
<th>Context: Unclear Questions</th>
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<td>Paige</td>
<td>Fixed</td>
<td>None</td>
<td></td>
</tr>
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<td><strong>Feedback:</strong> Next to the $3.25 \cdot 4x - 1$, the teacher wrote “what does this expression represent?”</td>
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</tr>
<tr>
<td><strong>Context:</strong> For problems 9 and 10 the student is asked to factor given expressions using the GCF. For problem 9, which has the student factor $24 - 9$, the student wrote $3(8 - 3)$. For problem 10, $14x + 63$, the student wrote $7(2x + 9)$</td>
<td>Erin</td>
<td>Fixed</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td><strong>Feedback:</strong> Next to these she wrote “how can you use the GCF to find these answers?”</td>
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<tr>
<td><strong>Context:</strong> For problem 1, the student set up the equation as $5 + 2w = 3 + 3 + 9 + 4w$. The student’s work is set up in a clear manner and arrives at the correct solution of $? = -5$.</td>
<td>Paige</td>
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<td><strong>Feedback:</strong> “Great! Is there another way to express the right hand side of the equation? Can we use parenthesis? Any grouping ideas?”</td>
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<td>Paige</td>
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<td><strong>Feedback:</strong> Paige writes “Great! Is there another way to express the right hand side of the equation. What if you grouped the blocks together? Any multiple groups of blocks that can use the same expression?”</td>
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<tr>
<td><strong>Context:</strong> Problem 8 asks the student to simplify the expression $5a + 7 - 3a - 2$. The student writes: $9 - 2a$</td>
<td>Erin</td>
<td>Fixed</td>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>
**Feedback:** The teacher writes “can we combine the 5a and 2? Why or why not?”

**Context:** Problem 10 asks students to factor the expression $14x + 63$ using the GCF. The student wrote (the student did not write the x):

\[10. \quad 14x + 63 \]

\[\text{Feedback:} \quad \text{The teacher wrote “what would } x \cdot x \text{ give us? What would, say, } 9 \cdot 9 \text{ mean?”}

**Context:** Student originally wrote $\frac{-150 + \sqrt{62}}{-32} = \frac{-150 \pm 8}{-32} = \frac{-142}{-32} = 4.44$.

**Feedback:** She circled the unclear number and drew an arrow to the 64 with a question mark. Above this she wrote “what happened to $b^2$?”

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**Category: Praise of a solution method or use of a mathematical property**

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<td>Growth</td>
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<td><strong>Context:</strong> For the written scenario, where the equation $y = 0.50x + 2.50$ was given, the student wrote “This doesn’t represent a proportional relationship because the equation also includes the y-intercept. If we were to a graph this equation wouldn’t pass through the orgin. And we know that if a street line doesn’t go through the orgin that is a non-proportional relationship.”</td>
<td>Alyssa</td>
<td>Growth</td>
<td>Probing Question</td>
</tr>
<tr>
<td><strong>Feedback:</strong> Below the problem, the teacher wrote “I like your clear explanation. You explained well why a y-intercept $\neq 0$ shows us that the relationship is non-proportional.” And then below that wrote “Consider: does a proportional relationship</td>
<td></td>
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</tr>
</tbody>
</table>
| Context: Problem 3 has students simplify the expression \(3 + (x + 12)\) and explain each step. The student wrote the following work: 
\[
(3 + 12) + x \\
15 + x
\]  |
| Feedback: The teacher wrote “excellent use of the commutative property!” |
| Erin | Fixed | None |

| Context: overall note to students |
| Feedback: At the bottom of the graphic organizer, the teacher wrote “Great job completing the graphic organizer. I am impressed by your decision to substitute 0 into the inequality to check your work. It is clear that you all are comfortable with the process of solving an inequality. Over the course of this unit, let’s build on our knowledge of inequalities to better explain the meaning behind the given inequality solution.” |
| Tess | Growth | None |

| Context: Problem 8 asked the student to simplify the expression \(5a + 7 - 3a - 2\). The student wrote the following work below the problem: 
\[
5a - 3a + 7 - 2 \\
2a + 5
\]  |
| Feedback: Next to the students work, the teacher wrote “very nice how you grouped like terms together using the commutative property” |
| Erin | Fixed | None |

| Context: The first object the student measured was a “rocketfish outlet box.” The object had a length of 11 cm, a width of 6 cm, and a height of 36 cm. When calculating surface area, the student wrote: 
\[
2(11 \cdot 6) + 2(11 \cdot 36) + 2(6 \cdot 36) \\
132 + 792 + 432 \\
1,356 \text{ cm}^2
\]  |
| Feedback: The teacher writes “Nice use of surface area formula!” as well as a check mark on this work. |
| Jensen | Growth | None |

| Context: For the bonus, the student wrote “because a number plus zero is itself, as well as minus zero and so \(-\frac{b+\sqrt{b}}{2a}\) will simplify to the same thing whether or not you add or subtract (the square root of 0 is 0) |
| Feedback: “Well articulated!” |
| Nellie | Fixed | None |

| Context: For problem 2, the student selected IMS and wrote “you would change the coefficient and the constant from one of the equations to the same as the other.” Then wrote out the following examples: \(5 + 2w = 5 + 2w\) or \(15 + 4w = 15 + 4w\). |
| Paige | Fixed | None |
Feedback: Next to the examples the student provided, Paige wrote “awesome you have multiple answers! Glad that you have found a pattern!”

| Context: For problem 3, the student set the parallel sides equal to each other to obtain the equation $2x + 17 = 6x + 9$ and correctly solved for $x$. The student then wrote $A = l \cdot w$
|--------|--------|--------|
| $A = 4(2) - 1 \cdot 6(2) + 9$
| $A = 8 - 1 \cdot 12 + 9$
| $A = 7 \cdot 21$
| $A = 147$

Feedback: At the bottom the teacher writes “Great job using the equals sign appropriately throughout your work! Next time, check to see if the work you show is accurately expressing your actual mathematical intentions. Remember that the reader of your math work may not fully understand your logic unless you accurately express them using standard conventions.”

| Context: In the top right box, the students provided the following graph (only black pen is what the student wrote) |
|--------|--------|--------|
| Feedback: The teacher crossed out the top number line. It looks like she may have drawn the number line below it, showing the correct answer. Above the incorrect answer she wrote the correct answer “$x \geq -22.5$” She also wrote “Good job shading in your circle! Please take a look at the graph with the correct solution.” |

Category: Effort

| Feedback |
|--------|--------|--------|
| Context: overall note to students |
| Feedback: At the bottom of the graphic organizer the teacher wrote “Great job group #15. You were given a challenging inequality and did an incredible job persevering and solving it without my help. I am happy to see that you were able to utilize your prior knowledge and correctly subtract a positive number from a negative number without the use of a calculator! Please read my comments carefully so that you will master the next inequality organizer in work-shop!” Note: workshop is an extra support class they have. |

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<td>Tess</td>
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**Feedback:** At the bottom of the graphic organizer the teacher wrote “Great job group #15. You were given a challenging inequality and did an incredible job persevering and solving it without my help. I am happy to see that you were able to utilize your prior knowledge and correctly subtract a positive number from a negative number without the use of a calculator! Please read my comments carefully so that you will master the next inequality organizer in workshop!” Note: workshop is an extra support class they have.

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<tr>
<td><strong>Name</strong></td>
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<td><strong>Feedback</strong></td>
</tr>
<tr>
<td><strong>Feedback:</strong> The teacher also underlined “explain using key words” in the directions of this problem. I think this is what led the student to not receive points (indicated by the lack of a check on the problem number) on this question.</td>
</tr>
<tr>
<td><strong>Feedback:</strong> The teacher underlined “explain each step” in the directions.</td>
</tr>
<tr>
<td><strong>Feedback:</strong> In response to (b), the teacher writes “show the work.”</td>
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<tr>
<td>Context</td>
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<tr>
<td>---------</td>
</tr>
<tr>
<td>In the final answer box, the student only wrote 150 + \sqrt{679.125}. It looks like the student may have divided by number in the radical by the denominator of 32.</td>
</tr>
<tr>
<td><strong>Category: Precision/Syntax/Vocab/ Organization</strong></td>
</tr>
<tr>
<td>Feedback</td>
</tr>
<tr>
<td><strong>Context:</strong> On problem #2 the student was asked to identify the property. For problem 2, (5 \cdot (3 \cdot z) = (5 \cdot 3) \cdot z), the student wrote “associative”</td>
</tr>
<tr>
<td><strong>Feedback:</strong> For problem 2 the teacher wrote “property of…what?”</td>
</tr>
<tr>
<td><strong>Context:</strong> For problem 2, the student selects “no solution” and writes that (5 + 2x = 15 + 4x) should be changed to (5 + 4x = 15 + 4x) by adding two more question mark boxes on the left. The student then crossed out the 4x’s and shows that 5 does not equal 15, so there is no solution.</td>
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<td><strong>Feedback:</strong> The teacher also underlined “explain using key words” in the directions of this problem. I think this is what led the student to not receive points (indicated by the lack of a check on the problem number) on this question.</td>
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<tr>
<td><strong>Context:</strong> Problem 3 has students simplify the expression (3 + (x + 12)) and explain each step. The student wrote the following work: [(3 + 12) + x] [15 + x]</td>
</tr>
<tr>
<td><strong>Feedback:</strong> The teacher underlined “explain each step” in the directions.</td>
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<td><strong>Context:</strong> For problem 2, the student selects “no solution” and writes that (5 + 2x = 15 + 4x) should be changed to (5 + 4x = 15 + 4x) by adding two more question mark boxes on the left. The student then crossed out the 4x’s and shows that 5 does not equal 15, so there is no solution.</td>
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<tr>
<td><strong>Feedback:</strong> At the bottom, the teacher wrote “what are some other key words or math terms you can use to accurately describe the changes you were making to the original equation?”</td>
</tr>
<tr>
<td><strong>Context:</strong> For problem 2, the student wrote “change 5 to 0 and 9,3,3” but then crossed it out. Below that the student wrote (5 + 2x = 5 + 2x), she subtracted 5 from both sides to obtain (2x = 2x) and then divided both sides by 2x to get and answer of (x).</td>
</tr>
</tbody>
</table>
**Feedback:** Paige underlined the “explain using key words” portion of the directions and wrote “What math terms can you use to describe the changes you made to the original equation?”

### Context
For problem 3, the student set the parallel sides equal to each other to obtain the equation $2x + 17 = 6x + 9$ and correctly solved for $x$, then he used his solution of $x=2$ to find the area. He writes $12 + 9 \cdot 8 - 1$. Below that he writes $21 \cdot 7$. Below that he writes $$\begin{align*}
21 \\
\frac{7}{147}
\end{align*}$$
He indicates no operations for this.

**Feedback:** For feedback to this error in syntax (he should have parenthesis around 12+9 and 8-1, she writes “When you show/present your calculation work, please try to follow the standard notation so that it makes clear logical sense. The work you showed here is your own ‘scratch’ work and the reader has to guess and fill in the missing operation/notations (+, −, ÷, ×, =). It is important to be able to express your mathematical work accurately and clearly.”

### Context
Student originally wrote $$\frac{-150 + \sqrt{41}}{-32} = \frac{-150 + 8}{-32} = \frac{-142}{-32} = 4.44.$$  

**Feedback:** He corrected the student by drawing in the minus for the plus or minus parts of the quadratic, he added that the student needed a “t=” in front of the expression the student had written, he circled the unclear number and then wrote the correct quadratic formula above the students work (it was unclear how the student arrived at their starting expression)

### Context
For problem 3, the student set the parallel sides equal to each other to obtain the equation $2x + 17 = 6x + 9$ and correctly solved for $x$, then he used his solution of $x=2$ to find the area. He writes $12 + 9 \cdot 8 - 1$. Below that he writes $21 \cdot 7$. Below that he writes $$\begin{align*}
21 \\
\frac{7}{147}
\end{align*}$$
He indicates no operations for this.

**Feedback:** For feedback to this error in syntax (he should have parenthesis around 12+9 and 8-1, she writes “Is this an accurate way to express your work? What numerical answer would you get if you used the PEMDAS rule?”

### Context
Student originally wrote $-16x^2 + 150x - 3$ and then said they would use quadratic equation to solve. When the student began solving he/she wrote $$\frac{-150 \pm \sqrt{2308}}{-32} = \frac{-150 \pm 149.36}{-32}.$$
Feedback: “Normally we don’t put words in expressions.” She then wrote, “you write it like this \( x = \frac{-150 \pm \sqrt{2308}}{-32} = \frac{-150 \pm 149.36}{-32} \).”

Context: On problems #1 and 2 the student was asked to identify the property. For problem 1, \( 6 + (4 + x) = (6 + 4) + x \), the student wrote “associative property” and for problem 2, \( 2 \cdot 3 \cdot (\cdot z) = (5 \cdot 3) \cdot z \), the student also wrote “associative property”

Feedback: For problem 1 she wrote “of addition (+)” and for problem 2 she wrote “of multiplication (\( \cdot \))” to indicate the student should specify

Context: On problems #1 and 2 the student was asked to identify the property. For problem 1, \( 6 + (4 + x) = (6 + 4) + x \), the student wrote “associative property”

Feedback: For problem 1 the teacher wrote “property of addition (+)” below the students answer.

Context: The first object the student measured was a bookshelf. The student labeled the length as 36 cm, width as 60 cm, and height as 183 cm. For the volume, the student wrote the following in a single line, “\( 36 \times 60 = 2,160 \times 183 = 395,280 \text{ cm}^3 \)”

Feedback: The teacher wrote a check mark in this box and then put parenthesis around “\( 2,160 \times 183 = 395,280 \)” and wrote “please start a new line.” She then demonstrated below, writing, “\( 2,160 \times 183 = 395,280 \)”

Context: For the student’s final answer they wrote “It will take 4.44 seconds for the mortar shell to hit the ground.”

Feedback: She wrote an ~ sign in from of the 4.44 and wrote “since you rounded this is not exact”. She also wrote “good context” next the students sentence.

Context: The student correctly wrote out the quadratic formula as \( t = \frac{-b \pm \sqrt{b^2-4ac}}{2a} \) but then forgot to write “t=” when substituting the values into the equation, then also only put the portion in the radical over 2a, \( -150 \pm \frac{-150^2-3(-16)(3)}{2(-16)} \).

Feedback: extended the fraction bar (aka the “vinculum”) to show that the student should have included -150 in the numerator as well. She also wrote “The whole numerator is over 2a”

Context: In the final answer box, the student only wrote \( 150 + \sqrt{679.125} \). It looks like the student may have divided by number in the radical by the denominator of 32.

Feedback: “Remember like we spoke in class \( \frac{22308}{-32} \neq \frac{-22308}{-32} \)

Context: The students work was a little disorganized, with the answer written above the work.
**Feedback:** There were also some arrows to help show the student how to better organize their work so that it may be easily followed.

**Context:** The student correctly wrote out the quadratic formula as \( t = \frac{-b \pm \sqrt{b^2-4ac}}{2a} \) but then forgot to write “\( t = \)” when substituting the values into the equation, then also only put the portion in the radical over \( 2a \), \(-150 \pm \frac{\sqrt{150^2-4(-16)(3)}}{2(-16)} \).

**Feedback:** She added “\( t = \)” in front of the expression.

**Context:** For problem 2, the student selects “no solution” and writes that \( 5 + 2x = 15 + 4x \) should be changed to \( 5 + 4x = 15 + 4x \) by adding two more question mark boxes on the left. The student then crossed out the 4x’s and shows that 5 does not equal 15, so there is no solution.

**Feedback:** For the suggestion of “add two more ?? on the left” the teacher writes “is there a math term that you can use to describe ‘?’”

**Context:** Student originally wrote \(-16x^2 + 150x - 3\) and then said they would use quadratic equation to solve. When the student began solving he/she wrote \(-\frac{150}{-32} \pm \sqrt{149.36} = \frac{-150 \pm \sqrt{2304}}{-32} \).

**Feedback:** “Remember that we are solving an equation not an expression.” She then added \( h(x) = \) before the \(-16x^2 + 150x - 3\) and \( x = \) before \(-\frac{150 \pm \sqrt{2304}}{-32} \).

**Context:** The first object the student measured was a bed with a length of 105 in, width 14.5 in, and height 45 in. When calculating the SA, the student calculated the area of each 2D side of the bed, then found the correct sum.

**Feedback:** The student did not indicate units, so the teacher wrote in \(^2\) at the end of their final answer.

**Context:** For problem 3, the student set the parallel sides equal to each other to obtain the equation \( 2x + 17 = 6x + 9 \) and correctly solved for \( x \). The student then wrote \( A = l \cdot w \) \( A = 4(2) - 1 \cdot 6(2) + 9 \) \( A = 8 - 1 \cdot 12 + 9 \) \( A = 7 \cdot 21 \) \( A = 147 \).

**Feedback:** At the bottom the teacher writes “Great job using the equals sign appropriately throughout your work! Next time, check to see if the work you show is accurately expressing your actual mathematical intentions. Remember that the reader of your math work may not fully understand your logic unless you accurately express them using standard conventions.”
**Context:** The second object the student measured was a table. The student labeled the height as 152 cm, the width as 42 cm, and the height as 73 cm. For the volume, the student wrote, “42 \times 73 = 3,066 \times 152 = 466,032 cm^3”

**Feedback:** The teacher wrote a check mark in this box and then put parenthesis around “152 = 466,032 cm^3” and wrote “Make sure you start from the next line when you do a new operation.” She then demonstrated below, writing, “3,066 \times 152 = 466,032”

---

**Context:** In the top left box, the following work was shown:

\[ \begin{array}{c}
12 < 3x + 6 \\
+ 6 < x \\
\end{array} \]

The number 6 was circle off to the side, with no x or inequality sign.

**Feedback:** The teacher drew an arrow from the last step shown in the solution to work that she had written out showing that after the students divide by 3, they should get 6 < x as an answer. She also wrote “we can’t forget about our inequality!”

---

**Context:** For problem 3, the student wrote 2x + 17 + 6x + 9 = (that’s not a typo, she didn’t set it equal to anything). She then subtracted 2x from the 2x and 6x and wrote 17 + 8x + 9. Then she added 9 to 17 and to -9. Below this work she wrote 26 = 8x. Then she divided both sides by 8 to get x = 3.25. She then tried to check her work by doing A = l \cdot h then wrote 3.25 \cdot 4x - 1. It looks like she tries to subtract 1 from 3.25 and then wrote 2.25 below 3.25. Here she stopped.

**Feedback:** Next to the step where she subtracted 2x from 2x and 6x in the expression 2x + 17 + 6x + 9 = Paige writes “you want to perform the same operation on each side of the equals sign, not twice on one side”

---

**Context:** In the bottom right box, the students wrote “a number is less then 3.”

**Feedback:** Under this response the teacher wrote, “Any number less than 3 will satisfy the inequality.”

---

**Context:** Problem 4 asks the student to simplify the expression (8 \cdot k) \cdot 4 and explain each step. The student wrote (8 \cdot 4) \cdot k 32 \cdot k

**Feedback:** The teacher wrote “32k” and “simplify all the way”

---

**Context:** For problem 1, the student correctly set up the equation 5 + 2x = 15 + 4x, then correctly subtracted 2x from both sides to obtain 5 = 15 + 2x. From here, the student subtracted 5 from both sides to obtain 10 = 2x instead of the correct 0 = 10 + 2x. This cause the student to obtain x = 5 as her answer, instead of the correct x = -5. The student also checked
her work by substituting 5 into her equation. To do this she wrote \( 5 + 2 \cdot 5 = 15 + 4 \cdot 5 \), \( 7 \cdot 5 = 15 + 20 \), then \( 35 = 35 \).

**Feedback:** Next to the work showing how the student checked her solution, Paige underlined the \( 5 + 2 \cdot 5 \) and wrote “What operation needs to be done first? Follow the PEMDAS rule! Is \( x=5 \) really the solution to your equation?”

**Context:** For problem 3, the student set the parallel sides equal to each other to obtain the equation \( 2x + 17 = 6x + 9 \) and correctly solved for \( x \). The student then wrote \( A = l \cdot w \)

\[
A = 4(2) - 1 \cdot 6(2) + 9 \\
A = 8 - 1 \cdot 12 + 9 \\
A = 7 \cdot 21 \\
A = 147
\]

**Feedback:** “In response to the \( A = 4(2) - 1 \cdot 6(2) + 9 \), the teacher writes “Is this an accurate way to express length and width? What numerical answer would you get if you followed PEMDAS?”

**Category: Praise of grade**

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<tr>
<td><strong>Context:</strong> The student scored 15/15. It appears they got the bonus right, but they missed a point for not having ( h(x) = ) in the original equation. <strong>Feedback:</strong> “15/15” and “nice” at the top of page, “-1” next to ( h(x)= ) and “+1” next to bonus.</td>
<td>Nellie</td>
<td>Fixed</td>
<td>None</td>
</tr>
<tr>
<td><strong>Context:</strong> n/a</td>
<td>Jensen</td>
<td>Growth</td>
<td>None</td>
</tr>
<tr>
<td><strong>Feedback:</strong> She wrote one check mark in each box (dimensions, volume, and SA) for each of the three objects. There is also one check mark for the questions at the end of the document. At the top of the page she wrote “Great work!” next to the score 2/2.</td>
<td>Erin</td>
<td>Fixed</td>
<td>None</td>
</tr>
<tr>
<td><strong>Context:</strong> This student was an ELL, so she attached a sheet of paper with this comment. <strong>Feedback:</strong> “You did very nice work on this quiz! Here are some comments I wrote about questions 12 and 13 for you to</td>
<td>Erin</td>
<td>Fixed</td>
<td>None</td>
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</tbody>
</table>
look at. I have translated them into Chinese using Google Translate. If something does not make sense, please ask me and [name redacted] to help you. Great job!”

| Category: Non-specific praise |
| Name | Mindset | Other Categories |
| Context: Problem 4 asked the students to simplify the expression \((8 \cdot k) \cdot 4\) and explain each step. The student included the following work, identifying the first step as having used the commutative property. \[8 \cdot 4 \cdot k\] \[32k\] Feedback: The teacher wrote “excellent” below where the student wrote “commutative property” | Erin | Fixed | None |

Context: Problem 4 asks the student to simplify the expression \((8 \cdot k) \cdot 4\) and explain each step. The student writes \(32k\) and below that writes \([(8 \cdot k) \cdot 4 = (8 \cdot 4) \cdot k]\) Feedback: She drew an arrow to the work and wrote “excellent work!” | Erin | Fixed | None |

Context: For the final portion of the exit ticket (the graph), the student wrote “Yes because this shows constant rate of change. No because the line not started from the origin.” Feedback: In response to the second sentence the teacher wrote “Great! Exactly!” With a check mark. | Alyssa | Growth | None |

Context: In the bottom left box, the students wrote: \[
\begin{align*}
10 &< 3(8) - 6 \\
10 &< 28 - 6 \\
10 &< 15
\end{align*}
\] Feedback: The teacher wrote “Great job!” next to this work. | Tess | Growth | None |

Context: Problems 9 and 10 have students factor the following two expressions using the GCF: 9. \(24 - 9\) 10. \(14x + 63\) For problem 9, the student wrote \(3(8 - 3)\) and for problem 10, the student wrote \(7(2x + 9)\) nothing else was written by the student for these problems. Feedback: The teacher wrote “great job!” to the right of problem 10. | Erin | Fixed | None |

Context: For problem 12, the student is given the formula to convert from C to F, \(F = (C \cdot 1.8) + 32\) and asks the student to find temp, in F, of water that is 10 degrees C. The student wrote the following work for this problem: \[(c \cdot 1.8) + 32\] \[(10 \cdot 1.8) + 32\] | Erin | Fixed | None |
Problem 13a gives the student the following word problem: “You and three friends go to a baseball game. You each pay $2 for a drink and $x dollars for nachos. A. Use the Distributive Property to write and simplify an expression for the total the group pays.” For (a), the student wrote the following work:

\[
4(2 + x) \\
8 + 4x
\]

**Feedback:** The teacher wrote “Beautiful work” below the student’s response to problem 12 but to the side of problem 13a. It’s unclear to which problem she is referring.

**Context:** For problem 2, the student selects “no solution” and writes that \( 5 + 2x = 15 + 4x \) should be changed to \( 5 + 4x = 15 + 4x \) by adding two more question mark boxes on the left. The student then crossed out the 4x’s and shows that 5 does not equal 15, so there is no solution.

**Feedback:** Next to the example, the teacher wrote “great example!”

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### Category: Elaborated Correction

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<tr>
<td><strong>Feedback:</strong> “Group #16, great job checking your work and substituting 7 in for x. I see that you originally substituted in 6 and discovered that 6 wouldn’t work. If that’s the case, how can the solution be 6? Please take a look at the given inequality symbol to determine where the error exists. If you resubmit the question boxed in red by tomorrow, you will receive full credit for that portion of the graphic organizer.”</td>
<td>Tess</td>
<td>Growth</td>
<td>Rhetorical Questions</td>
</tr>
<tr>
<td><strong>Context:</strong> overall note to students</td>
<td></td>
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</tr>
<tr>
<td><strong>Feedback:</strong> The teacher underlines the words “10 degrees Celsius” in the problem and writes “what does this mean?” and “what does the formula tell us to find? What does C mean here? Do we know/are we given a value for C?”</td>
<td>Nellie</td>
<td>Fixed</td>
<td>Guiding Questions</td>
</tr>
<tr>
<td><strong>Context:</strong> For the bonus the student wrote “The discriminant of zero would mean there is one solution because we are using</td>
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</table>

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the zpp to get equal to the quadratic”...I’m assuming zpp means zero product property.

**Feedback:** She wrote “we use zpp when factoring. Why does this not apply to the quadratic formula?”

**Context:** In the top left box, the following work was shown:

```
-5 ≤ x ≤ 5
-15 ≤ x ≤ 15
```

**Feedback:** The teacher drew a division bar under -15 and under 2/3 and wrote 2/3 under that division bar to indicate that the students needed to divide by the 2/3. She then drew an arrow below the graphic organizer and included the following work:

Next to that, she wrote “Great job subtracting 5 from both sides. In order to solve for x, we must divide 2/3 from both sides!”

**Context:** For problem 3, the student set the parallel sides equal to each other to obtain the equation 2x + 17 = 6x + 9 and correctly solved for x, then he used his solution of x=2 to find the area. He writes 12 + 9 • 8 − 1. Below that he writes = 21 • 7. Below that he writes

\[
\begin{align*}
21 & \\
7 & \\
147 & \\
\end{align*}
\]

He indicates no operations for this.

**Feedback:** For feedback to this error in syntax (he should have parenthesis around 12+9 and 8-1, she writes “When you show/present your calculation work, please try to follow the standard notation so that it makes clear logical sense. The work you showed here is your own ‘scratch’ work and the reader has to guess and fill in the missing operation/notations (+, −, ÷, ∗, =). It is important to be able to express your mathematical work accurately and clearly.”

**Context:** Student originally wrote \(-16x^2 + 150x - 3\) and then said they would use quadratic equation to solve. When the student began solving he/she wrote \(\frac{-150\pm\sqrt{72304}}{-32}\).

**Feedback:** Fixed

**Precision**
Feedback: “Normally we don’t put words in expressions.” She then wrote, “you write it like this: 
\[
\frac{-150 \pm \sqrt{22308}}{-32}.
\]

Context: The student correctly wrote out the quadratic formula as 
\[
t = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}
\] but then forgot to write “t=” when substituting the values into the equation, then also only put the portion in the radical over 2a, 
\[
-150 \pm \sqrt{150^2 - 4(-16)(3)}
\]

Feedback: extended the fraction bar (aka the “vinculum”) to show that the student should have included -150 in the numerator as well.

Context: In the final answer box, the student only wrote 
150 + \sqrt{679,125}. It looks like the student may have divided by number in the radical by the denominator of 32.

Feedback: “Remember like we spoke in class 
\[
\frac{22308}{-32}
\] ≠
\[
\sqrt[22308]{-32}
\]

Context: The second object the student measured was a table. The student labeled the height as 152 cm, the width as 42 cm, and the height as 73 cm. For the volume, the student wrote, “42 × 73 = 3,066 × 152 = 466,032 cm^{3}”

Feedback: The teacher wrote a check mark in this box and then put parenthesis around “152 = 466,032 cm^{3}” and wrote “Make sure you start from the next line when you do a new operation.” She then demonstrated below, writing, “3,066 × 152 = 466,032 ”

Context: For problem 3, the student wrote 
\[
2x + 17 + 6x + 9 = (\text{that’s not a typo, she didn’t set it equal to anything}).
\]
Then she subtracted 2x from the 2x and 6x and wrote 
\[
17 + 8x + 9.
\]
Then she added 9 to 17 and to -9. Below this work she wrote 
\[
26 = 8x.
\]
Then she divided both sides by 8 to get 
\[
x = 3.25.
\]
Then she tried to check her work by doing 
\[
M = N \cdot h
\]
then wrote 
\[
3.25 \cdot 4x - 1.
\]
It looks like she tries to subtract 1 from 3.25 and then wrote 2.25 below 3.25. Here she stopped.

Feedback: Next to the step where she subtracted 2x from 2x and 6x in the expression 
\[
2x + 17 + 6x + 9 = \text{ Paige writes “you want to perform the same operation on each side of the equals sign, not twice on one side”}
\]
<table>
<thead>
<tr>
<th>Feedback: At the bottom of the page she also wrote, “You need to review and remember the mistakes you made while working with equations. I see the same type of errors you made on your previous work. Before you copy down the different expressions given, why don’t you take time to clarify the end goal for the word problem? This will help you plan the steps more logically.”</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Context: The student got the equation incorrect by writing +3 instead of -3 as their “c” term in the quadratic.</td>
<td>Nellie</td>
<td>Fixed</td>
</tr>
<tr>
<td>Feedback: “Think about the scenario like a graph. If the mortar is 3 feet below ground and y=0 is the ‘ground’.”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Context: In the bottom right box, the students wrote “the solution is positive 6”</td>
<td>Tess</td>
<td>Growth</td>
</tr>
<tr>
<td>Feedback: The teacher wrote “when solving an inequality, we have more than one solution. Since x&gt;6, any number greater than 6 can satisfy the inequality.” Under this she wrote (boxed in red)” can the solution be 6?” and then an arrow to the comment “resubmit the answer to this question by tomorrow to receive credit for this portion”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Context: For problem 12, the student is given the formula to convert from C to F, ( F = (C \cdot 1.8) + 32 ) and asks the student to find temp, in F, of water that is 10 degrees C. The student writes “10 + (C \cdot 1.8) + 32” as their answer. This is all that is written.</td>
<td>Erin</td>
<td>Fixed</td>
</tr>
<tr>
<td>Feedback: “What is the given formula asking us to do? Do we know what C equals? Celsius = C = ? Can we use substitution?”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Context: Student originally wrote ( \frac{-150+\sqrt{unclear \ number}}{-32} = \frac{-150+8}{-32} = \frac{-142}{-32} = 4.44 ).</td>
<td>Nellie</td>
<td>Fixed</td>
</tr>
<tr>
<td>Feedback: Next to the answer 4.44 she wrote “Ok with work” and “two solutions” right below that.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Context: For problem 1, the student correctly set up the equation ( 5 + 2x = 15 + 4x ), then correctly subtracted 2x from both sides to obtain ( 5 = 15 + 2x ). From here, the student subtracted 5 from both sides to obtain ( 10 = 2x ) instead of the correct ( 0 = 10 + 2x ). This cause the student to obtain ( x=5 ) as her answer, instead of the correct ( x = -5 ). The student also checked her work by substituting 5 into her equation. To do this she wrote ( 5 + 5 = 15 + 4 \cdot 5 ), then she wrote ( 7 \cdot 5 = 15 + 20 ), then ( 35 = 35 ).</td>
<td>Paige</td>
<td>Fixed</td>
</tr>
<tr>
<td>Feedback: Next to the step of subtracting 5 from both sides, Paige wrote “Where should your equals sign be placed? Make sure to keep track of the ‘left hand side’ and ‘right hand side’ of the equation.”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Context: For the bonus the wrote “because zero has to be by itself [unclear writing]. Negative is none, positive is 2, zero is 1.”</td>
<td>Feedback: She wrote “This is true, but think about this: ( \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} ) and she put a box around ( \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} ).</td>
<td>Nellie</td>
</tr>
<tr>
<td>---</td>
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<tr>
<td>Context: The first object the student measured was a book shelf. The student labeled the length as 36 cm, width as 60 cm, and height as 183 cm. For the volume, the student wrote the following in a single line, “36 \times 60 = 2,160 \times 183 = 395,280 \text{ cm}^3”</td>
<td>Feedback: The teacher wrote a check mark in this box and then put parenthesis around “( \times 183 = 395,280 \text{ cm}^3 )” and wrote “please start a new line.” She then demonstrated below, writing, “( 2,160 \times 183 = 395,280 )”</td>
<td>Jensen</td>
</tr>
</tbody>
</table>

**Category: Correction**

<table>
<thead>
<tr>
<th>Feedback</th>
<th>Name</th>
<th>Participant Mindset</th>
<th>Other Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Context:</strong> Problem 9 asks students to factor the expression 24 − 9 using the GCF. The student wrote:</td>
<td>Erin</td>
<td>Fixed</td>
<td>Guiding Question</td>
</tr>
<tr>
<td>and</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Feedback:</strong> The teacher wrote “once you found 3 as the GCF, what can you do with it? What does it actually mean, GCF?” She also wrote :</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>and</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Context:</strong> On problems #1 and 2 the student was asked to identify the property. For problem 1, 6 + (4 + x) = (6 + 4) + x, the student wrote “associative property” and for problem 2, 5 \cdot (3 \cdot z) = (5 \cdot 3) \cdot z, the student also wrote “associative property”</td>
<td>Erin</td>
<td>Fixed</td>
<td>Precision</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Feedback:</strong> For problem 1 she wrote “of addition (+)” and for problem 2 she wrote “of multiplication (( \cdot ))” to indicate the student should specify</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Context:</strong> Student originally wrote ( \frac{-150 + \sqrt{\text{unclear number} - 192}}{-32} = )</td>
<td>Nellie</td>
<td>Fixed</td>
<td>Precision</td>
</tr>
</tbody>
</table>
Feedback: She corrected the student by drawing in the minus for the plus or minus parts of the quadratic, she added that the student needed a “t=” in front of the expression the student had written, she circled the unclear number and then wrote the correct quadratic formula above the students work (it was unclear how the student arrived at their starting expression.

Context: On problems #1 and 2 the student was asked to identify the property. For problem 1, $6 + (4 + x) = (6 + 4) + x$, the student wrote “associative”.

Feedback: For problem 1 the teacher wrote “property of addition (+)” below the students answer.

Context: Student originally wrote $-16x^2 + 150x - 3$ and then said they would use quadratic equation to solve. When the student began solving he/she wrote $\frac{-150 \pm \sqrt{22500}}{-32}$.

Feedback: “Remember that we are solving an equation not an expression.” She then added $h(x) =$ before the $-16x^2 + 150x - 3$ and $x =$ before $\frac{-150 \pm \sqrt{22500}}{-32}$.

Context: The first object the student measured was a bed with a length of 105 in, width 14.5 in, and height 45 in. When calculating the SA, the student calculated the area of each 2D side of the bed, then found the correct sum.

Feedback: The student did not indicate units, so the teacher wrote in$^2$ at the end of their final answer.

Context: For the pillow, the student calculated the SA as 25 square ft. The student again, drew out the net, shown below, and wrote scratch work surrounding that showed the student’s multiplication process of finding the answers in each box.

Feedback: The teacher crossed out the 4.5 in the left box and wrote 3.75. To the side, she also wrote:

Context: In the bottom right box, the students wrote “a number is less then 3.”
**Feedback:** Under this response the teacher wrote, “Any number less than 3 will satisfy the inequality.”

**Context:** In the bottom right box, the students wrote “you first subtract 5 from both sides so \(-10 - 5 = -15\) then you divide \(\frac{2}{3} \div -15\) which is \(-0.044\).”

Feedback: The teacher put a box around you divide \(\frac{2}{3} \div -15\) and wrote “we divide \(-15 \div \frac{2}{3}\).” She also wrote “any number greater than or equal to -22.5 will satisfy the inequality.”

**Context:** The first object the student measured was a bed with a length of 105 in, width 14.5 in, and height 45 in. When calculating the volume, the student wrote:

Feedback: The teacher circled the 977.5 and wrote 1522.5 to indicate the error in multiplication, as shown above.

**Context:** The last object measured by the student was a pillow with length 1.5 (no units), width 2.5 (no units), and height 2 in (after these measurements the student wrote that they were in “feet/in” without indicating which was ft and which was in).

Feedback: The teacher scratched out “feet” in “feet/in” with no indication (to the student) as to why she had done this. She also put a check mark in this box.

**Context:** Problem 4 asks the student to simplify the expression \((8 \cdot k) \cdot 4\) and explain each step. The student wrote \((8 \cdot 4) \cdot k = 32 \cdot k\)

Feedback: The teacher wrote “32k” and “simplify all the way”

**Context:** For their second object, the student measured a dresser with a length of 5.5 ft, width of 1.5 ft, and height of 4 ft. To calculate the volume, the student showed the following work:

Feedback: The teacher wrote an x next to the 240.0 feet^3 answer on the right. Next to that, she wrote:

\[
V = L \cdot W \cdot H \\
= 5.5 \cdot 1.5 \cdot 4
\]
\[ V = 33. \]

**Context:** For their second object, the student measured a dresser with a length of 5.5 ft, width of 1.5 ft, and height of 4 ft. To calculate the volume, the student showed the following work:

\[
\begin{array}{c|c|c|c|c|c|c|c}
4.0 & 4.0 & 22 & 22 & 24.0 & 24.0 \\
\hline
\times 1.5 & \times 5.5 & \times 5.5 & \times 5.5 & 120.0 & 120.0 \\
\hline
= 6.0 & = 82.5 & = 82.5 & = 82.5 & 240.0 & 240.0 \\
\hline
+ 10.00 & \text{move 2 decimal places} & \text{move 2 decimal places} & \text{move 2 decimal places} & \text{move 2 decimal places} & \text{move 2 decimal places} & \text{move 2 decimal places}
\end{array}
\]

**Feedback:** The teacher wrote an x over the work on the left, but then wrote the below comment next to that work:

**Context:** For the surface area of the dresser, the student drew out the net as shown below:

\[
\begin{array}{c|c|c|c|c|c|c|c}
4 & 1.5 & 33 & 22 & 24 & 24 \\
\hline
\times 24 & \times 24 & \times 24 & \times 24 & \times 24 & \times 24 \\
\hline
\end{array}
\]

There was also scratch work surrounding this image that showed the student’s multiplication process of finding the answers in each box.

**Feedback:** The teacher circled the 33 in the top box and wrote an x next to it. Next to the x she wrote 82.5 (I think she meant 8.25). She wrote checks on the two boxes that contain the number 22. Then she circled the 24 on the left and wrote 6 below it. The feedback from the volume shown below also applied to this problem.

**Context:** In the top right box, the students provided the following graph (only black pen is what the student wrote)

<table>
<thead>
<tr>
<th>Jensen</th>
<th>Growth</th>
<th>None</th>
</tr>
</thead>
</table>

Tess | Growth | Praise of Solution Method
**Feedback:** The teacher crossed out the top number line. It looks like she may have drawn the number line below it, showing the correct answer. Above the incorrect answer she wrote the correct answer “$x \geq -22.5$.” She also wrote “Good job shading in your circle! Please take a look at the graph with the correct solution.”

**Context:** In the top left box, the following work was shown:

\[
\begin{align*}
12 & < 3x + 6 \\
+6 & < 3x \\
\end{align*}
\]

Choose a number from the number line below.

The number 6 was circle off to the side, with no $x$ or inequality sign.

**Feedback:** The teacher drew an arrow from the last step shown in the solution to work that she had written out showing that after the students divide by 3, they should get $6 < x$ as an answer. She also wrote “we can’t forget about our inequality!”

**Context:** For the pillow, the student calculated the volume as 65 cubic ft, showing the following work:

\[
\begin{align*}
2 \\
2.5 \\
\times 1.5 \\
12.5 \\
+ 25.0 \\
37.5 \times 2 = 65 \text{ ft}^3
\end{align*}
\]

**Feedback:** The teacher wrote an arrow showing to move the decimal place from between the 7 and 5 to between the 3 and 7. To the side she wrote the following two lines of work:

\[
2 \cdot 2.5 \cdot 1.5 = 7.5 \\
3.75 \cdot 2 = 7.5 \text{ ft}^3
\]

Category: Uncategorized

<table>
<thead>
<tr>
<th>Feedback</th>
<th>Name</th>
<th>Participant Mindset</th>
<th>Other Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Feedback:</strong> At the bottom of the rubric, the teacher wrote “during math workshop you will be given the opportunity to resubmit the graphic organizer.”</td>
<td>Tess</td>
<td>Growth</td>
<td>None</td>
</tr>
<tr>
<td><strong>Context:</strong> Problem 13 gives the student the following word problem: “You and three friends go to a baseball game. You each pay $2$ for a drink and $x$ dollars for nachos. A. Use the Distributive Property to write and simplify an expression for</td>
<td>Erin</td>
<td>Fixed</td>
<td>None</td>
</tr>
</tbody>
</table>
the total the group pays. B. How much does the group pay when the nachos cost $3?" For (a), the student only writes: 
\[3(2 + x)\]
\[6 + 3x\]
For (b), the student only writes: 
\[6 + 9\]
\[15\]
**Feedback:** In response to (b), the teacher writes “15 is correct based on your expression in 13a.”

**Context:** For problem 2, the student selected IMS and wrote “you would change the coefficient and the constant from one of the equations to the same as the other.” Then wrote out the following examples: 
\[5 + 2w = 5 + 2w\] or \[15 + 4w = 15 + 4w\].

**Feedback:** For feedback, Paige underlined the words “coefficient”, “constant,” and “equations” and said “please use precise math terms! The algebraic representation of each side of the equals sign is called a __________.”

**Context:** For the written scenario, where the equation \[y=0.50x+2.50\] was given, the student wrote “This doesn’t represent a proportional relationship because the equation also includes the y-intercept. If we were to a graph this equation wouldn’t pass through the orgin. And we know that if a street line doesn’t go through the orgin that is a non-proportional relationship.”

**Feedback:** The teacher inserted the word “it” between “equation” and “wouldn’t” in the sentence “If we were to a graph this equation wouldn’t pass through…” She also corrected the spelling of the word “straight” (originally written as “street”).
Appendix G: SCALE Copyright Permission

copyright permission request - dissertation

Wed, Oct 7, 2015 at 5:19 PM

To: "Waid, Brandie" <bew2126@tc.columbia.edu>
Cc: Laura Gutmann <gutmann@stanford.edu>

Hello Brandie,

Consider this email SCALE’s written permission to use edTPA copyright material in your dissertation. Our best to you in completing your study and a successful doctoral experience. Please stay in touch regarding your results!

best,

Andrea

Andrea Whittaker, Ph.D.
Director, Teacher Performance Assessment
Stanford University
Graduate School of Education
1705 El Camino Real
Palo Alto, CA 94306
650 723-3899
andrew@stanford.edu