Student Self-Efficacy as Related to Portfolio Grading

By

Tara Johnson

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Mathematics

Middle Tennessee State University

August, 2022

Thesis Committee:

Dr. Alyson Lischka, Chair

Dr. James Hart

Dr. Rongjin Huang

Dr. Dovie Kimmins

ABSTRACT

Grades are used to inform parents, students, and educational institutions of student mastery of content. Colleges rely on research that indicates that high school grades are predictors of how students will perform in college (Atkinson & Geiser, 2009; Geiser & Santelices, 2007). Grading is also tied to development of positive mathematics self-efficacy. Therefore, it is important that teachers are grading in ways that show students' knowledge and ability while supporting self-efficacy development. Portfolio grading, an alternative grading structure, has potential to provide accurate reporting and impact self-efficacy.

The research question for this study is: How does the use of portfolio grading in high school mathematics classrooms effect student mathematics self-efficacy, if at all? The methodology for this study employed an action research approach involving pre- and post-surveys and interviews. Both the pre- and post-survey results and the interview findings indicate portfolio grading effects characteristics that influence self-efficacy.

Table of Contents

Table of Tables

CHAPTER I: INTRODUCTION

What is the most effective way to show and report what students know is a question that has been asked since formalized education came into being (Schneider & Hutt, 2014). In the 19th century, student progress was orally reported to parents during home visits. These oral reports eventually evolved into written reports on how students were doing in penmanship, arithmetic or reading (Guskey & Bailey, 2001). By the 20th century, the diversity of high school populations and specificity of subject area instruction led to the need for a less time-consuming way of reporting what students know, which led high schools to move to percentage grades (Farr, 2000; Guskey & Bailey, 2001). This provides an argument that with the move to percentage grades in the 20th century, clear, specific communication of student learning and knowledge was no longer part of grade reporting for most schools (Brookhart et al., 2016).

In this chapter I introduce the need for grading practices beyond percentage-based grading which leads to the purpose of this study. I then explain aspects of four types of alternative forms of grading, showing research on how they affect student efficacy. I also explain why student efficacy is important to student achievement and what research question this study will address. Finally, I define terms important to the research and this study.

Situating the Problem

Grades are used to inform parents, students, and educational institutions of student mastery of content. Colleges use student grades for admission and rely on research that indicates that high school grades are predictors of how students will perform in college (Atkinson & Geiser, 2009; Geiser & Santelices, 2007). Though students

seeking college admission may have an average to above average grade point average (GPA), colleges are still placing those students in remedial classes because of scores earned on placement tests such as the American College Testing (ACT) or Scholastic Assessment Test (SAT). Therefore, it is possible that percentage grades, which comprise GPAs, are not a clear indication of student knowledge.

The National Council of Teachers of Mathematics (NCTM) *Principles and Standards for School Mathematics* (2000) recommended that the study of mathematics include more than just mastering concepts and skills. Studying mathematics should include reasoning, investigation, communication and understanding of the content (NCTM, 2000). Furthermore, assessment should relay useful information to both teachers and students (NCTM, 2000). Also, since the release of Common Core Standards in 2010, standards in most states now include Standards for Mathematical Practice which include: reasoning abstractly and quantitatively, constructing viable arguments and critiquing the reasoning of others, and looking for and expressing regularity in repeated reasoning (CCSS, 2010). Traditional mathematics testing and grading, such as paper pencil assessments that mostly test decontextualized problems and recording grades based on work ethic and attendance, do not align with what NCTM says about learning mathematics, nor do they align with the Standards of Mathematical Practice. Thus, we need to assess students in ways that show their ability to reason, communicate, conceptualize, and problem solve.

Alternative Forms of Grading

Alternative forms of grading, compared to percentage grades, could be used to more accurately show student's ability to reason, communicate, conceptualize, and

problem solve. The alternative grading styles I will be highlighting are Reflective, Mastery-Based, Performance-Based, and Standards-Based grading.

Reflective grading is a grading strategy that uses a metacognitive formative approach, providing feedback to both teachers and students. Students perform tasks and teachers identify the areas of struggle and provide feedback to help students reflect on and move forward in their areas of struggle (Baliram, 2016). Baliram reported that reflective assessment allows students to regularly take ownership of their learning through reflecting on mistakes and correcting missed problems. The reflection and correction process allows students to learn at their own pace. Teachers get a better understanding of what students know since students, either through oral conversations or journaling, articulate what they learned, how they learned it, why the learning is significant, and how they will use the learning.

Mastery-based grading is a process where one "actively uses the grading system to improve learning" (Armacost & Pet-Armacost, 2003, p. T3A20). In mastery-based grading, students re-take assessment instruments until they master what is being evaluated (Armacost & Pet-Armacost, 2003). In mastery-based grading the course is structured so that learners are allowed the time and flexibility to focus on mastering a standard rather than achieving a number or letter grade. Thus, the first grade on an assessment is not necessarily the final grade. Teachers, typically, grade students' first attempt on an assessment. Then students are required to correct items they missed, detailing why they missed it and how they corrected it. Finally, students are allowed to retake an assessment similar to the one they corrected.

Standards-based grading is a method of grading in which a rubric-based criterion is applied to each learning target for teachers to grade student understanding of the learning target with consistency (Bromley, 2019; Sieling, 2013). The learning targets are typically created from the curriculum standards associated with the subject being taught. Students earn a proficiency score based on their performance of the standard. Students are allowed multiple opportunities to learn each standard and retest if needed. Only the most recent evidence of mastery counts toward the grade.

Performance-based grading is a grading form that poses problem solving opportunities in which students use multiple strategies and various skills (Alkhateeb, 2018; Fuchs et al., 1999). In performance-based grading students also have input in the development of the evaluation criteria and are responsible for demonstrating their learning (Alkhateeb, 2018). Students perform meaningful, real-world tasks that have learning standards embedded in them to show mastery of the standards. Rubrics are used to allow students to see teacher expectations and how they will be graded. Student reflection and teacher feedback play a role in performance-based grading since students are allowed to learn from their mistakes and work somewhat at their own pace.

In the 2021-2022 school year, Jones High School (all names and locations are pseudonyms) adopted an alternative grading strategy in their mathematics classrooms known as portfolio grading. Portfolio grading is a grading system that replaces numerical grades with high-quality feedback on formative assessments to support a growth mindset in mathematics. By examining feedback and making corrections, students can learn from their mistakes and build a portfolio that demonstrates their progress toward a learning goal without the pressure of grades. This grading system values each students' unique

abilities, values understanding over speed, and puts the onus on the student to put forth the efforts to learn.

Portfolio grading combines aspects of the previously described alternative grading forms. Much like these alternative grading styles, portfolio grading places an emphasis on high quality teacher feedback paired with students re-taking assessments until they have mastered the learning goal.

Purpose of the Study and Research Question

Several studies have found that student self-efficacy in mathematics has a positive effect on student achievement. Ma and Kishor (1997) and Ma and Xu (2004) found that student attitudes about mathematics are a predictor of student achievement in mathematics. Liu and Koirala (2009) studied the relationship between mathematics self-efficacy and mathematics achievement and found that there was a positive correlation between mathematics self-efficacy and mathematics achievement. Both Nicolaidou and Philipou (1997) and Liu and Koirala (2009) found that mathematics self-efficacy influenced mathematics achievement more than attitudes toward mathematics did.

With research showing a link between mathematics self-efficacy and mathematics achievement, it is important to look at ways to increase student's self-efficacy. Bandura (1986) stated that student self-efficacy is improved by experiencing successes in the area of study. Oldham (2018) studied the link between goals and efficacy and found that in classrooms where short-term interim goals were promoted, student self-efficacy rose. These goals could be as simple as completing the assignment for the day. Alternative forms of grading, namely portfolio-grading, offer students these goal-setting experiences to improve their self-efficacy. In portfolio-grading students are given daily goals as well

as unit goals. A goal sheet with both types of goals is given to students at the beginning of each quarter. In addition to providing short-term goals, portfolio grading allows students to experience success as they are allowed multiple attempts to master learning targets and only retest learning targets that have not been mastered. Also, some students being graded using portfolio grading experience the success of a higher math grade than they have had before because of the mastery aspect built into portfolio grading.

There is not research specific to portfolio-grading as described, however reflective grading, mastery-based grading, standards-based grading, and performance-based grading all share themes with portfolio grading. Since mathematics self-efficacy and student attitudes toward mathematics have been found to influence student achievement in mathematics, this study will address the question: How does the use of portfolio grading in high school mathematics classrooms affect student mathematics self-efficacy, if at all?

Significance of the Study

The results of this study can provide insight into the connection between grading systems and self-efficacy. In addition, the participants will know that their school is considering ways to grade that give more meaningful results than traditional grading. Participants will also know that their thoughts on the grading system matter to research and school administration. There are potential benefits to the mathematics education community and school administration in that this study could show portfolio grading to positively affect student mathematics self-efficacy.

Definitions

For clarity, I next define terms that are used throughout the following chapters.

Assessment

An assessment is an instrument students complete to show their knowledge of the standards deemed important in a subject area.

Attitude

In this study, attitude is a person's feelings about a mathematical task, such as whether they believe the mathematical task is important, enjoyable, or difficult (Fennema & Sherman, 1976).

Grade

A grade is the number or letter a teacher enters in a gradebook or on a report card to indicate student performance on tasks or objectives.

Grading

Grading is the way for educators to evaluate each individual student's performance and learning. Grading in this paper refers to how teachers individually track student progress, giving a clear picture of student strengths and weaknesses through reflection, feedback, and portfolios.

Mastery-Based Grading

Mastery-based grading is a process where one "actively uses the grading system to improve learning" (Armacost & Pet-Armacost, 2003, p. T3A20). In mastery-based grading, students re-take assessment instruments until they master what is being evaluated (Armacost & Pet-Armacost, 2003).

Performance-Based Grading

Students perform meaningful, real-world type tasks that have the learning standards embedded in them to show mastery of the standards. Rubrics are used to allow

students to see teacher expectations and how they will be graded. Student reflection and teacher feedback play a role in performance-based grading since students are allowed to learn from their mistakes and work somewhat at their own pace.

Portfolio Grading

Portfolio grading is a grading system that replaces numerical grades with high-quality feedback on formative assessments to support a growth mindset in mathematics. By examining feedback and making corrections, students can learn from their mistakes and build a portfolio that demonstrates their progress toward a learning goal without the pressure of grades.

Reflective Grading

Reflective grading is a grading strategy that uses a metacognitive formative approach, providing feedback to both teachers and students Through student reflection, teachers identify areas of struggle and provide feedback to help students move forward and take ownership of their learning (Baliram, 2016).

Self-Efficacy

In this study, self-efficacy is a person's self-confidence about their ability to accomplish a mathematical task (Bandura, 1986).

Standards-Based Grading

Standards-based grading is a method of grading in which a rubric-based criterion is applied to each learning target for teachers to grade student understanding of the learning target with consistency (Bromley, 2019; Sieling, 2013). The learning targets are typically created from the curriculum standards associated with the subject being taught.

Conclusion

This chapter has provided insight into the need for grading practices beyond percentage-based grading which led to the purpose of the study in this thesis. I identified the four types of alternative forms of grading that were most closely related to portfolio grading and provided research linking student self-efficacy in mathematics to student achievement in mathematics. Finally, for clarity in future chapters, I defined terms important to the research and this study.

In the next chapter, literature relevant to this study is presented. In subsequent chapters, details regarding methodology for this study, analysis of data, and findings and implications are presented.

CHAPTER II: LITERATURE REVIEW

Although percentage-based grades were originally designed to ease the process of reporting student performance (Farr, 2000), their use reduced the amount and quality of communication with parents and the amount of useful feedback provided to both teachers and students. In the 21st century, percentage grades continue to be used to inform parents, students, and educational institutions of student mastery of content (Atkinson & Geiser, 2009; Geiser & Santelices, 2007) even though these grades may include elements like behavior, attitudes, effort, and improvement as well as achievement (Brookhart et al., 2016). As a result, post-secondary institutions place many students with high GPAs in remedial coursework because the grade percentages do not line up with the content knowledge reflected in the grade based on ACT or SAT scores of students (Chen, 2016). Therefore, there is a need for more accurate methods of reporting what students know and can do in mathematics.

Alternative forms of grading could be used to more accurately report what students know and can do mathematically. Though there are many forms of alternative grading available, in this report I will be examining how standards-based, performance-based, mastery-based, and reflective/metacognitive forms of alternative grading affect student achievement and student beliefs and attitudes.

Research on Alternative Forms of Grading

The purpose of this study was to examine the effects of using portfolio grading on student's self-efficacy. In this chapter, research that is relevant to this study and provides a basis for this study is presented. I begin by examining what the research says about the four types of alternative grading related to feedback, self-efficacy, and achievement.

Reflective Grading

Reflective grading is an alternative form of grading that relies on both teacher and student feedback. Students are allowed multiple attempts on assessments. The first attempt allows teachers to identify areas of student struggle and provides high quality feedback to assist students in reflecting on and correcting the assessment. This reflection and correction process allows students to learn at their own pace. Reflective grading also requires students to communicate, either orally or through journaling, what they learned, how they learned it, why the learning is significant, and how they will use the learning. This process gives teachers a better understanding of what students know and when they have mastered the desired learning targets (Baliram, 2016). Three studies were reviewed in relation to reflective grading. Key aspects of the methodology of each study are summarized before synthesis of the findings of these studies.

Bond and Ellis (2013) conducted an experimental study to investigate the effects of reflective grading on student achievement in mathematics. The participants were 141 fifth and sixth-grade students from a suburban elementary school. Some of the participants were in a class practicing reflective grading and some were not. Employing a post-test-only design for the control group, a one-way analysis of variance and nonparametric procedures were used to analyze results.

Baliram (2016) conducted a study to determine the effects of reflective grading and content-specific feedback on student achievement in high school mathematics. Though not one of the research questions, Baliram (2016) also administered a survey at the end of the study to examine if there is a relationship between students' attitude about reflective grading and high-quality feedback. Participants for this study were ninth and

tenth grade honors geometry students in a private Daytona Beach, Florida high school "A quasi-experimental, nonequivalent control-group design with repeated-measures was employed in the study" (Baliram, 2016, p. 1).

The purpose of Edwards' (2008) study was to determine if reflective grading practices influence the learning of mathematics. Participants were 36 female and 35 male 10th graders attending a choice alternative high school in Washington. Statistical analysis compared a pre and post-test with scores grouped by male-reflective, male-nonreflective, female-reflective, and female-nonreflective categories (Edwards, 2008).

Though metacognitive strategies are said to have 0.60 effect size on student learning (Hattie, et al., 2017), Baliram (2016), Bond and Ellis (2013), and Edwards (2008) results regarding student achievement are conflicting. Baliram (2016) and Bond and Ellis (2013) found that students involved in the metacognitive reflective practice saw higher achievement, whereas Edwards (2008) found no significant statistical difference. However, Edwards did find that females achieved more and males achieved less when using reflective techniques.

Little research is found on the effects of reflective grading on student's beliefs and or attitudes. However, Baliram (2016) reported that reflective assessment allows students to regularly take ownership of their learning. Having students think about their own thinking, according to Baliram, creates a skill set students can use beyond the classroom.

Baliram (2016) found student reflection helps teachers understand their students' struggles and inform their instruction. Bond and Ellis (2013) stated reflective practices

are one of the more easily implemented and cost-effective strategies since the key is students reflecting on their thinking and teachers providing proper feedback.

Mastery-Based Grading

Mastery-based grading requires students to master each learning target being assessed (Armacost & Pet-Armacost, 2003). In traditional grading, students complete some type of assessment instrument, earn a grade, and then are expected to learn from their mistakes. However, the grade does not change. In mastery-based grading, students re-take assessment instruments until they master what is being evaluated, being able to improve their grade in doing so (Armacost & Pet-Armacost, 2003). Four studies were reviewed in relation to mastery-based grading. Key aspects of the methodology of each study are summarized before synthesis of the findings of these studies.

Groen et al. (2015) used a mixed methods design to examine the impact of mastery-based grading on student achievement and attitude for first-year undergraduate science, technology, engineering, and mathematics (STEM) students. Quantitatively, grade outcomes for six semesters of first-year undergraduate STEM classes at University of Technology at Sydney were compared using several different statistical tests. Qualitatively, students were given a survey of open-ended questions assessing the impact of mastery-based grading on confidence, anxiety, attitudes, and behavior. The survey responses were sorted and coded, looking for common themes in student answers (Groen et al., 2015).

Kulik et al. (1990) and Guskey and Gates (1986) followed a meta-analytic approach that required identification of studies on mastery-based grading that met predetermined criteria. In both cases, the studies were coded based on fifteen variables

that described treatments, methodologies, settings, and publication histories. Next, study outcomes were described on a common scale. Finally, they used statistical methods to find relationships between study features and study outcomes. Kulik and colleagues (1990) conducted a "meta-analysis of findings from 108 controlled evaluations" (p. 265) that examined the effects of mastery-based grading on achievement of college, high school, and upper grades in elementary school achievement as well as the effect on student attitudes toward course content. Although Guskey and Gates (1986) started out analyzing 144 studies, only 38 met the criteria for the meta-analysis.

Armacost and Pet-Armacost (2003) examined the effects of mastery-based grading on student learning. Students in an Operations Research course in Fall 2000 and Fall 2001 at the University of Central Florida were given the option to be graded using mastery-based grading. Researchers compared examination grades and reexamination grades of participants and overall grade increases for participants to determine positive effects to student learning.

These four studies showed an increase in student learning and achievement associated with mastery-based grading (Armacost & Per-Armacost, 2003; Groen et al., 2015; Guskey & Gates, 1986; Kulik et al., 1990). Armacost and Pet-Armacost's (2003) study showed a six to ten-point average increase on all reexaminations of the students they studied. When using mastery-based grading with STEM students Groen et al. (2015) found increased performance as well as improved retention of content. Guskey and Gates (2002), found that out of 27 studies they analyzed, 25 showed mastery-based grading improved student achievement. Moreover, when they analyzed the studies by grade level they found mastery-based grading to have an effect size of 0.89 among elementary

students studied, 0.93 among middle school students studied, and 0.72 among high school students studied (Guskey & Gates, 2002). Kulik et al. (1990) reported that, although gains were found in both low and high aptitude students in master-based programs, low aptitude students tended to have greater gains.

Mastery-based grading also showed an effect on student's attitudes toward a course being graded in this way (Groen et al., 2015; Guskey & Gates, 1986; Kulik et al., 1990). Guskey and Gates (1986) found that mastery-based grading led to students feeling more positive about learning as well as their ability to learn. Groen et al. (2015) and Kulik et al. (1990) found that mastery-based learning led to students developing a more positive attitude about mathematics. Students also felt less stress and anxiety by having more lower stakes tests and developed more confidence and independence in these classes (Groen et al., 2015).

Standards-Based Grading

In standards-based grading teachers apply a rubric-based criterion to each learning target to consistently assess student understanding of the learning target. Learning targets are based on the curriculum standards of the subject being taught (Bromley, 2019; Sieling, 2013). Two studies were reviewed in relation to standards-based grading. Prior to summarizing the findings of these studies, I have given some detail to the design, methodology, and participants each study used.

Bromley (2019) studied four different classes of Algebra I at the same high school with similar educational backgrounds, mathematical abilities, and socioeconomic status to determine:

> To what extent does implementing a standards-based grading system affect the overall student achievement in a statistically significant way in an Algebra I class at a rural high school in North Carolina? Similarly, to what extent do students gain motivation or academic purpose when given more specific feedback on their performance that is standards-based? (p. 39)

Two of the classes were the experimental group evaluated throughout the year using standards-based grading. The other two classes were the comparison group evaluated throughout the year using traditional grading. Bromley (2019) gave each group a pre- and post-test, running several statistical tests on the scores to compare and check for differences in the scores. After the post-test, a focus group of students and teachers were interviewed using a semi-structured interview protocol where students were asked about their feelings toward mathematics, grading, and their experiences during the semester with standards-based grading in their class. Interview recordings were transcribed and coded, then analyzed for common patterns and trends (Bromley, 2019).

Sieling's (2013) action research project investigated how standards-based grading impacted student achievement and attitude in a mathematics classroom. The population was rural public school seventh- and eighth-grade students in Southwest Minnesota over a two-year period. The data included standardized testing results, students' grades earned during the year, and a student likert scale survey that was "designed to gather data on the students' (a) anxiety and attitude towards mathematics, (b) knowledge of the learning goals of the math class, and (c) perception of achievement on the learning goals of the class" (p.31). An independent-samples *t* test was used to compare 2011 and 2012 Minnesota Comprehensive Assessment scores to determine overall achievement. The

survey results were analyzed using means to determine student anxiety and attitude. The focus group data was analyzed for common themes as related to attitude and anxiety (Sieling, 2013).

These studies showed standards-based grading improves student achievement (Bromley, 2019; Sieling, 2013). Bromley (2019) and Sieling (2013) found higher standardized test performance among students performing under standards-based grading than those under a traditional grading system. Furthermore, Sieling (2013) found that grades earned in a standards-based classroom were more indicative of how a student might score on standardized end of year/course exams.

Standards-based grading also has positive effects on student beliefs and attitudes about math (Bromley, 2019; Sieling, 2013). Sieling (2013) found that students experience less anxiety and more enjoyment in math when using standards-based assessment and grading. Under standards-based assessment and grading, students also have a better understanding of what they are learning (Bromley, 2019; Sieling, 2013). Students also liked the personalization and the student-teacher relationship fostering that the standards-based method allowed to take place (Sieling, 2013). Sieling's (2013) study brought up the relationship between standards-based grading and anxiety. Therefore, it is important to note that stress when faced with math-related situations is a cause and a characteristic of math anxiety (Sokolowski & Ansari, 2017).

Performance-Based Grading

Performance-based grading is a grading form that poses problem solving opportunities in which students use multiple strategies and various skills (Alkhateeb, 2018; Fuchs et al., 1999). Typically, teachers use tasks to assess several standards over a

period of time and challenge students to use higher-order thinking skills to create a product or complete a process (Chun, 2010). Teacher feedback and student reflection drive this formative process.

Alkahteeb (2018) studied 72 tenth grade students in Al-Zarqa city to determine the impact of performance-based grading on achievement and self-efficacy of students. Thirty-five of those students were in classes using a performance-based grading strategy, while the other 37 were in classes using traditional grading. Scores from a common achievement test given to all 10th grade math students were used to analyze any difference in achievement between the group using performance-based grading and the group using traditional grading. A Likert-scale survey to measure self-efficacy was given to the two groups; results were analyzed for any positive or negative differences between the performance-based grading group and the traditional grading group.

Liu (2000) studied the effects of performance-based grading on achievement and attitudes, motivation, and interest in mathematics. The participants were two mathematics classes of eighth-grade students in a New Franklin, Missouri High School. Both classes were taught by the same teacher. One class implemented performance-based grading, while the other class continued with traditional grading. The Stanford Achievement Test (9th edition) scores were used as the baseline (pre-test) for both classes. After 5 weeks a post-test designed to mimic the Stanford Achievement Test was given to both groups. Analysis of covariance was used to analyze the test scores for any signs of achievement differences between the two classes. After the post-test, teachers and students answered a questionnaire about their attitudes, opinions, interest level, and motivation in relation to mathematics.

Fuchs et al. (1999) examined the effects of classroom-based performance-based grading on teacher planning and student problem solving. Sixteen general educators from four schools in a southeastern urban district were the teacher participants. Student participants were students from the classrooms of the participating teachers for whom the researchers had complete information. Teachers were randomly assigned to performance-based conditions and non-performance-based conditions. Performance based teachers attended workshops, gave three performance-based assessments, and conferenced with colleagues to share ideas and score performance-based tasks.

These studies showed that performance-based grading positively impacts student achievement (Alkhateeb, 2018; Fuchs et al., 1999; Liu, 2000). However, the Fuchs et al. (1999) study showed some conflicting results. Fuchs et al. (1999) found that students who were performing at or above grade level did show higher achievement through performance-based grading. However, those students who were performing below grade level showed no improvement in achievement through performance-based grading (Fuchs et al., 1999).

Performance-based grading did have some effect on student attitudes towards mathematics and was found to increase self-confidence in mathematics (Alkhateeb, 2018; Liu, 2000). Alkhateeb (2018) stated that student's ability to participate in the development of evaluation criteria and their responsibility to demonstrate their learning all attributed to this increase in self-efficacy and self-confidence. Liu (2000) also found that the use of performance-based grading increased student motivation and interest which heightened their understanding of the content.

Portfolio Grading

Portfolio grading is a grading system that employs high-quality feedback on formative assessments to support a growth mindset in mathematics. Students examine teacher feedback and make corrections to learn from their mistakes and build a portfolio that demonstrates their progress toward a learning goal without being penalized for not getting it right the first time. This grading system values each student's abilities, values learning over speed and puts the responsibility on the student to put forth the efforts to learn. Grading periods are broken down into a series of short-term goals (daily or weekly assignments) as well as long term goals (formative assessments). This allows students to experience regular success through the completion of short-term goals. Long-term goals may require more effort to master, however, students are afforded the opportunity to master these goals through receiving teacher feedback to help them correct mistakes and eventually retest missed learning targets. The learning targets are designed based on the curriculum standards of the subject being taught.

There is not research specific to portfolio-grading as defined above, however portfolio grading shares similar themes with reflective grading, mastery-based grading, standards-based grading, and performance-based grading. Portfolio grading, performance-based grading, and standards-based grading use rubrics for a consistent method of determining a grade for students. Learning from mistakes, allowing corrections and retests, student ability to improve grade and the focus on feedback instead of grades are characteristics portfolio grading shares with mastery-based, reflective, and performance-based grading. Table 1 includes a summary of the different types of alternative forms of grading and how they relate to portfolio grading.

Table 1

Alternative Forms of Grading Summary

Type of Grading	Percentage Based (P) or Rubric Based (R)	Teacher Feedback	Student Feedback	Corrections Required	Retakes Allowed	Grade Can Change
Reflective Grading	P	Yes	Yes	Yes	Yes	Yes
Mastery-Based Grading	P	Yes	N/A	Yes	Yes	Yes
Standards-Based Grading	R	Yes	Yes	No	No	No
Performance-Based Grading	R	Yes	Yes	Yes	No	Yes
Portfolio Grading	R	Yes	Yes	Yes	Yes	Yes

Note. No information was found on the use of student feedback in mastery-based grading.

Feedback and Self-Efficacy

Feedback is a major component of all five grading methods included in this review as it is what drives students to begin the process of correcting and learning from their mistakes. Because of the importance of feedback to alternative grading practices, research about feedback regarding student learning and achievement is relevant. Also, feedback, along with other components of portfolio grading increases students' mathematics self-efficacy (Karl et al., 1993).

Research on Feedback

Hattie (2012) states that the most effective feedback happens when students lack mastery of a topic. Reflective, mastery-based, performance-based, and portfolio grading

all employ a learning from mistakes design and require teachers to provide feedback that redirects and or advances student learning (Alkhateeb, 2018; Armacost & Pet-Armacost, 2003; Baliram, 2016; Chun, 2010). Hattie (2009), in a synthesis of over 800 meta-analyses on achievement, found feedback to have a 0.75 effect score on student achievement. Hattie and Timperley (2007) stated effective feedback is one of the most crucial influences on student learning. Butler (1988), when studying twelve classes of fifth and sixth graders, found that scores and scores with feedback had little effect on student learning. They found students looked at the score and did not worry about why they missed problems. Students receiving feedback alone showed the most improvement. Portfolio grading emphasizes feedback, using the feedback to make corrections, and retesting the learning targets until mastery over a percentage grade. Teachers using portfolio grading give feedback specific to helping students move forward in the learning of specific standards and do not put a grade on assessments.

Thus, feedback is a component of portfolio grading and one way to increase self-efficacy is receiving feedback (Karl et al., 1993). There are other components of portfolio grading that also increase self-efficacy which I will discuss next.

Research on Self-Efficacy

Self-efficacy is the confidence a person has in their ability to complete a task or accomplish a goal (Bandura, 1986). Several studies have found that student self-efficacy in mathematics has a positive effect on student achievement. Liu and Koirala (2009), using a regression analysis of complex sample survey data, studied the relationship between mathematics self-efficacy and mathematics achievement of high school sophomores across the United States and found that there was a positive correlation

between mathematics self-efficacy and mathematics achievement. Both Nicolaidou and Philippou (1997) and Liu and Koirala (2009) found that mathematics self-efficacy influenced mathematics achievement more than attitudes toward mathematics did. Nicolaidou and Philippou (1997) studied 238 fifth-grade students using self-efficacy and attitude scales and a specially prepared test to analyze problem solving performance and found that there is a stronger correlation between self-efficacy and performance than between attitudes toward mathematics and performance. Research has also found a relationship between low self-efficacy and high anxiety (Comunian, 1989; Muris, 2002).

Research shows that students gain mathematics self-efficacy when they experience success with mathematics, set short term goals, and receive feedback (Bandura, 1986; Karl et al., 1993; Oldham, 2018; Özcan & Kültür, 2021). Setting short term goals, receiving feedback, and getting a chance to be successful at mathematics are principal tenets of portfolio grading and provide a basis to explore any effect portfolio grading may have on self-efficacy.

Conclusion

In this chapter I provided a review of literature that characterizes the study. I discussed four types of alternative forms of grading that share common themes with portfolio grading such as feedback, retesting, and individualized pacing. I then highlighted what research says about feedback and student learning. Finally, I shared some research about the effects of self-efficacy on student achievement and ways to promote self-efficacy. In the next chapter I will discuss the methodology used in implementing this study.

CHAPTER III: METHODOLOGY

Research shows several benefits to alternative forms of grading. Some studies found student mathematics achievement rose in mathematics classrooms using an alternative grading method (Alkahateeb, 2018; Baliram, 2016; Bond & Ellis, 2013; Bromley, 2019; Fuchs et al., 1997; Liu, 2000; Sieling, 2013). Students learning mathematics in a classroom implementing an alternative form of grading also showed an increase in mathematics self-efficacy (Alkhateeb, 2018; Bromley, 2019; Groen et al., 2015; Guskey & Gates, 1986; Kulik et al., 1990; Liu, 2000; Sieling, 2013). Furthermore, additional studies found setting short term goals, receiving feedback, and experiencing mathematical success all foster mathematical self-efficacy (Bandura, 1986; Karl et al., 1993; Oldham, 2018; Özcan & Kültür, 2021).

This study was designed to explore the mathematics self-efficacy of students after one semester of instruction in a mathematics classroom that used portfolio grading. An action research cycle was implemented for this study (Costello, 2003) with data including a pre- and post-survey and student interviews. This study specifically addresses the question: How does the use of portfolio grading in high school mathematics classrooms effect student mathematics self-efficacy, if at all?

In this chapter, the details about research design, research methods, what was measured, and how it was measured are discussed, including details about the population of the study and the instruments used to conduct the study. Finally, I will detail the data collection and analysis process used during this study.

An Action Research Approach

"Action research is a form of investigation designed for use by teachers to attempt to solve problems and improve professional practices in their own classrooms" (Parsons & Brown, 2002). The action research cycle involves observation and data collection which then leads to reflection and decision making by the teacher/researcher to improve student learning or classroom environment. Therefore, this study best fit an action research methodology approach.

As a department, Jones High School mathematics department saw a need for change in its grading approach in mathematics classes and thus implemented portfolio grading. I observed outcomes and effects of this grading change, paying particular attention to student self-efficacy with data from pre- and post-surveys and student interviews. Finally, time was spent analyzing and reflecting on the data to plan for further action.

Context of the Study

In this section, I address the components of the context of this study. I begin with a description of the setting for the study, and then describe the portfolio grading system and the student participants.

Setting

The study was conducted at Jones High School in the 2021-2022 school year (pseudonyms have been used for all names and places throughout this report). Jones High School is a public high school in a southeastern United States school district. Jones High School has an enrollment of 1787 students. The demographics for Jones High School are shown in Table 2.

Table 2

Jones High School Sociodemographic Characteristics

Demographics	Totals	Percent of Population
Males	934	52.3%
Females	853	47.7%
American Indian or Alaskan	4	0.002%
Asian	53	5.2%
Black or African American	270	15.1%
Native Hawaiian or Other Pacific Islander	1	0.0005%
White	1191	66.6%
Hispanic/Latino Ethnicity	210	11.8%
Multi-Racial	58	3.2%

Note. Demographics from the 2021-2022 school year.

Mechanics of Portfolio Grading

The study was conducted in select 9th, 10th, 11th, and 12th grade mathematics courses. Portfolio grading was implemented in all Integrated Math 1, 2 and 3 classrooms as well as the Bridge Mathematics classrooms at Jones High School in the 2021-2022 school year. The teachers and administrators at Jones High School, realizing parents would need a detailed explanation of what portfolio grading is and how it works, made a video and a newsletter detailing the rubric-like grade sheet, how the grade sheet is used to calculate grades and what is expected of students. The video and newsletter were sent to parents during the first week of the 2021-2022 school year. At the beginning of the school year teachers explained the portfolio grading process to students in their classes and gave each student a grade sheet (Appendix A).

At the beginning of each quarter every student in a classroom participating in portfolio grading starts with a grade of 96, which is an A on the Jones High School

grading scale. Students maintain the 96/A by completing all given tasks, on time, to 100% mastery. Tasks not completed on time will have penalties that are deducted from the starting grade of 96. Students can earn the 4 additional points to get to 100 by completing additional enrichment tasks.

Students receive a copy of the portfolio grading rubric (Appendix A) at the beginning of each quarter. This sheet is for students to use to keep up with the tasks and make sure they are completed within the time frame given. Each teacher's rubric may have a few differences based on their subject or grade level. On part one of the grading rubric students are expected to complete all tasks on time. Many of these tasks include correcting and or retaking assignments to 100% mastery since 100% mastery is expected. Students could have several attempts at achieving mastery. When retaking an assessment, students are only asked to retake the questions that they originally missed. Teachers give students a time frame by which to have assignments, corrections, and retakes completed. If students complete an assignment but it is past the due date, one point is deducted from the 96. Thus, if one assignment is turned in late, all quarter the student's grade will be a 95. If an assignment is never completed, additional penalties are given.

In part two of the grading rubric, students have the option of completing several enrichment activities to earn additional points for their grade. These tasks may vary from teacher to teacher. However, they are all worth one point each that can be added to the student's final grade. When the student receives the grading rubric, there is a detailed explanation of what is expected for each enrichment activity to earn the point. Because this is different from the traditional grading system, it will look slightly different when it is entered into the grading platform. Each student starts with a 96 as the first

grade. Each quarter as assignments are given a 1, 0, negative 1, negative 2 or possibly a negative 3 is recorded in the grade book. One means that the student completed an enrichment activity to add one point to their grade. For example, if they had a 96, meaning everything was completed to mastery on time, they would have one point added to their grade so their final grade would be a 97. Zero means that the assignment was completed to 100% mastery on time, with no additional points to be given or taken away. So, if they have a 96, they will keep a 96. Negative 1 means that the assignment was completed to 100% mastery, but it was turned in late. So, if they had a 96 but turned in the assignment late, they would now have a 95. Any other negative amount would mean that the assignment was never completed, and that number of points would be deducted from the grade. Participants in this study, described in the next section, were all enrolled in classrooms using this portfolio grading system.

Participants

The participants of this study were students in eight classrooms at Jones High School (see Table 3). I chose to work with these specific teachers' classrooms because these teachers had piloted portfolio grading in the 2020-2021school year, allowing teachers to practice some trial and error to create solid methods for task corrections and task retakes that work for their classroom instruction and management style. From these eight classes, I selected a diverse set of ten case study participants.

Table 3

Participant Classes

Teacher Name	Course	Grade	Period	Case Study Participant
Ms. Neat	Integrated Math 1	9	1	Lewis
Ms. Neat	Integrated Math 1	9	5	Lisa
Ms. Neat	Integrated Math 1	9	1	Nathan
Mrs. Roe	Integrated Math 2	10	1	None
Mrs. Roe	Adv. Integrated Math 2	9	3	Sam
Mr. Bean	Integrated Math 3	11	2	Bonnie
Mr. Bean	Adv. Integrated Math 3	10	7	Callie
Mr. Bean	Adv. Integrated Math 3	10	7	Grant
Ms. Jensen	Bridge Math	12	3	None
Ms. Jensen	Bridge Math	12	7	Sadie
Ms. Jensen	Bridge Math	12	7	Sarah
Ms. Jensen	Bridge Math	12	7	Tim

Note. Adv. indicates an advanced honors class.

Survey participants consisted of 30 students from the eight classrooms listed in Table 3. From the 30 survey participants, I selected five female and five male case study participants. Also, participants were selected to represent a variety of grade levels.

Instrument and Data Sources

This study focused on student mathematics self-efficacy as related to portfolio grading. I collected data using the Fennema-Sherman Mathematics Attitude Scales (1976) and recorded and transcribed interviews of the participants. My data sources and research questions guided my decision to use both a qualitative and quantitative approach to data collection (Stake, 1995). The next section presents a description of each of the data sources I employed.

Fennema-Sherman Mathematics Attitude Scales (1976)

The Fennema-Sherman Mathematics Attitudes Scales (see Appendix B; Fennema & Sherman, 1976) are "nine domain specific Likert type scales" (p. i) designed to measure crucial attitudes concerning learning mathematics. Fennema and Sherman included the following nine scales in their research: Attitude Toward Success in Mathematics Scale, Mathematics as a Male Domain Scale, Confidence in Learning Mathematics Scale, Mother Scale, Father Scale, Teacher Scale, Usefulness of Mathematics Scale, Mathematics Anxiety Scale, and Effectance Motivation in Mathematics Scale. Because these scales have been validated to be used individually, I chose to use the following scales in the survey used in data collection: Confidence in Learning Mathematics Scale, Mathematics Anxiety Scale, and Effectance Motivation in Mathematics Scale. I chose the confidence in learning mathematics scale, the mathematics anxiety scale, and the effectance motivation in mathematics scale because these three scales measure the constructs that have been found to have an impact on self-efficacy. The confidence in learning mathematics scale was used because self-efficacy is defined as the confidence one has in their ability to do certain tasks or reach certain goals (Bandura, 1986). Therefore, self-efficacy in mathematics reflects student's confidence in their ability to learn and do mathematics. I used the mathematics anxiety scale on the survey because studies have shown a relationship between low self-efficacy and high anxiety (Comunian, 1989; Muris, 2002). Also, in relation to anxiety, it is important to note that feelings of stress when facing math related situations is a characteristic of math anxiety (Sokolowski & Ansari, 2017).

Finally, the effectance motivation scale was used because, according to White (1959), effectance motivation is the rewarding feeling of engaging in an activity and effecting the activity. He goes on to define that rewarding feeling as efficacy (White, 1959). Therefore, the effectance motivation score in mathematics and student mathematics self-efficacy are related.

Research Journal

I maintained a research journal throughout this study. This journal provided a retrospective view for decisions made during data collection and analysis (Borg, 2001). In this journal I wrote about my method for choosing interview cases and any changes I had to make such as not having signed consent. I kept track of the classrooms I chose to use in my research and why I chose them. Also, as I was analyzing data from the surveys, I reflected on how I administered the surveys and interviews and noted the things I wished I had done differently. This assisted me in the writing of the limitations and delimitations section of this paper.

Interviews

Case study interviews were conducted as a follow-up to investigate survey responses (McNamara, 1999). The case study participants were interviewed, using a semi-structured interview protocol (see Appendix C), privately by the researcher both at the beginning and end of the semester during a time in the school day where they would not miss instruction. The classroom teachers gave me access to the portfolios of the case study participants so I could use samples of their work for stimulated recall during the interview process. Transcripts of the interviews were analyzed, and case narratives were

written for each interview participant. Then I analyzed similarities and differences across the cases.

Procedures

As stated above, I used three categories from the Fennema-Sherman Mathematics Attitude Scales for the pre- and post- survey (see Appendix B). The survey was given to all students in the participating classes. Prior to giving the pre-surveys I explained the study to the students in each participating classroom. I then handed out parent and student consent forms. To keep participation anonymous, I gave the surveys (pre and post) to everyone and only used the data of students from whom I received signed consent forms. I gave the pre-survey in the first 3 weeks of the semester. The post-survey was given in the last 2 weeks of the semester. The survey was scored according to the validated key (see Appendix D). I used the pre-survey to identify participants for the interview case studies. Then I compared pre/post measures by calculating confidence intervals for each scale surveyed.

Each survey category had 12 statements. Each statement had the following response options: A representing strongly agree, B agree, C neutral, D disagree, E strongly disagree. The first six statements on each scale were worded to indicate a most favorable attitude or belief if the student agreed. The last six statements on each scale were reversed and worded to indicate a most favorable attitude or belief if the student disagreed. The response choices were equated to scores so that the most favorable response was assigned 5 points and the least favorable response was assigned 1 point.

Recorded data from the survey consisted of the participant identifier, course taken, grade classification, teacher name, agreement to be interviewed and numerical

value equal to the letter response chosen for each statement of each scale. This data was organized in a spread sheet with a column for the participant identifier, course, grade, teacher, and agreement to be interviewed. Each statement from each category for pre- and post- surveys were represented in a column as were individual scale totals and overall scale totals.

To analyze the data from the pre- and post- survey, I calculated confidence intervals on the mean of the differences in the pre- and post-survey scores for each of the individual scales (Confidence in Learning Mathematics Scale, Mathematics Anxiety Scale, and Effectance Motivation in Mathematics Scale). I also calculated the confidence interval on the mean of the differences in the pre- and post-survey of the overall scores on the survey. To calculate the intervals, I took the difference between the post-survey and the pre-survey for the three individual scales and the total survey scores. Then I ran the descriptive statistics on those differences in Excel using a 95 percent confidence level. This process gave the mean, the standard error, the number of observations, and the confidence level (confidence coefficient times the standard error). Finally, I took the mean for each scale and added and subtracted the confidence coefficient times the standard error to find the upper and lower bound number of the confidence intervals.

Interviewees were chosen based on scores in specific scales on the survey and on their agreement to be interviewed. A male and female were chosen based on the following scores: highest overall survey score, lowest overall survey score, lowest confidence score and lowest anxiety score. Note that on the anxiety scale a low score indicates high anxiety.

Interviews were conducted near the beginning and the end of the first semester using a semi-structured interview protocol (see Appendix C). The interviews were transcribed. I analyzed the interview responses and wrote case narratives for each interview participant. Then I analyzed similarities and differences across the cases.

Limitations and Delimitations

There were some factors of this study that were either out of my control (limitations) or within my control (delimitations) that may have impacted the research and or results. Below I discuss these limitations and delimitations of this study.

Limitations

Limitations of the study include factors outside of my control that impeded my methodology and conclusions. Two limitations that should be considered are sample size and subjectivity of data.

The first limitation of this study was the smaller sample size. I had 30 students return the signed consent forms. Therefore those 30 were the only students I could use as participants, out of the 141 I invited to participate in the study. A small sample size could make it harder to determine if certain outcomes are generalizable to the population.

The other limitation of this study was the data type. All the data collected was somewhat subjective. The surveys depended on students reading the statements and responding based on how they felt about that statement. I had no control over how seriously the participants took the survey or how accurately they responded to it. Also, as the interviews were based upon the participants spoken responses, if the participants failed to answer honestly and candidly, the conclusions may not accurately reflect the effects of portfolio grading.

Delimitations

Certain decisions were made regarding factors that were under my control. These decisions serve as delimitations for this study. The primary delimitations of this study that should be considered are the classes from which I chose to pull participants, how the post-survey was administered, and the time span of the study.

First, even though the whole mathematics department at Jones High School was practicing portfolio grading, I limited this study to 2 classes each of 4 teachers. This decision was made based on teacher experience with portfolio grading. The 4 teachers' had piloted portfolio grading the school year prior to this study, allowing them a better understanding of the portfolio grading process. Also because of their previous experience with portfolio grading they had created reliable methods for task corrections and task retakes that worked for their classroom instruction and management style.

Another delimitation of this study was how I chose to administer the post-survey. I did not give the participants their pre-survey back when administering the post-survey. In retrospect, I think had participants been able to see how they felt in the pre-survey about each statement they could have more accurately responded on the post-survey.

A further delimitation involved the choice I made for the length of the study. I chose to conduct this study for an 18-week period (one full semester). The participants had no experience with alternative forms of grading. Therefore, by starting at the beginning of the school year I felt I would get better responses to their feelings about mathematics and mathematics classes. The choice to end the study at the end of the first semester was made since a full semester would allow participants to have experienced

two grading periods of portfolio grading, I felt this to be enough time to see any effects portfolio grading may have on student self-efficacy.

I believe the choices I made at the time set reasonable boundaries for this study. Limitations were minimized, allowing me to make some contribution to the literature that already exists on alternative forms of grading as well as starting a literature base for portfolio grading as defined in this study.

Conclusion

In this chapter, I detailed the methodology of this study. The action research design was discussed. I provided aspects about the context of the study, discussing the setting of the study as well as information concerning the participants. A summary of the instruments used and sources of data collection were given, followed by the procedures for analyzing the data. Finally, I discussed limitations and delimitations to this study. In the following chapter, I will discuss the results of my analysis.

CHAPTER IV: FINDINGS

In this study, I examined the effects of using portfolio grading in mathematics classrooms on students' mathematics self-efficacy. To attain this goal, I conducted pre- and post- surveys using the Fennema-Sherman Mathematics Attitude Scales (1976) and conducted semi-structured interviews based on several components of the pre-survey. This chapter describes the findings of this study. I begin with an analysis of the pre- and post-survey data using confidence intervals in that analysis. Then, I present the findings that emerged from the semi-structured interviews before concluding with a cross-case analysis.

Pre- and Post-Surveys

In this section I present the analysis of the data collected from the pre- and post-surveys. These surveys consisted of three of the scales from the Fennema-Sherman Attitude Scales (1976), specifically the Confidence in Learning Mathematics Scale, the Mathematics Anxiety Scale, and the Effectance Motivation in Mathematics Scale. Table 4 shows the 95% confidence intervals of the means of the differences from pre- to post- of the 30 participants on each of the three scales and the total of the three scales. Additionally, Table 4 contains the important values which were needed to calculate the confidence intervals. I will give a description of these values and the findings in the following paragraphs.

Table 4

Pre- and Post-Survey Mean Differences Confidence Intervals

Name of Scale	Mean Diff.	Standard Error	95% CI
Confidence in Learning Mathematics	3.433	0.748	[1.81, 5.05]
Mathematics Anxiety	3.367	1.107	[0.963, 5.770]
Effectance Motivation	1.133	0.88	[-0.776, 3.042]
Three-Scale Total	7.933	1.468	[4.584, 11.282]

Note. N = 30

Confidence Survey Score

The mean of the differences in pre- and post-survey scores for the 30 participants for the Confidence in Learning Mathematics Scale was 3.433 with a standard error of 0.748. This produces a 95% confidence interval of [1.9, 4.9]. Because this interval is entirely above zero, I can conclude, with 95% confidence, that participants experiencing portfolio grading had an increased mean gain on the Mathematics Confidence Scale.

Mathematics Anxiety Score

The mean of the differences in pre- and post-survey scores for the 30 participants for the Mathematics Anxiety Scale was 3.367 with a standard error of 1.107. This produces a 95% confidence interval of [1.1, 5.7]. Since this interval is entirely above zero, I can conclude, with 95% confidence, that participants experiencing portfolio grading had an increased mean gain on the Mathematics Anxiety Scale.

Effectance Motivation in Mathematics Score

The mean of the differences in pre- and post-survey scores for the 30 participants for the Effectance Motivation Scale is 1.133 with a standard error of .88. This produces a

95% confidence interval of [-.7, 2.9]. Since this interval includes zero, I cannot conclude that participants experiencing portfolio grading have any change on the Effectance Motivation Scale.

Total Survey Score

The mean of the differences in pre- and post-survey scores for the 30 participants for the three-scale total was 7.933 with a standard error of 1.468. This produces a 95% confidence interval of [4.9, 10.9]. Because this interval is entirely above zero, I can conclude, with 95% confidence, that students experiencing portfolio grading had an increased mean gain on the three-scale total.

Interviews

Interviews were conducted as a follow-up to investigate survey responses (McNamara, 1999). Ten students, Bonnie, Nathan, Callie, Sadie, Tim, Sam, Sarah, Lewis, Lisa, and Grant were interviewed using a semi-structured interview protocol (see Appendix C). I interviewed these students at the beginning of the semester and again at the end of the semester.

Bonnie

Bonnie is in the 11th grade in an Integrated Math 3 class at Jones High school. She was chosen as an interview subject based on her confidence scale pre-score from the Fennema-Sherman Survey. Her score was a 12 out of 60 (see Table 5), which was the lowest confidence scale score observed out of the consenting survey participants. Her post-survey scores all increased, with her anxiety scale score increasing by 13 points indicating a decrease in math anxiety (see Table 5).

Table 5

Bonnie's Survey Scores Compared to the Participants as a Whole

Scale Name	Bonnie's Pre	Bonnie's Post	Pre Min	Post Min	Pre Max	Post Max
CLM	12	17	12	15	56	60
MA	12	25	12	12	47	57
EM	19	23	12	12	54	54
3-Scale Total	43	65	41	46	150	163

Note. CLM abbreviation for Confidence in Learning Mathematics Scale MA abbreviation for Mathematics Anxiety Scale. EM abbreviation for Effectance Motivation Scale.

> When asked to tell me about her experiences in mathematics classes, Bonnie said: I don't do very good. I try just, I don't understand numbers, no matter how hard I study or if I look it up on YouTube or ask the teacher 100 questions, it just doesn't go easy for me at all. (Bonnie, Interview 1)

Also, when I asked her in the first interview how she felt about mathematics in general she stated, "I don't like it. I hate it" (Bonnie, Interview 1). When asked if she felt like she had ever had any success in a mathematics class she said "No, I fail like all the tests" (Bonnie, Interview 1). These statements from Bonnie align with her responses to statements from the pre-survey confidence scale. For example, Bonnie strongly disagreed with the following two statements: "Generally I have felt secure about attempting mathematics" and "I have a lot of self-confidence when it comes to math" (Fennema-Sherman, 1976, p. 21). She strongly agreed with: "I'm no good in math" and "Math has been my worst subject" (Fennema-Sherman, 1976, p. 21).

Bonnie's confidence score on the post survey was a 17 out of 60, which is five points higher than her pre-survey score. After a semester of portfolio grading, instead of

strongly disagreeing with the statement “Generally, I have felt secure about attempting mathematics” Bonnie now has a neutral feeling about that statement (Fennema-Sherman, 1976, p. 21). She also changed from strongly agreeing with “I’m no good in math” to feeling neutral about that statement. This change to a more neutral tone is also observed in Bonnie’s second interview. When asked how she feels about mathematics in general after experiencing a semester of an Integrated Math 3 class that employed portfolio grading, she said “It’s just the same”. When asked about portfolio grading, she said “I mean, it's a better way to grade than normally. Like, you get a better grade on stuff. Or you get to make stuff up” (Bonnie, Interview 2). Bonnie also said that portfolio grading allowed her more time to learn concepts by doing corrections and retesting (Bonnie, Interview 2). When I asked about feeling successful this year, Bonnie said “I am passing right now” (Bonnie, interview 2). Though she still does not love mathematics, she has seen that she has some opportunity to do better with portfolio grading.

In summary, Bonnie’s post-survey scores increased on all three scales (see Table 5). Her past experiences with mathematics classes had not been positive. After a semester of portfolio grading, she was earning higher math grades than she had in previous math classes. She also felt like she was learning and understanding mathematical concepts better under this type of grading. Even though she did not express in the interviews anything about portfolio grading allowing her to feel less anxiety, her mathematics anxiety scale score did go up 13 points. This rise in score indicates lower feeling of anxiety with portfolio grading.

Nathan

Nathan, a 9th grade Integrated Math 1 student, was also selected as an interview subject based on his confidence scale pre-survey score. His score was a 30 out of 60 (see Table 6), which was a low confidence scale pre-survey score for males in this sample. He did have a 6-point increase on the confidence in learning mathematics after a semester of portfolio grading.

Table 6

Nathan's Survey Scores Compared to the Participants as a Whole

Scale Name	Nathan's Pre	Nathan's Post	Pre Min	Post Min	Pre Max	Post Max
CLM	30	36	12	15	56	60
MA	26	24	12	12	47	57
EM	27	35	12	12	54	54
3-Scale Total	83	95	41	46	150	163

Unlike Bonnie, Nathan had not always disliked mathematics nor had bad experiences with mathematics.

> Before this year, I feel like I used to enjoy math a lot more up until seventh grade. That's when I don't know why just things didn't seem to click as much as they used to. I don't think I answered this question well. I think in eighth grade, I started to understand it more. Then this year, just kind of that all went out the window again (Nathan, Interview 1).

Many of Nathan's early experiences with mathematics were enjoyable. It seems that his difficulties came as the mathematics became more complex.

After a semester of a mathematics class that employed portfolio grading, Nathan's confidence scale survey score rose six points. In his pre-survey he disagreed with the statement "I am sure I could do advanced work in mathematics" (Fennema-Sherman, 1976, p. 21). In the post-survey he had a neutral opinion for that same statement. Also, Nathan agreed with the following statements: "I'm no good in math", "I don't think I could do advanced mathematics", and "I'm not the type to do well in math" in the pre-survey coming to a neutral stance on those same statements after a semester of portfolio grading (Fennema-Sherman, 1976, p. 21). In his second interview, when talking about his experience with portfolio grading, he stated "The ability to redo everything, you know, it's been a lifesaver for my grades. And I think it helps me understand it (the concepts) a little bit more" (Nathan, Interview 2). Nathan felt that the process of correcting work helped him to better understand the material.

In summary, Nathan's confidence in learning mathematics score and effectance motivation score went up on the post-survey. His math anxiety score decreased slightly but interview data did not reveal any reason for this decrease. He expressed that portfolio grading allowed him to keep his grade up even though he was struggling with some concepts. He also felt portfolio grading allowed him to take the time he needed to understand concepts better.

Sadie

Sadie was a 12th grade Bridge Math Student at Jones High School. Sadie was selected as an interview subject due to having the lowest pre-survey score on the anxiety scale. As shown in Table 7, Sadie scored low on all three of the scales given. Also, her

anxiety score was the lowest score that one could get, signifying that mathematics classes make her anxious.

Table 7

Sadie's Survey Scores Compared to the Participants as a Whole

Scale Name	Sadie's Pre	Sadie's Post	Pre Min	Post Min	Pre Max	Post Max
CLM	13	19	12	15	56	60
MA	12	18	12	12	47	57
EM	16	18	12	12	54	54
3-Scale Total	41	55	41	46	150	163

Her feelings about mathematics were also evident in her initial interview. When asked about her previous experiences and successes with math and how she felt about math, Sadie said she had never had good experiences in math classes and that math is very hard for her.

> I've never really had good experience in math classes, I never understand it. And most, some teachers don't really care enough to like, see how I'm not getting it. Instead, they just like, explain it, and I'm still not getting it. So, I've just never had a good experience in math. I don't like it. (Sadie, Interview 1)

Sadie's pre-survey score and interview statements align. She does not like math and has not had good experiences in math, which explains her low confidence and anxiety scores.

Sadie did have a score increase of six points on the anxiety scale for the post-survey. On the pre-survey she strongly disagreed with the following statements: I haven't

usually worried about being able to solve math problems" and "I almost never have gotten shook up during a math test" (Fennema-Sherman, 1976, p. 22). However, on the post-survey she agreed with those same two statements. Also, at the time of her first interview students had been in class for about 30 days so she had some experience with portfolio grading and was already feeling less pressure to have to do everything perfectly on the first try. "Yeah, it's made me not feel like, pressured when I feel like I can, like mess up and then like, redo what I did wrong. Or like, it makes me feel like I might have another shot at trying" (Sadie, Interview 1). In her second interview when asked about her feelings about math class this year, she stated,

> I feel like this math class has been easier than all the other ones because it's, I don't feel like I have to like, stress myself out to do the work. And I have been able to keep a really good grade in math this year. (Sadie, Interview 2)

She also put emphasis on how portfolio grading allows her to take a little more time to understand concepts. "I can go back several times, until I can understand. And if I don't finish this one assignment this day. I could work on it the next day and still get the next one finished too" (Sadie, Interview 2).

In summary, Sadie's scores on all three scales of the post-survey increased. Also, after a semester of portfolio grading, she was feeling more successful and less anxiety. She also felt she was understanding concepts better than in previous math classes.

Tim

Tim, like Sadie, was a 12th grade Bridge Math student at Jones High School. He was also chosen based on his pre-survey score on the Fennema- Sherman Anxiety Scale. His score on the anxiety scale was one of the lower male scores observed (see Table 8).

Table 8

Tim's Survey Scores Compared to the Participants as a Whole

Scale Name	Tim's Pre	Tim's Post	Pre Min	Post Min	Pre Max	Post Max
CLM	37	40	12	15	56	60
MA	32	35	12	12	47	57
EM	35	36	12	12	54	54
3-Scale Total	104	111	41	46	150	163

In the pre-survey, Tim disagreed with the statement "Math doesn't scare me at all" Fennema-Sherman, 1976, p. 28). He agreed with the statements "A math test would scare me" and I get a sinking feeling when I think of trying hard math problems" (Fennema-Sherman, 1976, p. 28). His feelings about these statements indicate some anxious feelings about mathematics. In interview 1 when I asked Tim how he feels about math classes in general, he stated "I know you really need it for your everyday. But I wish it wasn't a requirement" (Tim, Interview 1). Also, when I asked Tim about any success he has experienced in mathematics, he said "It's (math) always a struggle" (Tim, Interview 1). Most of the first interview with Tim consisted of him making statements about how he has used math in real-life situations and how important concepts like measurement and area are in his father's cabinet business. When I asked Tim about his feelings about mathematics he stated the following,

> I use it to help my dad with his cabinet company. We have to measure two by fours and everything. Math helps me in knowing how much material and stuff I

> have to use, you know. I mean, so I don't have to buy more material or just waste it (Tim, Interview 1).

Even though Tim's experiences with math have not been totally positive, he sees the need and usefulness of math.

Tim's post-survey anxiety score rose three points. The response change that stood out the most was to the statement "Math doesn't scare me at all" (Fennema-Sherman, 1976, p. 28). On the pre-survey he disagreed with that statement on the post-survey he agreed with it. In the second interview when I asked Tim about how he has felt about his math class so far this year, he stated "Well, the teacher makes it pretty easy. She helps us whenever we need it" (Tim, Interview 2). When asked him specifically about the grading, he indicated that he likes that he has been able to have a good cumulative grade in math. "I like that I have had a decent math grade this year for once. But the grading is pretty weird. Like, I see my mom go on the online gradebook and get onto me for all the zeros on there" (Tim, Interview 2). Portfolio grading has allowed Tim to feel some success in math class but after a semester of portfolio grading his mom does not understand how the grading works.

In summary, after a semester of portfolio grading, Tim's post-survey scores increased on all three scales. He also had been able to experience some success in mathematics due to portfolio grading.

Sarah

Sarah was a 12th grade Bridge Math student at Jones High School. She was chosen based on her low score on the effectance scale of the pre-survey. She did not have the lowest score on this scale, but the two females with lower scores than her were

Bonnie and Sadie. So, since I had chosen Bonnie and Sadie for other scales, Sarah was next in line. Sarah's post-survey effectance scale score was two points lower than her pre-survey score on that same scale (see Table 9).

Table 9

Sarah's Survey Scores Compared to the Participants as a Whole

Scale Name	Sarah's Pre	Sarah's Post	Pre Min	Post Min	Pre Max	Post Max
CLM	14	15	12	15	56	60
MA	12	12	12	12	47	57
EM	21	19	12	12	54	54
3-Scale Total	47	46	41	46	150	163

The only statement from the effectance scale with a significant response change was "I would rather have someone give me the solution to a difficult math problem than to have to work it out for myself" (Fennema-Sherman, 1976, p. 29). On the pre-survey she disagreed, and on the post-survey she strongly agreed. In interview 1 when I asked Sarah about her experiences in mathematics classes, she stated "I've never done very well, because I struggle with numbers. I've always, this is probably like my best year in math" (Sarah, Interview 1). She told me she was "not a big fan" of mathematics in general (Sarah, Interview 1). Also, when asked in Interview 1 and 2 about how she felt about portfolio grading, she indicated that she liked it better than traditional grading. She also said the reason she liked it was because it made her go back and look at her mistakes which helps her understand better. "Portfolio grading is better. Because you can go back

and look at your mistakes. And you can keep practicing and try again to get it right and it helps understand better" (Sarah, Interview 1).

Looking over all the survey scales for Sarah, only her confidence score went up by one point, with her anxiety scale staying the same and the effectance going down. However, there were statements made in the interviews that spoke differently to how she scored on the surveys. For instance, in interview 1 when I asked her about successes in mathematics, she stated "I'm improving. So that's a good thing. It went from like, horrible to like, this is my first time ever having an *A* on a report card in my math class. So that's pretty cool" (Sarah, Interview 1). She also has felt less pressure in math this year. "I don't feel as much pressure in this math class as previous math classes. And now we're going at a slower pace, so I can actually understand it" (Sarah, Interview1). In interview 2 when I asked her if this year's math class has been better than previous years she said "yes" (Sarah, Interview 2). I followed that up with what do you think has contributed to that and she stated, "Probably with like the grading system this year, I can do multiple attempts of trying and before the grade you earned the first time was the grade you kept" (Sarah, Interview 2). She had a better math experience this year than she had in the past and attributes that to portfolio grading.

In summary, although Sarah's survey scores changed very little from pre- to post-survey, in her interviews she expressed feeling more successful and less anxiety after a semester of portfolio grading. She also felt like portfolio grading allowed her to learn concepts better than she had been able to in the past.

Lewis

Lewis was a 9th grade Integrated Math 1 student at Jones High School. He was chosen as an interview case based on his low pre-survey effectance scale score. Although his score was not the lowest pre-survey effectance score, it was one of the lower male scores on that scale. Lewis's did have a small increase on each scale score of 1 to 3 points (see Table 10).

Table 10

Lewis's Survey Scores Compared to the Participants as a Whole

Scale Name	Lewis's Pre	Lewis's Post	Pre Min	Post Min	Pre Max	Post Max
CLM	47	50	12	15	56	60
MA	43	45	12	12	47	57
EM	27	28	12	12	54	54
3-Scale Total	117	123	41	46	150	163

Lewis's confidence scale score and his anxiety scale score indicated that he is not lacking in mathematics confidence, nor does math make him highly anxious. But his effectance score is low. On his post-survey only two statement responses changed from his pre-survey. In the pre-survey, Lewis answered disagree to the statement "When a math problem arises that I can't immediately solve, I stick with it until I have the solution" (Fennema-Sherman, 1976, p. 29). But on the post-survey he answered neutral to the same statement increasing his score by 1 point. Also, in the pre-survey he answered agree to the statement "Figuring out mathematical problems does not appeal to me" but answered neutral to this statement on the post-survey (Fennema-Sherman, 1976, p. 29).

From pre to post survey his answers only changed the score by one point. Lewis has had a good experience with math classes. When I asked him how he feels about math class in general, he said "I feel pretty good. It's usually like, mid-level hard. Tests, I usually do pretty well on, so that's good" (Lewis, Interview 1). Lewis also feels he's able to learn math while feeling less pressure and stress by being in a math class that employs portfolio grading. "Yeah. I feel less pressured. But then also at the same time because you get to keep going back and revisiting through corrections, you eventually learn it" (Lewis, Interview 1). When I asked him if he had felt any kind of anxiety associated with math class this year, Lewis stated "Not about grades. No, like, like work and grades, anything like that. It hasn't really been like, stressful or anything like that to go to class" (Lewis, Interview 2). I followed that response up by asking him what he thought might contribute to that. He stated, "Um, I think the portfolio grading definitely has something to do with it" (Lewis, Interview 2). Lewis has not felt any kind of anxiety associated with math this year and he feels portfolio grading has allowed that.

In summary, Lewis's survey scores went up 2 to 3 points on each scale from pre- to post-survey. Lewis indicated he enjoys mathematics and has seen success in mathematics classes in the past and has continued to do so. He also indicated after a semester of portfolio grading, he felt less stress and anxiety related to math class. Finally, he felt that due to having to reflect on and correct his work, he had learned concepts better this year than in years past.

Callie

Callie was a 10th grade, Advanced Honors Integrated Math 3 student at Jones High School. She was selected to be interviewed based on having a low total pre-survey

score and consenting to participate and be interviewed. There was very little change between Callie's total pre-survey score and total post-survey score. Also, her pre-survey and post-survey anxiety scale scores were lower than the average for those scales (see Table 11).

Table 11

Callie's Survey Scores Compared to the Participants as a Whole

Scale Name	Callie's Pre	Callie's Post	Pre Min	Post Min	Pre Max	Post Max
CLM	43	40	12	15	56	60
MA	27	30	12	12	47	57
EM	38	38	12	12	54	54
3-Scale Total	108	108	41	46	150	163

On examination of her surveys, the two statements showing the most change in response was the statement, "Most subjects I can handle O.K., but I have a knack for flubbing up math" and "I haven't usually worried about being able to solve math problems" (Fennema-Sherman, 1976, p. 29). Callie answered strongly agree to the statement "Most subjects I can handle O.K., but I have a knack for flubbing up math" (Fennema-Sherman, 1976, p. 29) on the pre-survey. On the post-survey she gave a neutral response to that statement. Also, on the pre-survey Callie answered disagree to the statement "I haven't usually worried about being able to solve math problems" (Fennema-Sherman, 1976, p. 29). Her response changed to strongly agree for that statement on the post-survey. During interview 1 with Callie, she told me she had always felt pretty good about math classes and had always made good grades until her 9th grade

year because everything was virtual. During virtual learning she failed math for the first time (Callie, Interview 1). Callie also stated in interview 1 and 2 that she likes portfolio grading. In interview one when I asked her about how she felt about portfolio grading she stated, “Yeah, I feel confident in my grade at all times. And that's really nice. Is that like, there's less pressure and there's less stress. Like the less stress the easier it is for me to focus” (Callie, Interview 1).

And in interview 2 she said,

> I still really like portfolio grading, as in the fact that I can make up for my tests. But I have noticed that the more I started relying on oh, I'll just do test corrections, the less, I started to pay attention. Because I didn't do test corrections in the first quarter, which dropped my grade a little bit, because I didn't fully understand how portfolio grading worked. So, in the first semester, I tried my best and I got like 80s and 90s and above on all my tests. But I didn't fully understand the test corrections and I thought it was optional. And you only did it if you wanted a better score. But then once I started to understand what test corrections were, then I got used to doing test corrections no matter what. So, it makes no difference if I get 12 wrong or two wrong. (Callie, Interview 2)

Callie is an advanced honors math student and though she likes the portfolio grading she thinks it’s made her reliant on the fact that she will have chance to do better, so she is not studying as much for the first attempt.

In summary, Callie is an advanced honors student who has always liked math and been successful with it. She stated that portfolio grading has allowed her to feel less

pressure and anxiety related to math. However, she did indicate that the nature of portfolio grading allowed her to be somewhat apathetic in math this year.

Sam

Sam was a 10th grade Advanced Honors Integrated Math 2 student at Jones High School. He was selected to be interviewed based on having a low total pre-survey score and consenting to participate and be interviewed. Between pre-survey and post-survey, Sam had an eight-point score decrease (see Table 12).

Table 12

Sam's Survey Scores Compared to the Participants as a Whole

Scale Name	Sam's Pre	Sam's Post	Pre Min	Post Min	Pre Max	Post Max
CLM	56	54	12	15	56	60
MA	41	48	12	12	47	57
EM	41	28	12	12	54	54
3-Scale Total	138	130	41	46	150	163

Sam had an increase in the anxiety scale score of 7 points from pre- to post-survey. After a semester of portfolio grading, Sam changed his response from disagree to agree on the statement, "It would not bother me at all to take more math courses" (Fennema-Sherman, 1976, p. 28). This indicates he may be feeling more comfortable with math classes in general. However, looking at the effectance scale score that went down 13 points from pre- to post-survey. There were two statement answers from pre- to post-survey that stand out. The first statement "When a math problem arises that I can't immediately solve, I stick with it until I have the solution," pre-survey Sam answered

neutral changing to strongly disagree post-survey (Fennema-Sherman, 1976, p. 29) The second statement "I would rather have someone give me the solution to a difficult math problem than to have to work it out for myself," pre-survey Sam answered strongly disagree changing to neutral in the post-survey. This could indicate some change in his feelings about math, however I did not see any indication of that in the interviews or on the other two scales.

During Sam's interviews I learned that he has "very little trouble with math" and math is one of the easier subjects in school for him (Sam, Interview 1). Sam likes portfolio grading he stated, "it makes math a little less stressful" (Sam, Interview 2).

In summary, Sam is an advanced honors student who has always like math and done well in mathematics classes. The main takeaway from Sam's interviews were that he felt less anxiety and pressure with portfolio grading than he had with traditional grading.

Lisa

Lisa was a 9th grade Integrated Math 1 student at Jones High School. She was selected to be interviewed because she had a high total pre-survey score (see Table 13).

Table 13

Lisa's Survey Scores Compared to the Participants as a Whole

Scale Name	Lisa's Pre	Lisa's Post	Pre Min	Post Min	Pre Max	Post Max
CLM	54	55	12	15	56	60
MA	37	48	12	12	47	57
EM	54	53	12	12	54	54
3-Scale Total	145	156	41	46	150	163

Even though Lisa had a high total score on the pre-survey (see Table 13), her pre anxiety score was low indicating she experiences some anxiety associated with mathematics. However, that score did increase by 9 points (see Table 13) after a semester of portfolio grading indicating her feeling less anxious. The high pre-survey score was supported by Lisa's comments in Interview 1. For example, when I asked her how her experiences and successes with math classes were, her responses were positive. She explained she has always liked math and had good experiences and made "at least above a 90 in math" (Lisa, Interview 1).

The main theme in the second interview was portfolio grading lessened the stress and pressure she felt to do well immediately. For example, when I asked her how portfolio grading has helped with her learning, she stated, "I don't have to rush so much material in my head. I can take it and be like, I knew I wasn't going to be 100% sure about it, but I can do corrections to keep learning and understand the material. And I feel I have the material covered more than I did in previous years" (Lisa, Interview 2). In Interview 2 Lisa also stated,

> There's a less stress level for me. So, then I'm like, it's okay if I don't understand this one question. I'll just go over it, correct it learn from it, and then I'll be more confident for future tests like the midterm. (Lisa, Interview 2)

These statements from interview 2 indicate lower stress and better grasp of material associated with portfolio grading.

In summary, Lisa has always like math and performed well in math. Her experience with portfolio grading made her feel less anxiety and pressure. She also felt portfolio grading allows her to learn and understand the material better.

Grant

Grant was a 10th grade, Advanced Honors Integrated Math 3 student at Jones High School. I chose to interview Grant based on his high overall pre-survey score (see Table 14). Like Lisa, Grant had good experiences and was successful in math classes (Grant, Interview 1). However, unlike Lisa, Grant's survey scores increased from pre- to post-survey on all the scales surveyed (see Table 14).

Table 14

Grant's Survey Scores Compared to the Participants as a Whole

Scale Name	Grant's Pre	Grant's Post	Pre Min	Post Min	Pre Max	Post Max
CLM	55	57	12	15	56	60
MA	47	52	12	12	47	57
EM	48	50	12	12	54	54
3-Scale Total	150	159	41	46	150	163

Grant had the largest increase, five points, on the mathematics anxiety score, indicating his anxiety decreased. Grant initially answered C (neutral) to "It wouldn't bother me at all to take more math courses" (Fennema-Sherman, 1976, p. 28), but on the second survey he agreed with that statement. He also answered disagree with the statement "Mathematics usually makes me feel uncomfortable and nervous" (Fennema-Sherman, 1976, p. 28) on the pre-survey and on the post-survey he answered strongly disagree. His answers that changed followed this pattern of only move by one point in the positive direction. His scores initially were high to only become higher after a semester of portfolio grading. This decrease in feelings of anxiety shown on the survey were supported in Grant's second interview. When I asked Grant how he feels about portfolio grading, after a month of experiencing it, he stated, "It relaxes the setting of test taking," which indicates he felt less anxious in association with math testing (Grant, Interview 1). He also stated, "it (portfolio grading) helps me understand concepts better. I get to reevaluate questions and my answers and see my mistakes and learn from them" (Grant, Interview 2).

In summary, Grant is an Advanced Honors Integrated Math 3 student who has always enjoyed math and been successful with it. He feels that the nature of portfolio grading allows him to understand concepts better and lessens any stress or anxiety when it comes to math tests.

Cross Case Comparison

There were four common themes among the interview cases. Common experiences with previous math classes, lower stress and anxiety related to mathematics, increased understanding, and feeling more successful in mathematics were the themes

noticed among the participants. Two students discussed two different issues that no other students touched on. One of those differences was parent issues with portfolio grading and the other was a possible hindrance to effort.

The participants seemed to fall into two groups when it came to enjoying math and success in math. The participants that solidly felt that they had always liked math and had experienced success with math were Callie, Grant, Lewis, Lisa, and Sam. In contrast, the participants who stated they did not like or enjoy math and not been very successful with math were Bonnie, Sadie, Sarah, and Tim. Nathan was an exception to this observation because he stated he had enjoyed math in the past and has experienced success but in 7th grade and now in 9th grade his enjoyment lessened as did his success.

All but three of the participants noted that they experienced less stress and anxiety in mathematics. Callie, Lewis, Lisa, Grant, Sam, Sadie, and Sarah felt that portfolio grading allowed them to feel less stress and anxiety than they had in the past. Also, all of these participants except Sarah had an increase in their mathematics anxiety score between the pre- and post-survey indicating a lowered level of anxiety.

Eight of the ten students interviewed (Bonnie, Lewis, Lisa, Grant, Nathan, Sadie, and Sarah) felt that portfolio grading helped them to understand concepts better because they had to correct/redo/retest until mastered. This aspect of persistence that is required of participants in portfolio grading is related to effectance motivation. Therefore, it is important to note that, excluding Lisa and Sarah, there was a post-survey score increase on the effectance motivation scale for these participants (White, 1959).

Bonnie, Nathan, Sadie, Sarah, and Tim felt more successful in math while being graded under the portfolio grading construct. Also, since being successful is one of the

ways to build confidence as well as efficacy, note that these participants' post-survey score on the effectance motivation scale increased (Bandura, 1986; Karl et al., 1993; Oldham, 2018; Özcan & Kültür 2021).

Conclusion

This chapter has provided an analysis of the data collected from The Confidence in Learning Mathematics Scale, The Mathematics Anxiety Scale, and The Effectance Motivation Scale pre- and post-surveys and interviews revealing student perceptions of portfolio grading. A cross-case comparison was also provided in this chapter. The following chapter will provide a discussion of the results, corresponding implications for both practice and research, and any suggestions for future research in related areas.

CHAPTER V: DISCUSSION

The purpose of his action research study was to explore the effects of the use of portfolio grading in mathematics classes on student math self-efficacy. Because research has shown a correlation between student mathematics self-efficacy and student mathematics achievement, this study examined the effects, if any, of portfolio grading in mathematics classes on students' mathematics self-efficacy (Liu & Koirala, 2009; Nicolaidou & Philippou, 1997). Because there is not research specific to portfolio grading as defined in this study, I reviewed research on other alternative forms of grading, specifically reflective grading, mastery-based grading, standards-based grading, and performance-based grading, that had characteristics associated with portfolio grading.

Feedback, allowing corrections, allowing retakes, and allowing grades to change are the common characteristics on which I focused because they align with what research says about ways to improve student mathematics self-efficacy. Research has shown that student mathematics self-efficacy is promoted when students experience success, receive feedback, and set and meet short term goals (Bandura, 1986; Karl et al., 1993; Oldham, 2018; Özcan & Kültür, 2021). The scales used on the survey were based on research as well. The Confidence in Learning Mathematics Scale, Mathematics Anxiety Scale, and Effectance Motivation Scale were used on the survey because research has shown these areas to be indicators of self-efficacy (Bandura, 1986; Comunian, 1989; Muris, 2002; White, 1959).

Although some promising results emerged based on the collected data, there are also some implications for further research regarding portfolio grading and its effect on student's math self-efficacy. This chapter provides a discussion of the quantitative results

of the pre- and post-survey scores and qualitative results of the case study interviews. I also discuss the implications for practice and future research.

Summary of Results and Conclusion

The research question for this study was: How does the use of portfolio grading in high school mathematics classrooms effect student mathematics self-efficacy, if at all? Both the quantitative data resulting from the pre- and post-survey and the qualitative data from the interviews of this study indicate portfolio grading effects characteristics that influence self-efficacy. Confidence, anxiety, perseverance (effectance motivation), and experiencing success are all characteristics that influence self-efficacy (Bandura, 1986; Comunian, 1989; Muris, 2002; White, 1959).

Survey Discussion

Thirty participants took the pre- and post-surveys. The surveys examined participants' confidence in learning math, math anxiety, and effectance motivation. These three scales were chosen because confidence, anxiety and effectance motivation influence self-efficacy (Bandura, 1986; Comunian, 1989; Muris, 2002; White, 1959).

The results of the pre- and post-surveys were analyzed by finding 95% confidence intervals on the mean of their differences. All the scales with the exception of the effectance motivation scale indicated that students learning through portfolio grading will experience an increase in these measures. An increase in confidence related to learning mathematics can have a positive influence on mathematics self-efficacy since self-efficacy is one's confidence in their ability to perform certain tasks (Bandura, 1986). Also, an increase in the mathematics anxiety score means lowered anxiety, and research has shown a relationship between high anxiety and low self-efficacy (Comunian, 1989;

Muris, 2002). Therefore, the findings from the surveys indicate that portfolio grading influences students' mathematics self-efficacy by lowering anxiety and allowing mastery experiences (success) related to mathematics.

It is important to note here that because the confidence interval for effectance motivation included zero, we say there was no effect for that scale. However, because the confidence interval was [-.7, 2.9], students could see a decrease, increase, or no effect at all. The short time period of this study could have contributed to this as students could have been in the process of change. It also may be that the items on the effectance motivation scale might not be related to portfolio grading. Though this scale was inconclusive, an examination of the participants individual scores on the effectance motivation scale shows a great fluctuation in both positive and negative directions.

Case Study Discussion

Ten of the thirty participants were selected to be interviewed twice, once at the beginning of the study and once at the end of the study. The interviewer used a semi-structured protocol (see Appendix D) when conducting these interviews. The interviews were voice recorded and transcribed and then analyzed to write a narrative for each case. Then a cross-case comparison was written by analyzing the narratives. Students experiencing success, students feeling less stress, and students feeling they understand concepts better are the common themes related to the effects of portfolio grading as they relate to self-efficacy.

This study indicates that portfolio grading allows students to experience success. Before discussing the findings, it is important to note that when asked about success some of the students interviewed related experiencing success to having a good grade

whereas others related it to eventually being able to get wrong concepts right. For example, when I asked Lisa if she had experienced success in math before she said, “I’ve always made above a 90” (Lisa, Interview 1). Then when I asked Bonnie about feeling successful this year, Bonnie said “I am passing right now” (Bonnie, interview 2). Also, when I asked Nathan about his experiences and successes with portfolio grading, he said, “The ability to redo everything, you know, it’s been a lifesaver for my grades. And I think it helps me understand it (the concepts) a little bit more” (Nathan, Interview 2). Bonnie, Lisa, and Nathan related success to grades. However, Nathan also related success to understanding concepts better through being able to redo tasks.

Having made the above clarification, I will now show examples to the statement that portfolio grading allows students to experience success. One example of portfolio grading allowing students to experience success is, when asked about math success at the beginning of this study Bonnie said, “I don’t do very good. I fail like all the tests” (Bonnie, Interview 1). And Sadie said, “I never understand it” (Sadie, Interview 1). When asked the same question at the end of the study Bonnie stated, “I have a passing grade right now” (Bonnie, Interview 2). And Sadie said, “I feel like this math class has been easier than all the other ones. And I have been able to keep a really good grade in math this year” (Sadie, Interview 2). These statements indicate a feeling of more success under portfolio grading. The indication that portfolio grading allows students to experience success is important because research shows that to increase mathematics self-efficacy one must experience success with mathematics (Bandura, 1986).

This study indicates that portfolio grading decreases students’ stress. For example, when I asked Lewis if he had felt any kind of anxiety associated with math class this

year, Lewis stated “Not about grades. No, like, like work and grades, anything like that. It hasn't really been like, stressful or anything like that to go to class” (Lewis, Interview 2).This indicates that being able to go back and correct mistakes allows students to feel more at ease when faced with math. And when Lisa was explaining how she has felt about math this year she stated,

> There's a less stress level for me. So, then I'm like, it’s okay if I don't understand this one question. I'll just go over it, correct it learn from it, and then I’ll be more confident for future tests like the midterm. (Lisa, Interview 2)

This indicates that students experiencing portfolio grading feel less anxiety in association with doing or testing mathematics. It is important to note here that feelings of stress when facing math related situations is a characteristic of math anxiety (Sokolowski and Ansari, 2017).

This study indicates that portfolio grading allows students to better understand math concepts. For example, Sarah explained “Portfolio grading is better, because you can go back and look at your mistakes. And you can keep practicing and try again to get it right and it helps you understand better” (Sarah, Interview 1). Another example, when I asked Grant how he felt about portfolio grading after experiencing a semester of it he said, “It (portfolio grading) helps me understand concepts better. I get to reevaluate questions and my answers and see my mistakes and learn from them” (Grant, Interview 2). Both Sarah’s and Grant’s statements indicate that because they revisit their mistakes and keep trying until they get the concept correct, they understand the concepts better. This is an example of mastery experiences, which Bandura (1986) stated is important to increasing self-efficacy.

The case study interviews indicate portfolio grading allows opportunities for students to experience success and feel less anxiety. Therefore, these interviews indicate portfolio grading impacts student self-efficacy.

This study also indicates that portfolio grading supports average and lower-level learners but may create a hindrance to effort for accelerated learners. Nathan, a standard math student, explained in his interview that "The ability to redo everything, it's been a lifesaver for my grades. And I think it helps me understand it (the concepts) a little bit more" (Nathan, Interview 2). This indicates that portfolio grading supports lower-level learners to persist. Callie, an advanced honors student, explained "I have noticed the more I started relying on corrections, the less I started paying attention (in class)" (Callie, Interview 2). This statement indicates that higher level learners may not be encouraged to put forth the same effort.

Implications

Although this study only focused on one semester of a school year, there were indications that portfolio grading can impact student self-efficacy. There are some implications for teachers and schools related to implementing portfolio grading. The first is the importance of making sure students and parents understand the process. I found during the second set of interviews that even though teachers were supposed to explain the process of portfolio grading multiple times and in multiple ways, there were some students that did not really understand how portfolio grading worked. They did not realize that if they corrected and retested missed learning targets they would not lose any points and could maintain an A. The same was true for parents as well. Tim discussed with me how his mom got really upset because he had zeros in the online gradebook for

all his assignments (Tim, Interview 2). And zeros in portfolio grading are good, since it means the student has completed everything learning target to 100 percent mastery. Another implication is that some thought needs to be put into how to get learners to not rely on retesting but rely more on doing it right the first time. Callie, an advanced honors student, said she basically doesn't pay that much attention in class and just relies on retesting. Finally, schools should consider implementing portfolio grading as a way to increase student self-efficacy, which has shown to increase achievement (Liu & Koirala, 2009; Nicolaidou & Philippou, 1997).

Further Studies

Portfolio grading, as defined in this study, has not been formally researched until now. More studies on portfolio grading need to be conducted. A future study like this one which looks at portfolio grading's effect on self-efficacy is warranted. However, it could be more insightful if it covered an entire school year instead of just one semester. Since the participants are students who have experienced traditional grading for nine plus years prior to this introduction to an alternative form of grading. Therefore, students have had years of indoctrination on a particular way of grading. It would also be beneficial for a future study to be designed as a control group (traditional grading) and a treatment group (portfolio grading) and the effects on efficacy or achievement or both.

Summary

The purpose of this study was to explore how portfolio grading in mathematics classes effects student mathematics self-efficacy. The results of this study indicate that portfolio grading impacts student self-efficacy. With research showing mathematics self-

efficacy influences mathematics achievement, this study is relevant to teachers and schools (Liu. X. et al., 2009; Nicolaidou, M. & Philippou. G., 1997).

Implications for teachers concerning implementation of portfolio grading were discussed. The first implication was teachers need to make sure all stakeholders are well informed on the processes of portfolio grading. The second implication was planning for student apathy. The last implication was schools should consider implementing portfolio grading as a method to increase self-efficacy, since research shows self-efficacy has a positive impact on achievement (Liu & Koirala, 2009; Nicolaidou & Philippou, 1997). Future studies on the use of portfolio grading may improve its implementation while also building understanding of the aspects of it that support positive self-efficacy.

REFERENCES

AlKhateeb, M. A. (2018). The effect of using performance-based assessment strategies to tenth-grade students' achievement and self-efficacy in Jordan. *Cypriot Journal of Educational Sciences, 13*(4), 489–500. https://doi.org/10.18844/cjes.v13i4.2815

Armacost, R. L., & Pet-Armacost, J. (2003). Using mastery-based grading to facilitate learning. *Proceedings - Frontiers in Education Conference, FIE, 1*, T3A20-T3A25. https://doi.org/10.1109/FIE.2003.1263320

Atkinson, R. C., & Geiser, S. (2009). Reflections on a century of college admissions tests. *Educational Researcher, 38*(9), 665–676. https://doi.org/10.3102/0013189X09351981

Baliram, N. S. (2016). *Reflective assessment, feedback and academic achievement in high school mathematics*. Seattle Pacific University.

Bandura, A., & National Inst of Mental Health. (1986). Social foundations of thought and action: A social cognitive theory. Prentice-Hall, Inc.

Bond, J. B., & Ellis, A. K. (2013). The effects of metacognitive reflective assessment on fifth and sixth graders' mathematics achievement. *School Science and Mathematics, 113*(5), 227–234. https://doi.org/10.1111/ssm.12021

Borg, S. (2001). The research journal: A tool for promoting and understanding researcher development. *Language Teaching Research, 5*(2), 156–177. https://doi.org/10.1177/136216880100500204

Bromley, J. M. (2019). *The effects of standards-based grading in a secondary mathematics classroom*. Northeastern University.

Brookhart, S. M., Guskey, T. R., Bowers, A. J., McMillan, J. H., Smith, J. K., Smith, L. F., Stevens, M. T., & Welsh, M. E. (2016). A century of grading research: Meaning and value in the most common educational measure. *Review of Educational Research*, *86*(4), 803–848. https://doi.org/10.3102/0034654316672069

Butler, R. (1988). Enhancing and undermining intrinsic motivation. *British Journal of Educational Psychology*, *58*(1), 1–14.

Chen, X. (2016). Remedial Coursetaking at US Public 2-and 4-Year Institutions: Scope, Experiences, and Outcomes. Statistical Analysis Report. NCES 2016-405. *National Center for Education Statistics*.

Chun, M. (2010). Taking teaching to (performance) task: Linking pedagogical and assessment practices. *Change: The Magazine of Higher Learning*, *42*(2), 22–29. https://doi.org/10.1080/00091381003590795

Comunian, A. L. (1989). Some characteristics of relations among depression, anxiety, and self-efficacy. *Perceptual and motor skills*, *69*(3, Pt 1), 755-764. https://doi.org/10.2466/pms.1989.69.3.755

Costello, P. J. M. (2003). *Action Research*. Bloomsbury Publishing.

Edwards, T. G. (2008). Reflective assessment and mathematics achievement by secondary at-risk students in an alternative secondary school setting. In *Thesis and Dissertations*. Seattle Pacific University.

Farr, B. P. (2000). Grading practices: An overview of the issues. In E. Trumbull & B. Farr (Eds.), *Grading and reporting student progress in an age of standards* (pp. 1–22). Christopher-Gordon.

Fennema, E., & Sherman, J. A. (1976). Fennema-Sherman mathematics attitude scales: Instruments designed to measure attitudes toward the learning of mathematics by females and males. *Catalog of Selected Documents in Psychology*, *6*(1), 2-29.

Fuchs, L. S., Fuchs, D., Karns, K., Hamlett, C. L., & Katzaroff, M. (1999). Mathematics performance assessment in the classroom: Effects on teacher planning and student problem solving. *American Educational Research Journal*, *36*(3), 609–646. https://doi.org/10.3102/00028312036003609

Geiser, S., & Santelices, M. V. (2007). Validity of high-school grades in predicting student success beyond the freshman year: High school record vs. standardized tests as indicators of four-year college outcomes. *CSHE Research & Occasional Paper Series*, 35.

Groen, L., Coupland, M., Langtry, T., Memar, J., Moore, B., & Stanley, J. (2015). The mathematics problem and mastery learning for first-year, undergraduate STEM students. *International Journal of Learning, Teaching and Educational Research*, *11*(1), 141–160.

Guskey, T., & Gates, S. (1986). Synthesis of research on the effects of mastery learning in elementary and secondary classrooms. *Educational Leadership, 43*(8), 73–80.

Guskey, T. R., & Bailey, J. M. (2001). *Developing grading and reporting systems for student learning*. Corwin Press.

Hattie, J. (2008). Visible learning: A synthesis of over 800 meta-analyses relating to achievement. In *Visible Learning: A Synthesis of Over 800 Meta-Analyses Relating to Achievement*. https://doi.org/10.4324/9780203887332

Hattie, J. (2012). *Visible learning for teachers: Maximizing impact on learning.* Routledge/Taylor & Francis Group.

Hattie, J., & Timperley, H. (2007). The power of feedback. *Review of educational research, 77*(1), 81-112.

Karl, K. A., O'Leary-Kelly, A., & Martocchio, J. J. (1993). The impact of feedback and self-efficacy on performance in training. *Journal of Organizational Behavior*, *14*(4), 379–394. http://www.jstor.org/stable/2488290

Kulik, C. L., Kulik, J. A. & Bangert-Drowns, R. L. (1990). Effectiveness of mastery learning programs: A meta-analysis. *Review of Educational Research*, *60*(2), 265–299. https://doi.org/10.2307/1170612

Liu, J. (2000). The effect of performance-based assessment on eighth grade students' mathematics achievement. In *Proquest*. University of Missouri-Columbia.

Liu, X., & Koirala, H. (2009). *The effect of mathematics self-efficacy on mathematics achievement of high school students*. Northeastern Educational Research Association (NERA) Annual Conference. Paper 30.

Ma, X., & Kishor, N. (1997). Assessing the relationship between attitude toward mathematics and achievement in mathematics: A meta-analysis. *Journal for Research in Mathematics Education*, *28*(1), 26–47. https://doi.org/10.2307/749662

Ma, X., & Xu, J. (2004). The causal ordering of mathematics anxiety and mathematics achievement: a longitudinal panel analysis. *Journal of Adolescence*, *27*(2), 165–179. https://doi.org/10.1016/j.adolescence.2003.11.003

Mcnamara, C. (1999). *General guidelines for conducting interviews*, Authenticity Consulting, LLC. http://www.managementhelp.org/evaluatn/intrview.htm

Muris, P. (2002). Relationships between self-efficacy and symptoms of anxiety disorders and depression in a normal adolescent sample. *Personality and Individual Differences*, *32*(2), 337-348.

National Council of Teachers of Mathematics (NCTM). 2000. *Principles and standards for school mathematics*. Author.

National Governors Association Center for Best Practices & Council of Chief State School Officers. (2010). *Common Core State Standards for Mathematics.* Author.

Nicolaidou, M., & Philippou, G. (2003). Attitudes towards mathematics, self-efficacy and achievement in problem solving. *European Research in Mathematics Education III. Pisa: University of Pisa*, *1*(11).

Oldham, H. H. (2018). *Mathematics self-efficacy in high school students and the effects of interim goal setting: How goals and efficacy are linked in the self-effcacy goal spectrum*. [Doctoral Dissertation, Georgia State University] doi: https://doi.org/10.57709/12039255

Özcan, B., & Kültür, Y. Z. (2021). The relationship between sources of mathematics self-efficacy and mathematics test and course achievement in high school seniors. *SAGE Open*, *11*(3). https://doi.org/10.1177/21582440211040124

Parsons, R., and Brown, K. (2002). *Teacher as Reflective Practitioner and Action Researcher*. Wadsworth/Thomson Learning.

Schneider, J., & Hutt, E. (2014). Making the grade: A history of the A-F marking scheme. *Journal of Curriculum Studies*, *46*(2), 201–224. https://doi.org/10.1080/00220272.2013.790480

Sieling, C. J. (2013). *Standards-based grading in mathematics: Effects on student achievement and attitude* (Publication No. 1523840) [Master's thesis, Southwest Minnesota State University]. ProQuest Dissertations and Theses Global.

Sokolowski, H. & Ansari, D. (2017) Who is afraid of math? What is math anxiety? And what can you do about it? *Frontiers for Young Minds, 5*(57). doi: 10.3389/frym.2017.00057

Stake, R. (1995). The art of case study research (pp. 49-68). Sage.

White, R. W. (1959). Motivation reconsidered: The concept of competence. *Psychological Review*, *66*(5), 297–333. https://doi.org/10.1037/h0040934

APPENDICES

Appendix A

Portfolio Scoring Sheet Quarter Name _____

Strengths:	**Weaknesses:**	**Areas of Growth:**

Part 1

Test Corrections and Retakes

	Made All Corrections	Retook all Major Mistakes until Mastery
Chapter ___Test	On Time □ Late □ Never □	On Time □ Late □ Never □
Chapter ___Test	On Time □ Late □ Never □	On Time □ Late □ Never □
Chapter ___Test	On Time □ Late □ Never □	On Time □ Late □ Never □
Chapter ___Test	On Time □ Late □ Never □	On Time □ Late □ Never □

Quiz Corrections and Retakes

	Made All Corrections	Retook all Major Mistakes until Mastery
Quiz #_____	On Time □ Late □ Never □	On Time □ Late □ Never □
Quiz #_____	On Time □ Late □ Never □	On Time □ Late □ Never □
Quiz #_____	On Time □ Late □ Never □	On Time □ Late □ Never □

Essential Tasks

#_____ On Time □ Late □ Never □
#_____ On Time □ Late □ Never □
#_____ On Time □ Late □ Never □
#_____ On Time □ Late □ Never □

Help Sessions

Attended All Help Sessions Invited to Yes □ No □

Please list dates attended on the back of this sheet.

How many corrections, retakes, or assignments were completed, but not on time? _____ (-1 pt)

How many corrections, retakes, or assignments were not completed? _____ (-2 pts)

____ Part 1 Total = 93 – deductions = _____

Part 2

Mathematical Practices (+1pt)

□ Gave/Reveived help during PI Time □ Practice ACT □ Multiple Pathways*

□ Gave/Reveived help during PI Time □ Correct Practice ACT □ Mistake*

*Evidence Required for Each, Blog Video Required for those with **

Part 1 Total + Part 2 Total = _____ Final Quarter Grade

Portfolio Part 2. Evidence of Mathematical Practices:
*To enhance your learning of mathematics, there are certain activities you can participate in. These are things an actual mathematician or engineer would do! Every piece of evidence earns you an extra point. For example, let's say you earned an 89 in part 1. If you did 4 practices, you would get a 93. Be sure to explain how you learned through each of these practices. Evidence required for each. Those with an * require a video.*

Description of Each Mathematical Practice:

Gave/Received Help(Can only be used twice.): Provide evidence regarding a time in which you gave/received help to/from another Integrated III student for at least 25 minutes (one study hall). Evidence would be the notes taken on the tutoring form, which is online. For example, Tim and Carol are friends. Tim is struggling with finding the incenter of a triangle, so he asks Carol for help. They meet up during study hall and Carol teaches, while Tim takes notes on the tutoring form. Both take a picture of the form and add it to Seesaw.

Practice ACT/Correct Practice ACT: You may pick up a practice ACT from Mrs. Rich to complete in your own time. The tests are previous released tests, that will help you prepare to do your best on your actual ACT your Junior year! Once your "graded" test is returned to you, you may complete corrections for the questions your missed to possibly earn another point! (questions missed over content that will be taught in the next years courses will not be held against you when it comes to corrections.)

*Multiple Solution Paths or Representations: Discuss and provide evidence regarding a time in which you were able to use multiple solution paths or multiple representations to analyze a task/problem and how it helped you (An idea that you came up with yourself). For example, Josh found the x-value of the vertex of a parabola by calculating $x = -b/(2a)$. He then noticed that if he found the x-intercepts of the quadratic, he could simply

average those two x-values instead. He took a picture and added audio over the picture when he uploaded it to Seesaw. An example regarding multiple representations: Bob solved a problem by comparing two functions' graphs and their tables. He added it to Seesaw and explained how he used the different representations to solve the problem.

*Mistake: Discuss and provide evidence regarding a time in which you made a conceptual mistake (not a simple mistake like multiplying wrong or missing a sign) and **how you learned through that process**. For example, Greg forgot to add when doing synthetic division. He added a picture of his mistake to Seesaw and explained his mistake and what he learned from it.

PI Time attendance Record:

Date:	Required?	Did another student assist you? If so, who?
_____/_____/_____	☐ Yes ☐No	☐ Yes ☐No Who? _______________
_____/_____/_____	☐ Yes ☐No	☐ Yes ☐No Who? _______________
_____/_____/_____	☐ Yes ☐No	☐ Yes ☐No Who? _______________
_____/_____/_____	☐ Yes ☐No	☐ Yes ☐No Who? _______________
_____/_____/_____	☐ Yes ☐No	☐ Yes ☐No Who? _______________
_____/_____/_____	☐ Yes ☐No	☐ Yes ☐No Who? _______________
_____/_____/_____	☐ Yes ☐No	☐ Yes ☐No Who? _______________
_____/_____/_____	☐ Yes ☐No	☐ Yes ☐No Who? _______________
_____/_____/_____	☐ Yes ☐No	☐ Yes ☐No Who? _______________
_____/_____/_____	☐ Yes ☐No	☐ Yes ☐No Who? _______________

_____/_____/____	□ Yes □No	□ Yes □No Who? _____
_____/_____/____	□ Yes □No	□ Yes □No Who? _____
_____/_____/____	□ Yes □No	□ Yes □No Who? _____
_____/_____/____	□ Yes □No	□ Yes □No Who? _____
_____/_____/____	□ Yes □No	□ Yes □No Who? _____
_____/_____/____	□ Yes □No	□ Yes □No Who? _____
_____/_____/____	□ Yes □No	□ Yes □No Who? _____
_____/_____/____	□ Yes □No	□ Yes □No Who? _____

*If you attend more sessions than listed above, feel free to attach an additional sheet when you turn this in at the end of the 9 weeks.

Appendix B

DIRECTIONS
FENNEMA-SHERMAN MATHEMATICS ATTITUDE SCALES
Elizabeth Fennema – Julia A. Sherman
University of Wisconsin-Madison

On the following pages is a series of statements. There are no correct answers for these statements. They have been set up in a way which permits you to indicate the extent to which you agree or disagree with the ideas expressed. Suppose the statement is:
Example 1. I like mathematics.

As you read the statement, you will know whether you agree or disagree. If you strongly agree, choose A. If you agree but with reservations, choose B. If you disagree with the idea, indicate the extent to which you disagree by choosing D for disagree or E if you strongly disagree. But if you neither agree nor disagree, that is, you are not certain, choose circle C for undecided.
Example 2. Math is very interesting to me.

Do not spend much time with any statement but be sure to answer every statement. Work fast but carefully.

There are no "right" or "wrong" answers. The only correct responses are those that are true for you. Whenever possible, let the things that have happened to you help you make a choice.

THIS INVENTORY IS BEING USED FOR RESEARCH PURPOSES ONLY AND NO ONE WILL KNOW WHAT YOUR RESPONSES ARE.
Name of survey participant:
_____
Student ID (as assigned by researcher)
_____ please put this ID at the bottom of each subsequent page.
Name of mathematics class you are a member of this school year
_____
I am in (circle one) 9^{th} 10^{th} 11^{th} 12^{th} grade.
Are you willing to participate in an **optional** follow-up interview with the researcher? Please check one:
_____ YES, I am willing to participate in an optional follow-up interview.
_____ NO, I would prefer not to participate in a follow-up interview.

		Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1.	Generally, I have felt secure about attempting mathematics.	A	B	C	D	E
2.	I am sure I could do advanced work in mathematics.	A	B	C	D	E
3.	I am sure that I can learn mathematics.	A	B	C	D	E
4.	I think I could handle more difficult mathematics.	A	B	C	D	E
5.	I can get good grades in mathematics.	A	B	C	D	E
6.	I have a lot of self-confidence when it comes to math.	A	B	C	D	E
7.	I'm no good in math.	A	B	C	D	E
8.	I don't think I could do advanced mathematics.	A	B	C	D	E
9.	I'm not the type to do well in math.	A	B	C	D	E
10.	For some reason even though I study, math seems unusually hard for me.	A	B	C	D	E
11.	Most subjects I can handle O.K., but I have a knack for flubbing up math.	A	B	C	D	E
12.	Math has been my worst subject.	A	B	C	D	E

		Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1.	It would make me happy to be recognized as an excellent student in mathematics.	A	B	C	D	E
2.	I'd be proud to be the outstanding student in math.	A	B	C	D	E
3.	I'd be happy to get top grades in mathematics.	A	B	C	D	E
4.	It would be really great to win a prize in mathematics.	A	B	C	D	E
5.	Being first in a mathematics competition would make me pleased.	A	B	C	D	E
6.	Being regarded as smart in mathematics would be a great thing.	A	B	C	D	E
7.	Winning a prize in mathematics would make me feel unpleasantly conspicuous.	A	B	C	D	E
8.	People would think I was some kind of a grind if I got A's in math.	A	B	C	D	E
9.	If I had good grades in math, I would try to hide it.	A	B	C	D	E
10.	If I got the highest grade in math, I'd prefer no one knew.	A	B	C	D	E
11.	It would make people like me less if I were a really good math student.	A	B	C	D	E
12.	I don't like people to think I'm smart in math.	A	B	C	D	E

		Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1.	I'll need mathematics for my future work.					
2.	I study mathematics because I know how useful it is.	A	B	C	D	E
3.	Knowing mathematics will help me earn a living.	A	B	C	D	E
4.	Mathematics is a worthwhile and necessary subject.	A	B	C	D	E
5.	I'll need a firm mastery of mathematics for my future work.	A	B	C	D	E
6.	I will use mathematics in many ways as an adult.	A	B	C	D	E
7.	Mathematics is of no relevance to my life.	A	B	C	D	E
8.	Mathematics will not be important to me in my life's work.	A	B	C	D	E
9.	I see mathematics as a subject I will rarely use in my daily life as an adult.	A	B	C	D	E
10.	Taking mathematics is a waste of time.	A	B	C	D	E
11.	In terms of my adult life it is not important for me to do well in mathematics in high school.	A	B	C	D	E
12.	I expect to have little use for mathematics when I get out of school.	A	B	C	D	E
		A	B	C	D	E

		Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1.	Math doesn't scare me at all.					
2.	It wouldn't bother me at all to take more math courses.	A	B	C	D	E
3.	I haven't usually worried about being able to solve math problems.	A	B	C	D	E
4.	I almost never have gotten shook up during a math test.	A	B	C	D	E
5.	I usually have been at ease during math tests.	A	B	C	D	E
6.	I usually have been at ease during math classes.	A	B	C	D	E
7.	Mathematics usually makes me feel uncomfortable and nervous.	A	B	C	D	E
8.	Mathematics makes me feel uncomfortable, restless, irritable, and impatient.	A	B	C	D	E
9.	I get a sinking feeling when I think of trying hard math problems.	A	B	C	D	E
10.	My mind goes blank and I am unable to think clearly when working mathematics.	A	B	C	D	E
11.	A math test would scare me.	A	B	C	D	E
12.	Mathematics makes me feel uneasy and confused.	A	B	C	D	E
		A	B	C	D	E

		Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1.	I like math puzzles.					
2.	Mathematics is enjoyable and stimulating to me.	A	B	C	D	E
3.	When a math problem arises that I can't immediately solve, I stick with it until I have the solution.	A	B	C	D	E
4.	Once I start trying to work on a math puzzle, I find it hard to stop.	A	B	C	D	E
5.	When a question is left unanswered in math class, I continue to think about it afterward.	A	B	C	D	E
6.	I am challenged by math problems I can't understand immediately.	A	B	C	D	E
7.	Figuring out mathematical problems does not appeal to me.	A	B	C	D	E
8.	The challenge of math problems does not appeal to me.	A	B	C	D	E
9.	Math puzzles are boring.	A	B	C	D	E
10.	I don't understand how some people can spend so much time on math and seem to enjoy it.	A	B	C	D	E
11.	I would rather have someone give me the solution to a difficult math problem than to have to work it out for myself.	A	B	C	D	E
12.	I do as little work in math as possible.	A	B	C	D	E
		A	B	C	D	E

Appendix C

Semi-structured Interview Protocol

- Tell me about your experiences in mathematics classes. How do you feel about math class in general?
- How would you describe your success in mathematics? What has contributed to that?
- I saw on this assignment (show student work sample) that you struggled with this concept.
    - Have you progressed from here?
    - How did that happen?
    - How do you feel about learning this concept?
- How did you feel about learning this concept in a classroom using portfolio grading?
- In what ways does portfolio grading make learning this concept easier/harder?
- Would you rather have learned this concept in a classroom that did not use portfolio grading?

Appendix D

Scoring Directions for the Fennema-Sherman Scales (1976):

ON each scale numbers 1-6 are considered positive statements, and numbers 7-12 are considered negative statements.

Each positive item receives the score based on points

A = 5 B = 4 C = 3 D = 2 E = 1

The scoring for each negative item should be reversed

A = 1 B = 2 C = 3 D = 4 E = 5

Add the scores for each group to get a total for that scale.

The highest possible score for each scale of statements is 60 points.

Appendix E

IRB
INSTITUTIONAL REVIEW BOARD
Office of Research Compliance,
010A Sam Ingram Building,
2269 Middle Tennessee Blvd
Murfreesboro, TN 37129
FWA: 00005331/IRB Regn. 0003571

MIDDLE TENNESSEE STATE UNIVERSITY

IRBN001 - EXPEDITED PROTOCOL APPROVAL NOTICE

Wednesday, August 18, 2021

Protocol Title	***Student Self Efficacy as Related to Portfolio Grading***
Protocol ID	**22-2011 7im**
Principal Investigator	**Tara Johnson** (Student) *Faculty Advisor:* Alyson E. Lischka
Co-Investigators	NONE
Investigator Email(s)	*thj2i@mtmail.mtsu.edu; Alyson.lischka@mtsu.edu*
Department	Mathematics
Funding	NONE

Dear Investigator(s),

The above identified research proposal has been reviewed by the MTSU IRB through the **EXPEDITED** mechanism under 45 CFR 46.110 and 21 CFR 56.110 within the category *(7) Research on individual or group characteristics or behavior*. A summary of the IRB action is tabulated below:

IRB Action	**APPROVED for ONE YEAR**
Date of Expiration	**8/31/2022** *Date of Approval:* 8/18/21 *Recent Amendment:* NONE
Sample Size	ONE HUNDRED AND TWENTY (120)
Participant Pool	*Target Population 1:* Primary Classification: **Healthy Minors (14 to 17 years of age)** Specific Classification: **Students of Siegel High School** *Target Population 2:* Primary Classification: **Healthy Adolescents** (18 or older) Specific Classification: **Students of Siegel High School**
Type of Interaction	☐ Non-interventional or Data Analysis ☐ Virtual/Remote/Online interaction ☒ **In person or physical interaction – Mandatory COVID-19 Management**
Exceptions	Permitted to use audio recording and collect handwriting samples.
Restrictions	**1. Mandatory SIGNED parental consent, child assent (administered independently) and informed consent (for students 18 or older).** **2. Other than the exceptions above, identifiable data/artifacts, such as, audio/video data, photographs, handwriting samples, personal address, driving records, social security number, and etc., MUST NOT be collected. Recorded identifiable information must be deidentified as described in the protocol.** **3. Mandatory Final report (refer last page).** **4. CDC guidelines and MTSU safe practice must be followed** **5. Research site restriction applies (refer Appendix B)**
Approved Templates	*IRB Templates:* Combined parental consent/child assent and Adult informed consent *Non-MTSU Templates:* Recruitment scripts and follow up messages
Research Inducement	NONE
Comments	NONE

Post-approval Requirements

The PI and FA must read and abide by the post-approval conditions (Refer "*Quick Links*" in the bottom):

- ***Reporting Adverse Events:*** The PI must report research-related adversities suffered by the participants, deviations from the protocol, misconduct, and etc., within 48 hours from when they were discovered.
- ***Final Report:*** The FA is responsible for submitting a final report to close-out this protocol before **8/31/2022** **(Refer to the Continuing Review section below)**; REMINDERS WILLNOT BE SENT. **Failure to close-out or request for a continuing review may result in penalties** including cancellation of the data collected using this protocol and/or withholding student diploma.
- ***Protocol Amendments***: An IRB approval must be obtained for all types of amendments, such as: addition/removal of subject population or investigating team; sample size increases; changes to the research sites (appropriate permission letter(s) may be needed); alternation to funding; and etc. The proposed amendments must be requested by the FA in an addendum request form. The proposed changes must be consistent with the approval category and they must comply with expedited review requirements
- ***Research Participant Compensation:*** Compensation for research participation must be awarded as proposed in Chapter 6 of the Expedited protocol. The documentation of the monetary compensation must Appendix J and MUST NOT include protocol details when reporting to the MTSU Business Office.
- ***COVID-19:*** Regardless whether this study poses a threat to the participants or not, refer to the COVID-19 Management section for important information for the FA.

Continuing Review (Follow the Schedule Below)

This protocol can be continued for up to THREE years by requesting a continuing review before **8/31/2022**. Refer to the following schedule to plan your annual progress report; **REMINDERS WILL NOT BE SENT**. Failure to obtain an approval for continuation will result in cancellation of this protocol..

Reporting Period	Requisition Deadline	IRB Comments
First year report	7/31/2022	NOT COMPLETED
Second year report	7/31/2023	NOT COMPLETED
Final report	7/31/2024	NOT COMPLETED

Post-approval Protocol Amendments:

The current MTSU IRB policies allow the investigators to implement minor and significant amendments that would fit within this approval category. ***Only TWO procedural amendments will be entertained per year*** *(changes like addition/removal of research personnel are not restricted by this rule).*

Date	Amendment(s)	IRB Comments
NONE	NONE.	NONE

Other Post-approval Actions:

The following actions are done subsequent to the approval of this protocol on request by the PI/FA or on recommendation by the IRB or by both.

Date	IRB Action(s)	IRB Comments
NONE	NONE	NONE

COVID-19 Management:

The PI must follow social distancing guidelines and other practices to avoid viral exposure to the participants and other workers when physical contact with the subjects is made during the study.

- The study must be stopped if a participant or an investigator should test positive for COVID-19 within 14 days of the research interaction. This must be reported to the IRB as an "adverse event."
- The MTSU's "Return-to-work" questionnaire found in Pipeline must be filled by the investigators on the day of the research interaction prior to physical contact.
- PPE must be worn if the participant would be within 6 feet from the each other or with an investigator.
- Physical surfaces that will come in contact with the participants must be sanitized between use
- **FA's Responsibility:** The FA is given the administrative authority to make emergency changes to protect the wellbeing of the participants and student researchers during the COVID-19 pandemic. However, the FA must notify the IRB after such changes have been made. The IRB will audit the changes at a later date and the FA will be instructed to carryout remedial measures if needed.

Data Management & Storage:
All research-related records (signed consent forms, investigator training and etc.) must be retained by the PI or the faculty advisor (if the PI is a student) at the secure location mentioned in the protocol application. The data must be stored for at least three (3) years after the study is closed. Additional Tennessee State data retention requirement may apply (*refer "Quick Links" for MTSU policy 129 below*). The data may be destroyed in a manner that maintains confidentiality and anonymity of the research subjects.

The MTSU IRB reserves the right to modify/update the approval criteria or change/cancel the terms listed in this letter without prior notice. Be advised that IRB also reserves the right to inspect or audit your records if needed.

Sincerely,

Institutional Review Board
Middle Tennessee State University

Quick Links:

- Post-approval Responsibilities: http://www.mtsu.edu/irb/FAQ/PostApprovalResponsibilities.php
- Expedited Procedures: https://mtsu.edu/irb/ExpeditedProcedures.php
- MTSU Policy 129: Records retention & Disposal: https://www.mtsu.edu/policies/general/129.php