Student and teacher response to formative assessment feedback in eighth-grade mathematics: a design experiment

Desiree Dawn Rones

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ABSTRACT

STUDENT AND TEACHER RESPONSE TO FORMATIVE ASSESSMENT FEEDBACK IN EIGHTH-GRADE MATHEMATICS: A DESIGN EXPERIMENT

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Northern Illinois University, 2019  
Lee Shumow, Director

Formative assessment is a tool for learning that virtually every educator uses in the classroom to some extent. While teachers may be motivated to use formative assessment for a variety of reasons, its intended purpose is to be a tool for both teachers and students for teaching and learning, respectively. However, many teachers, even those with the best intentions, misunderstand and misuse formative assessment, and may cause more harm than good in the way that it is implemented in the classroom. Three critical factors for student success in learning are mindset, goal orientation, and autonomy. Research has shown that students with growth mindset, mastery goal orientation, and high levels of perceived autonomy are more resilient, independent, and empowered learners. The purpose of this study is to investigate the relationship between mindset goal orientation, and autonomy and formative assessment feedback. More specifically, this research describes the effects of students selecting interventions immediately after receiving formative assessment feedback to be implemented in the classroom by the teacher-researcher, using the design research methodology.
STUDENT AND TEACHER RESPONSE TO FORMATIVE ASSESSMENT

FEEDBACK IN EIGHTH-GRADE MATHEMATICS:

A DESIGN EXPERIMENT

BY

DESIREÉ D. RONES

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A DISSERTATION SUBMITTED TO THE GRADUATE SCHOOL
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE
DOCTOR OF PHILOSOPHY

DEPARTMENT OF LEADERSHIP, EDUCATIONAL
PSYCHOLOGY AND FOUNDATIONS

Doctoral Director:
Lee Shumow
ACKNOWLEDGMENTS

I would like to express my gratitude to Dr. Lee Shumow for her guidance throughout my graduate career; I deeply appreciate her vast knowledge of – and enthusiasm for – educational psychology, her timely and thorough responses to my frequent questions, and her enduring support throughout the dissertation process. I would also like to thank Dr. Hidetada Shimizu, for his humble and genuine fascination with anthropology, and for ultimately drawing me into the educational psychology department. Additionally, thank you to Dr. Daryl Dugas, Dr. Stephen Tonks, and Dr. Paul Dawkins for providing counsel, feedback, and support as committee members.

I would also like to thank those whom have supported me in the formative years leading up to my academic career: to my mother, for her endless cheerleading in all of my crazy endeavors; to Dave Williams, for convincing me to go to college and for teaching me the most important academic skill I ever learned – writing (and to never use “you”); to Brenda Silkman, for investing me in the turbulent adolescent years and for teaching me how to pursue huge goals; and to my husband, for his patience and tolerance throughout this demanding process.
DEDICATION

For dad, who taught me to be too proud to give up
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A purpose of this study was to document the semester-long implementation of formative assessment feedback in an eighth-grade mathematics classroom. By identifying how assessment feedback might be used to motivate students to learn, teachers may discover ways to efficiently provide effective feedback on formative assessments and motivate students to master course objectives prior to summative assessments. While administrators continue to encourage educators to utilize formative assessment at an increasing rate, the definition and use of formative assessment varies (Marzano, 2010). Consequently, formative assessment feedback prompts a variety of responses from students, based on how teachers deliver the assessment feedback (Nolen, 2011). If formative assessment data are to be used as a tool for learning that will empower students, research is needed to clarify how teachers can most effectively engage their students in the process of formative assessment feedback to promote student motivation; this study seeks to do just that.
Problem

Formative assessment, done well, can be a powerful learning tool and motivator for students. According to Shute (2008), “good [formative] feedback can significantly improve learning processes and outcomes, if delivered correctly” (p. 154). Shute stresses the two most crucial features of formative assessment feedback: verification and elaboration. Verification refers simply to whether student responses are correct or incorrect. Elaboration goes beyond verification, as it addresses a particular problematic topic, identifies a student’s specific errors, and provides an explanation of the correct response.

Formative assessment done poorly can frustrate students and reduce motivation. This is because unclear feedback causes insecurity, feelings of loss of control, and avoidant behaviors (Marzano, 2006). Students who feel defeated by formative assessment scores typically later earn low or failing grades and perform poorly on standardized tests (Heritage, 2007). Therefore, poorly delivered formative assessment feedback can have lasting detrimental effects, and learning how to carefully communicate student progress in the most sensitive way is an important skill for educators.

Information gathered in this mixed-method design study aims to be relevant for students, teachers, and administrators. The primary objective is to learn how students respond to formative assessment feedback over the course of a school semester and to identify practices that could benefit students. Assessment feedback can empower a student to overcome obstacles, or it can discourage a student from learning. Students learn and perform better when they feel like they have control over their success and enjoy the process of learning (Reeve, 2006).
Furthermore, teachers aspire to provide effective assessment feedback in efficient and practical ways (Sato, Wei, & Darling-Hammond, 2008). It is important for teachers to provide effective formative assessment feedback that is both manageable and consistent (McCarthy, Lambert, O’Donnell, & Melendres, 2009). Not only do teachers want their students to learn, they want this learning reflected in standardized test scores, which are now used to measure teacher effectiveness (The Danielson Group, 2013). It is now required that educators prove that their instruction has increased student learning in order to maintain high teacher ratings. However, emphasizing test scores could actually promote movement towards a fixed mindset and performance goal orientation for learners and educators alike; a purpose of this study is the opposite: to describe how a classroom teacher might encourage a growth mindset, mastery goal orientation, and autonomy in his or her students, which should consequently improve learning and provide students with tools they can use to continue improving in the future.

On a larger scale, administration and curriculum directors must find ways to improve the quality of assessment feedback tools in their districts and schools. Knowing the best practices that correlate to positive student responses to formative assessment feedback can inform principals and allow them to lead their teachers in this area. If students are properly motivated by feedback on formative assessments, they likely perform better on summative—and eventually standardized—tests, become better educated, and demonstrate a district’s success.
Theoretical Framework

Self-Determination Theory (SDT)

E. L. Deci and Ryan’s self-determination theory (SDT; 2002) is concerned with human motivation; it focuses on the processes by which humans pursue their goals as well as on how well the pursuit of these goals meets basic psychological needs. Educators, coaches, and parents can harness the key components of SDT in order to motivate young people intrinsically, rather than by external rewards and punishments. SDT encompasses three primary psychological needs: competence (one’s perceived ability to accomplish a goal), relatedness (the fundamental need to be connected to others and to be loved and cared for), and autonomy (the degree of freedom that humans have in a particular experience). E. L. Deci and Ryan (2002) theorized that when these needs increase, students will be more intrinsically motivated and will persist in difficult tasks; conversely, if these needs decrease, students will have a diminished sense of well-being, and performance and persistence will drop. As E. L. Deci and Ryan (2000) expressed,

these three needs can be satisfied while engaging in a wide variety of behaviors that may differ among individuals and be differentially manifested in different cultures, but in any case their satisfaction is essential for the healthy development and well-being of all individuals regardless of culture. (p. 231)

SDT has profound implications in classrooms. As competency and autonomy are nourished, SDT predicts that intrinsic motivation and interest will thrive. However, when students receive feedback regarding skills that they have performed poorly, they tend to feel incompetent, and intrinsic motivation decreases; educators must learn and utilize techniques to
prevent or minimize the negative impact that formative feedback has on a student’s perceived competence.

Students demonstrate greater levels of intrinsic motivation when they are with teachers who they perceive to be caring. In short, “how a teacher teaches and motivates has a substantial and direct impact on how free and self-determining each student perceive[s] himself or herself to be” (Reeve, 2002, p. 188). E. L. Deci and Ryan (2002) asserted that by applying what is known about SDT, educators can identify and implement factors in educational environments that promote student self-motivation and well-being.

Of the three components of SDT, this study focused on autonomy. According to research conducted by Reeve (2006), students of autonomy-supportive teachers demonstrate greater perceived competence, higher mastery motivation, enhanced creativity, a preference for optimal challenge over easy success, increased conceptual understanding, active and deeper information processing, greater engagement, positive emotionality, higher intrinsic motivation, enhanced well-being, better academic performance, and academic persistence rather than dropping out of school. (p. 228)

Autonomy-supportive teachers strive to nurture inner motivation by promoting choice, considering students’ interests and preferences, and providing appropriate challenges; autonomy-supportive behaviors do not include incentive programs, deadlines, and demands for compliance (Reeve, 2006). This study describes both student and teacher perspectives about student responses to the implementation of autonomy-supportive feedback practiced by a middle school mathematics teacher over the course of a school semester.
Mindset

Carol Dweck’s (2006a) research on mindset articulates the concept of mindset as a “simple idea” that determines achievement and success not only in education but also in business, sports, and relationships. Mindset theory asserts that there is a range between two types of mindset: fixed to growth. People who have a more fixed mindset believe that intelligence and talent are fixed, out of their control, and cannot be improved with time or effort. They tend to be focused on the end product, rather than on the process of learning over time. Instead of working to develop intelligence, people with a more fixed mindsets become interested in documenting their intelligence to justify their successes or failures; they link their level of success—or lack thereof—to their level of intelligence. Conversely, people who have a more growth mindset believe that intelligence and talent are malleable, within their control, and can be improved with additional time or effort. People with a more growth mindset believe that their intelligence and talent can increase and, through work and effort, success will eventually come in time (Dweck, 2006a).

Not surprisingly, mindset beliefs are closely tied to students’ motivation in education. In the classroom, students with more a fixed mindset are more likely to experience helplessness and tend to give up on challenging tasks. These learners believe that they cannot create their own future success, and by contrast, they believe those who can succeed do so through a natural ability—not by effort. In short, “the fixed mindset limits achievement” (Dweck, 2006a, p. 67). People with a more growth mindset, however, are more likely to persist with challenging tasks, aspire to learn new things, and have a general love for learning. They are resilient, and they believe that success can come with hard work, time, and dedication.
Research has shown that adolescent students who received mindset interventions had an increased sense of control, greater interest in the content, and were able to maintain constant levels of learning over time (J. Schmidt, Shumow, & Kacker-Cam, 2017). Conversely, students who did not receive mindset interventions experienced the opposite: a decreased sense of control, interest, and learning.

In terms of teacher feedback, students with a more fixed mindset believe that their capacity for learning cannot be changed and that there is a limit to what they are able to learn; therefore, feedback may seem useless or frustrating. Conversely, students with a more growth mindset know that their capacity for learning has no bounds, so therefore constructive feedback is useful and motivating because it informs students of how they can perform better. Mindset can determine the trajectory of how feedback shapes a child’s education, and it is crucial for teachers to educate their students about the malleability of the mind and the benefits of persistence. One purpose of this study was to describe changes in students’ mindset after receiving formative assessment feedback, which is feedback that encourages students to keep working on mastering particular skills and may potentially be associated with the development of a growth mindset and an improvement in motivation for learning. Another purpose was to describe a classroom teacher’s perspective on providing such feedback over the course of a school semester.

**Goal Orientation**

Research on performance and mastery goal orientation indicated that the type of goal orientation a person has—ranging from performance to mastery—will determine his or her level of motivation in achieving goals (E. M. Anderman and Maehr, 1994). Mindset also affects
levels of engagement in learning. Students who have a more performance goal orientation are focused on performance, which is demonstrated in grades, ranked position, and standardized measures. Value is placed on avoiding failure by so-called winning in a perceived constant competition with others. Learners who have a more performance goal orientation are most concerned with being the best among their peers and with establishing themselves as being better than others. Conversely, students who have a more mastery goal orientation are focused on improvement, innovation, and progress. Value is placed on effort and persistence with difficult tasks. Learners who have a mastery goal orientation are most concerned with progress over time and eventual mastery. Kaplan and Maehr made the important clarification that “whereas mastery goal orientation refers to the purpose of developing competence, performance goal orientation refers to the purpose of demonstrating competence” (2007, p. 143).

In the classroom, a person may observe students’ goal orientations by observing how they learn and interact with others. Students with a more performance goal orientation tend to use rudimentary strategies, such as rote memorization (Gehlbach, 2006). These students balk at difficult tasks and will immediately seek help from teachers rather than attempt those challenges on their own. With the alternative approach of mastery goal orientation, students are more likely to learn and persevere independently. Unlike their more performance-focused counterparts, the students with a more mastery goal orientation are more likely to persist with difficult tasks and are resilient in challenging situations.

After comparing students’ performance and mastery goal orientations, it is clear that teachers would help their students most by working to move children away from a performance goal orientation and towards a mastery goal orientation. In addition, educators must also
perceive mathematical tasks as learning tasks rather than performance tasks. Research has shown that teachers can enhance the development of a mastery goal orientation among at-risk adolescent students (Blackwell, Trzesniewski, & Dweck, 2007). In Blackwell et al.’s study, students learned study and self-regulatory skills that are necessary for mastering new concepts; consequently, their achievement in mathematics improved.

In interacting with students who have different goal orientations, teachers must be attuned to the dispositions of each individual. This allows educators to use their students’ strengths most effectively and to ultimately steer children towards strategies that result in deeper learning, perseverance with complex tasks, and the ability to problem-solve with minimal teacher support. A purpose of this study was to describe how formative assessment feedback is related to students’ goal orientation, especially in how feedback could potentially promote a student’s mastery goal orientation and improve motivation for learning.

**Research Questions**

A purpose of this study was to examine the effects of assessment feedback among eighth-grade students in a mathematics classroom.

1. With what mindset, goal orientation, and level of autonomy do eighth-grade students enter mathematics class at the beginning of a school year?

2. How do students’ mindset, goal orientation and autonomy change over a school semester during which they received formative assessment feedback? Do students who select interventions after receiving formative assessment feedback decline significantly in mindset, goal orientation, and autonomy over the school semester (as is the typical case in middle school classrooms)?
3. Does change in students’ mindset, goal orientation, and autonomy over the school semester vary by student demographic characteristic?

4. What is the teacher-researcher’s reflection on the implementation of student-selected interventions in the classroom? What did the teacher learn about using student-selected interventions in the classroom?

Operational Definitions

Assessment

Formative Assessment

Formative assessment is a common classroom practice that is conducted with the intention of informing both the student and teacher about which concepts have (or have not) been mastered; most importantly, formative assessment is meant to be a tool used for learning, rather than a measurement of what students have learned. In response to formative assessment, teachers may change future lessons to teach difficult material from a different perspective, to allow students to use a different modality to reveal learning, or to demonstrate readiness to move on to the next topic. Students can use formative assessment feedback to focus attention on what students have learned and what still needs to be learned to reach learning goals and normative understandings. Formative assessment is not limited to written or graded assessments but can also be spontaneous, informal, practical, or oral. However, in response to evolving standards and teacher evaluation systems that are based on student growth, school districts are now driven toward formalized formative assessments that are common for each
grade level and are tied to state standards so that data can be collected to predict scores on state standardized tests. In addition to using these data to identify students who would benefit from pull-out interventions, teachers can use the results from these formative assessments to determine which content areas to reteach in their general education classrooms before high-stakes tests. For this study, a formative assessment is a teacher-designed, written, largely procedural, short (less than 25 items) assessment given regularly within a larger unit. Referred to as a quiz by students, these formative assessments are the midpoint between instruction and the summative assessment and are used to inform teaching and learning across all eighth-grade mathematics classrooms in this study’s school district.

**Mindset**

**Fixed Mindset**

According to Dweck and Leggett (1988),

a child who believes that intelligence is fixed is concerned with documenting the amount of intelligence he or she possesses, and therefore is likely to interpret task outcomes as indices of ability. If this child then performs poorly, he or she will attribute the performance to low ability. The implications of this conclusion are relatively devastating because intelligence is seen as fixed. Thus the resultant response of giving up, blaming one’s lack of ability, and experiencing negative affect [sic] can be seen as reasonable within the entity belief system. (as cited in Cain & Dweck, 1995, p. 27)

Beliefs related to mindset were measured using three 6-item survey questions from Carol Dweck’s mindset questionnaire (2006b).
Growth Mindset

Dweck and Leggett (1988) illustrated that

a child who believes intelligence is malleable is more concerned with learning new things and improving his or her ability level than with documenting the absolute amount of ability present. Task outcomes are seen as indictors of what needs to be learned, rather than as measures of underlying ability. Even when such a child concludes that he or she lacks ability, the implications of this condition are less serious because ability can be changed if effort is applied in the future. The mastery-oriented response of persistence, enhanced effort, neutral or positive affect [sic], and few ability attributions is logically consistent within the incremental framework. (as cited in Cain and Dweck, 1995, p. 27)

Beliefs related to mindset were measured using three questions from Carol Dweck’s mindset questionnaire, each of which consisted of 6 points on a scale (2006b).

Goal Orientation

Performance Goal Orientation

According to E. M. Anderman and Maehr (1994), “students who adopt ability-focused (performance) goals tend to use surface-level strategies, such as the rote memorization of facts and immediately asking a teacher for assistance when confronted with difficult academic tasks” (p. 295). Performance goal orientation is relevant to this study because students with this mindset are less likely to persevere in learning difficult material independently. Performance goal orientation was measured by three 6-item survey questions adapted from the Performance Mastery Goal Orientation Scale, the Student Perceptions of Classroom Goal Orientation Scale, and the Checklist of Goal Orientation from the Patterns of Adaptive Learning Scale (PALS) manual (2000).
Mastery Goal Orientation

According to E. M. Anderman and Maehr (1994), “numerous studies have found that students who adopt task-focused (mastery) goals are more likely to engage in deep cognitive processing, such as thinking about how newly learned material relates to previous knowledge and attempting to understand complex relationships” (p. 295). Mastery goal orientation is relevant to this study because students with this mindset are more likely to persevere in learning difficult material without frequent external guidance or extrinsic motivation. Mastery goal orientation was measured by three questions adapted from the Student Perceptions of Classroom Goal Orientation Scale and the Checklist of Goal Orientation from the Patterns of Adaptive Learning Scale (PALS) manual (2000).

Self-Determination Theory

The Theory

According to psychologists Edward Deci and Richard Ryan (2000),

Self-determination Theory (SDT) maintains that an understanding of human motivation requires a consideration of innate psychological needs for competence, autonomy, and relatedness. Social contexts and individual differences that support satisfaction of the basic needs facilitate natural growth processes including intrinsically motivated behavior and integration of extrinsic motivations. (p. 227)

Beliefs related to SDT were measured using three 6-item survey questions from a modified questionnaire written by researchers E. Deci and Ryan (2017).
**Autonomy**

Shumow and Schmidt (2013a) defined autonomy as “the students’ perception that they can determine their own goals, intentions, and actions regarding learning” (p. 41). When autonomy is increased, so is intrinsic motivation and engagement. Autonomy is one element of SDT and was measured using three 6-item survey questions from a questionnaire written by researchers E. Deci and Ryan (2017).

**Perspectives**

**Student Perspective**

Student perspective, in this study, refers to students’ interpretations of the effectiveness of the ability to choose interventions after receiving formative assessment feedback on learning. This perspective was communicated in focus group interviews, students’ written responses, class discussions, and survey responses.

**Teacher Perspective**

Teacher perspective, in this study, refers to a teacher’s interpretation of the effectiveness of allowing students to choose interventions after receiving formative assessment feedback on mindset, goal orientation, and autonomy. This perspective was informed by class observations, student surveys, interactions with students (individuals, group interviews, class discussions), students’ written responses, anecdotal notes, and personal reflection.
Interviews

At the completion of this study’s research, after all surveys were completed, 4-6 randomly selected students from each class period participated in a focus group interview. The students were asked questions about learning difficult math skills and the factors they attribute their grades to, their responses to assessment feedback and elements of learning that are in their control, and their evaluations of how approachable their teachers are and how capable students are to study independently in order to perform well on assessments. The nature of these questions relates to mindset, goal orientation, and autonomy, and student comments were thereby coded as having these characteristics.

Method Summary

To measure beliefs related to mindset, goal orientation, and autonomy, eighth-grade students completed a modified questionnaire based on three resources: mindset items were adapted from the mindset questionnaire provided by Carol Dweck (2006b), goal orientation items were adapted from the Checklist of Goal Orientation by Shumow and Schmidt (2013a), and autonomy items were adapted from tools developed by Deci and Ryan (2017). This modified questionnaire was completed at the beginning of this study (initial survey, Appendix A) and then repeated seven additional times throughout this study’s research (post assessment survey, Appendix B), each time directly following formative assessment feedback; the surveys were spaced out approximately 2 weeks from one another, and this entire study was conducted over one academic semester (18 weeks).
For this study, formative assessment feedback included how the assessment was scored, an explanation of correct answers, feedback regarding frequently missed questions, and an opportunity for students to ask questions. Next, the post assessment survey was preceded by a brief summary of the interventions already selected, instructions on how to complete the survey, and an opportunity to select the next intervention after answering survey questions related to mindset, goal orientation, and autonomy. In order to select an intervention, students were encouraged towards a growth mindset (accepting that every student can learn and improve), mastery goal orientation (focusing on ongoing learning rather than a one-time performance), and increased autonomy (deciding what intervention would benefit their education the most).

This study implemented the design-research methodology developed by design scientist Ann Brown (1992). This methodology is unique, because it does not follow the strict requirements of a normal experiment (Cohen, Manion, & Morrison, 2011). However, this methodology is similar to an experiment in the sense that it is focused on specific, intentional interventions. This methodology aims to improve current educational situations and is highly useful to teachers as researchers in a classroom setting. Shavelson, Phillips, Towne, & Feuer state that the design-research methodology seeks to answer the following questions: “What is happening? Is there a systematic effect? Why or how is it happening?” (2003, p. 28). Although this methodology is seemingly messier than standard experiments, the benefit of the design-research methodology is that it takes the intricacies of education into account and takes an authentic look at learning and instruction. In doing so, the findings are functional in both theory and practice (Gorard, Roberts, & Taylor, 2004). Based on this methodology, students
selected one intervention that they wanted to have implemented in the classroom each time that they completed a post assessment survey. The intervention with the greatest interest, as shown by getting the majority of the students’ votes, was implemented at the start of the next class period.

Because there was reason to believe that the interventions selected would benefit all of the students, there was an obligation to educate every student, not just some students. Therefore, conducting a traditional experiment would have been problematic and, therefore, the findings presented are only descriptive associations and cannot be interpreted as causal.
CHAPTER 2

FRAMING OF STUDY

Rationale

A purpose of this study was to describe how formative assessment feedback was related to changes in eighth-grade mathematics students’ mindset, goal orientation, and feelings of autonomy. These factors were chosen because they are linked strongly to student learning and achievement, which are later described in greater detail. The use of formative assessment is on the rise in our nation’s schools, because quantifiable student performance has become increasingly more important to policymakers. Nancy Sharkey and Richard Murnane (2006) reported that “the underlying logic is that providing teachers with timely information on student skills will enable them to improve instruction and better prepare students to excel on high-stakes, state-mandated tests” (p. 579). This study is timely, as teachers are encouraged--some mandated--to use formative assessment in their classrooms, often not as much as a tool to promote learning in itself but more as a tool to predict achievement on upcoming standardized tests and the effectiveness of teachers (Trimble, Gay, & Matthews, 2005).

The way that educators perceive formative assessment as a tool for mastering skills varies significantly between and within schools, indicating that not all teachers or school districts truly understand the definition and purpose of formative assessment. Education is needed to show teachers how formative assessment is not merely a required teaching practice
but that it can be an effective and valuable tool for teaching. More importantly, formative assessment is ultimately intended for learning and mastery of important skills more than it is used for predicting performance on high-stakes tests. Formative assessment, properly executed, is meant to empower, encourage, and inspire students to take control of their learning. However, some formative assessment has been implemented so poorly that it actually discourages students from persevering in learning. Yorke (2003) expressed that assessment “can discourage students from developing to their full potential” (p. 489). Furthermore, Boud (1995) wrote, “Too often staff-driven assessment encourages students to be dependent on the teacher or the examiners to make decisions about what they know and they do not effectively learn to be able to do this for themselves” (p. 39).

Eighth graders were chosen as the focus for this study because these students are at a transitional point in their educational journey. According to the National Center for Education Statistics (2003), “course failures, suspension and expulsion rates, and high school dropout rates are higher in the ninth grade than any other high school grade levels” (as cited in Smith, Akos, Lim, & Wiley, 2008). As students leave middle school and prepare to take on greater responsibility in high school, it is important for them to utilize effective learning strategies to acquire the skills necessary for college and careers. Written formal assessments such as quizzes are a common way through which teachers communicate to students what has been mastered and what students should continue to focus on in order to pass summative exams or standardized tests; therefore, if eighth-grade students can learn how to use formative assessment feedback as a tool for learning, they will have a valuable advantage as they advance into the critical high school years.
Jennie Golding (2003) succinctly clarified the purpose of formative assessment as a means through which students and teachers obtain information that reflects the effectiveness of learning and teaching. Formative assessment may take the form of informal written prompts, practical and oral tasks, and also formal (written) assessment by identifying and clarifying misconceptions in students’ independent thinking. “It is often referred to as ‘assessment for learning’ as opposed to ‘assessment of learning’” (p. 12).

Valerie Shute (2008) built on Golding’s definition, stating that formative feedback is intended to be “nonevaluative, supportive, timely, and specific” and that it is “intended to modify… thinking or behavior to improve learning” (p. 153). The foundational elements of effective formative feedback are verification (confirming that answers are correct or incorrect) and elaboration (clarifying where a student has made a mistake, explaining why an answer is correct, identifying student errors, and providing additional examples to be worked out). Shute also suggested that educators provide a manageable amount of feedback: enough information that students can correct their errors but not so much that they are overwhelmed. Furthermore, assessment feedback must be specific, clear, simple, and unbiased. Shute also made the point that feedback should promote a learning goal orientation, which is discussed in greater detail later in this chapter. Conversely, Shute cautioned teachers about what they should not do with formative assessment: teachers should avoid comparisons, they should resist giving overall grades, and feedback should be delivered in writing rather than orally.

Time spent investing in formative assessment feedback is a positive investment that teachers make in the education of their students. According to Rolland (2012), teacher
academic support promotes not only academic achievement but also increased motivation, mastery goal orientation, increased self-efficacy, greater interest in course content, and more pro social behaviors; conversely, lack of teacher support and external goal-setting has a negative effect in these areas.

While information related to formative assessment or middle school or mathematics is abundant (or any combination of two of these categories), empirical research specifically on formative assessment in middle school mathematics is lacking (Rakozy, Harks, Klieme, Blum, & Hochweber, 2013). However, three studies—two of which are international—relate to this study. Researchers Phelan, Choi, Vendlinski, et al. found in a 2011 study of 85 American teachers and 4,091 students that incorporating formative assessments into the middle school mathematics curriculum significantly increased learning when compared to a comparison group that was not exposed to formative assessments, especially for those who started the school year with higher pretest scores. Also, in a unique study of 146 German ninth-grade students, it was found that formative assessment feedback had no effect on achievement or on interest, though it did have a moderate effect on encouraging a mastery goal orientation. Another German study conducted by Steuer, Rosentritt-Brunn, and Drwesel (2013) had similar conclusions. It sought to investigate error climate, which encompasses the self-threatening effect that formative assessment feedback often has on adolescents. In studying over 1,000 high school students, the researchers concluded that students who adapted better to feedback were significantly more inclined to have a mastery goal orientation and increased motivation for learning.

More research is needed to supplement these studies, to investigate American middle schools, and to describe relationships between the implementation of formative assessment
feedback in a classroom and students’ mindset, goal orientation, and autonomy. Moreover, in the previous definitions, of how formative assessment is used practically in classrooms, and in research, formative assessment is perceived as something done to students, rather than with them. There is extensive research available regarding how teachers can best use formative assessment in their classrooms, but this is not the case for teachers studying how to engage students as collaborators in the process of using formative assessment as a tool for learning.

The timing of when formative assessment feedback is given is crucial, so it is not surprising that a great deal of research related to formative feedback has been dedicated to the use of technology to provide instant feedback. One of the most common technological tools at the time of this study is the classroom response system (CRS), as described by Ian Beatty and William Gerace (2009). Using the CRS, teachers can poll their students’ knowledge throughout a course of instruction, and students respond with handheld clickers. Student responses are anonymously displayed on a bar chart for both students and teachers to see instantly. Currently, free applications such Plickers or Google forms and websites such as Edutopia and Kahn Academy accomplish the same thing. Though CRSes and similar applications and programs are limited by generally focusing on knowledge-level queries that can be answered through multiple choice or true/false questioning, students benefit significantly from immediate feedback and teachers are able to alter their instruction based on real-time assessment data.

Though timely—or instant—formative assessment feedback is invaluable to students and teachers, not every school (and certainly not every pupil) has access to electronic devices. While technology is improving in American schools, some teachers still must find ways to give rapid feedback without the use of advanced technology. Furthermore, technology does not
always make it easier for students to demonstrate their mastery of content; for example, it is far easier to demonstrate how to solve a multistep algebra equation using a pencil and paper assessment than it would be for a student to type and format all of the steps on a computer.

Rather than excusing themselves from using formative feedback because of technical limitations, proactive teachers seek to reduce the disparity between students by determining how to provide timely formative feedback in ways that do not require technology. Providing assessment feedback through written mathematics quizzes is a common and practical means that teachers can communicate assessment feedback to their students. Therefore, this study tested how students respond to formative assessment feedback after receiving their graded, written quizzes, as this is a commonly used method of assessment and will likely continue to be a source of feedback to students. It is important that teachers identify the best ways to utilize formative assessment feedback—as this study sought to do—in a format that is relevant to teachers and helpful to students.

Because formative assessment is so broadly defined, this study focused on one small, common practice in mathematics classrooms: the written quiz. The assessments were short (less than 25 items), paper-pencil assessments that reviewed content from the previous 5-8 instructional days. These assessments were scored and returned to the students at the next class meeting. Students viewed their results, received a verbal and written explanation of correct answers, participated in brief reteachings related to questions frequently missed, and had the opportunity to ask clarifying questions. After a summary of previous interventions that had been previously selected, as well as reminders on how to complete the survey correctly, the students completed the post assessment survey and chose their next intervention. By structuring this study in this way, several of Keeley and Tobey’s (2011) criteria for
mathematics formative assessment were met: Engage students in learning, make students’ thoughts explicit to the teacher, encourage reflection on learning, utilize feedback, inform adjustments to the curriculum, and increase confidence in sharing personal ideas.

Mindset

The idea of mindset, originated by Carol Dweck, is a simple concept that can make a monumental difference in the lives of both children and adults. According to Dweck (2006), a person’s mindset is his or her set of beliefs about his or her most basic qualities, including intelligence, talents, and personality. A person can range from a fixed mindset to a growth mindset, or may waver between the two extremes. This is how she defines the two mindset types (2006a):

Believing that your qualities are carved in stone – the fixed mindset – creates an urgency to prove yourself over and over, [that] you have only a certain amount of intelligence, a certain personality and a certain moral character. The growth mindset is based on the belief that your basic qualities are things you can cultivate through your efforts. Although people may differ in every which way – in their initial talents and aptitudes, interests, and temperaments – everyone can change and grow through application and experience. (pp. 6-7)

The effects of mindset are significant. In fact, Dweck and Legget (1988) suggested that mindset is not limited to intelligence and talents only but that mindset even affects personality, morality, and motivation. Cain and Dweck (1995) made the point that children with a fixed mindset “are more likely to show the helpless response pattern of nonpersistence and negative ability attributions when faced with a challenging task” (p. 27). The authors went on to share that both motivational patterns and personal theories of intelligence are established by the fifth grade.
The type of mindset that a person has can change, meaning that a person with a more fixed mindset can potentially be persuaded into having a more growth mindset. However, this is an increasingly difficult process depending on the age and resolve of the learner, and it is unlikely that change will happen naturally. This is where teachers have the opportunity to teach a growth mindset to their students, which could potentially change the trajectories of students’ lives. Before this can happen, however, educators must be informed about mindset, and perhaps converted themselves. If teachers have a more fixed mindset, they may be transmitting damaging information to impressionable minds.

Blackwell et al. (2007) conducted two studies related to the mathematics achievement of seventh-graders, including one that focused on how each type of mindset affected grades over 2 years. The researchers used a variety of measures, in addition to student grades, including a 6-point Likert motivation profile that revealed students’ mindsets, goal orientations, and effort beliefs. Not surprisingly, there was a downward trajectory in grades of students with a more fixed mindset and an upward trend for those with a more growth mindset. These important findings are especially relevant to this study, which extends the results found by Blackwell et al. In the 2007 study, the focus was on how mindset affected grades, and this study is ultimately concerned with how teacher feedback through formative assessment affects mindset, goal orientation, and autonomy, while keeping in mind the aforementioned findings that a more growth mindset is a natural motivator for learning.

While there are numerous articles that discuss mindset in great detail, there are currently no scholarly articles that report empirical research related specifically to adolescent students in mathematics classes. There has, however, been research conducted that is related to mindset and young students (Pawlina & Standord, 2011) or other content areas, such as engineering
or employe and supervisor relationships (Van Vianen, Dalhoeven, & De Pater, 2011), but none (except the previously mentioned 2007 study) discuss mindset in a context similar this study. Therefore, the results of this study contribute to the present research base.

Goal Orientation

The concept of goal orientation, as credited to Eric Anderman (1994), is concerned with motivation for learning. Similar to mindset, a students’ goal orientation lies within a range of two extremes: performance and mastery goal orientations. It is preferred that students have a mastery goal orientation through which they “are more likely to engage in deep cognitive processing” (E. Anderman & Maehr, 1994, p. 295). These students “use more adaptive help-seeking strategies [and] show higher levels of creativity” (p. 296). According to these authors, students who have a more mastery goal orientation define success as improvement or progress over time, they value effort and attempting difficult tasks, they are satisfied with progress and eventual mastery, and they put forth effort as a result of their intrinsic desire to participate in learning. The other outcome is performance goal orientation, through which students “tend to use surface-level strategies, such as rote memorization of facts and immediately asking the teacher for assistance when confronted with difficult tasks” (p. 295). EAnderman and Maehr’s (1994) described those who have a more performance goal orientation are the opposite of those who have a more mastery goal orientation. Those who are oriented more towards performance define success as achieving high grades and performing better than their peers, they place value on avoiding failure, they are motivated by being the best in their class.

E. Anderman and Maehr (1994) gave special attention to motivation in the middle grades. In their 1993 study that compared school environments that focused on goal
orientation, the authors stressed that “the time for reinventing schools has arrived… [and] the nature and quality must change. Such cultural change… is a necessity if all children are to actualize their potential” (p. 603). In a later article, Anderman and Wolters (2006) stressed that adolescent motivation is the driving force for increased effort towards learning, performance, positive classroom behavior, and overall academic success. E. M. Anderman and Maehr warned that “during the middle grades, students often exhibit a disturbing downturn in motivation. Negative attitudes and behavioral patterns, which defeat any major investment in schooling, are common” (p. 288). Furthermore, the authors asserted that dispositions formed in the middle grades have implications for a student’s entire life. A negative attitude towards mathematics may discourage a student from studying mathematics in high school or from pursuing math-related careers later in life. It is even warned that “this lack of investment all too often eventuates in dropping out of school before graduation” (p. 289).

Based on the urgency to motivate adolescent learners, this study is timely and important. It is essential to learn how the educational environments of middle school mathematics classrooms influence students away from motivation to learn. Of course, not all students are so extremely entrenched in the performance goal orientation, but it benefits all students who have any component of this extreme to identify areas in which they have a performance goal orientation so that teachers can educate and encourage students towards elements of a mastery goal orientation instead.

There is a variety of research studies available that investigated differences in achievement between students with a performance goal orientation versus a mastery goal orientation, as well as studies that track a gradual shift in goal orientation over time. In Shumow and Schmidt’s (2013a) research, it was found that teachers with an understanding of
goal orientation—and its impact—possessed the skills to promote a mastery goal orientation. The students in classes taught by these teachers adopted better study habits, processed content more deeply, monitored their own comprehension more effectively, and made stronger connections to prior learning. Shumow and Schmidt recommended that teachers actively promote a mastery goal orientation when preparing class activities. Implementing pretests and formative assessments, including active learning activities, promoting goal-setting, using time efficiently, and incorporating assignments that develop study strategies are not only examples of what teachers ought to be doing already, but they are ways that teachers can practically encourage development of a mastery goal orientation.

In a study conducted by Martinek and Williams (1997), the goal orientations of 16 middle school students were studied in relation to persistence in their physical education class. It was found that students inclined toward mastery would attempt motor tasks a greater number of times than students who were oriented toward performance. Additionally, students with a more mastery goal orientation were more task-oriented, whereas their counterparts were concerned with their egos. In the end, a significant relationship was found between goal orientation and persistence. While the 1997 study is limited in its usefulness to this study because the earlier one concerns physical education rather than mathematics, persistence is essential for learning mathematics, and therefore the earlier study is helpful in informing this study.

This study seeks to describe which interventions impact student goal orientation most significantly, such as teaching students ways to study effectively, helping students to use formative assessments as tools for learning, and revealing strategies for learning difficult math concepts. By identifying beneficial strategies that can be utilized by students, it follows that
students will learn math content more deeply and will make stronger connections with math topics.

**Self-Determination Theory & Autonomy**

SDT is credited to researchers Edward Deci and Richard Ryan. Like E. Anderman’s goal orientation theory, SDT is mostly concerned with human motivation. One difference between SDT and goal orientation, however, is that SDT describes how basic psychological needs drive motivation. E. L. Deci and Ryan (2000) explained that SDT is built upon the fundamental human needs for competence, autonomy, and relatedness.

While the concepts of competence and relatedness are significant, autonomy is special. E. L. Deci and Ryan (2000) noted that autonomy is unique versus competence and relatedness because it is essential for self-determined goal-directed behavior. It is for this reason that this study focused on the subcomponent of autonomy. Ryan and Powelson (1991) defined autonomy as self rule, i.e., regulating one’s own behavior and experience and governing the initiation and direction of action… One experiences the self to be the agent… of one’s behavior” (p. 52). Possessing autonomy is vital to the success of students, as a lack of autonomy implies that students are unable to regulate their own behaviors and that their actions are without direction. It is especially important to provide opportunities to develop autonomy to adolescents because their cognitive abilities and identity are developing at a high rate (E. Anderman, Hicks-Midgley, & Carol, 1998). Specifically considering autonomy in the context of formative assessment, it is crucial for students to autonomously respond to formative
assessment feedback by initiating behaviors of persisting with challenging tasks and spending additional time and effort to independently make sense of difficult topics.

Shumow and Schmidt (2013a) suggested five key components for autonomy support: respond positively, provide choices, monitor communication, use inquiry, and promote student control (p. 49). When lessons are interesting, enjoyable, engaging, and are deemed important by the students, they will invest more effort into mastering difficult concepts. By providing choices, young people feel a greater sense of ownership and are free to select the mode of representation that demonstrates their learning best. Though the idea of so-called student controls may cause anxiety for educators, avoiding micromanagement and systems of rewards and punishments is expected to promote autonomy and ultimately lead to increased engagement and compliance.

In 2003, researchers Schweinle, Meyer, and Turner investigated motivation in the mathematics classroom by applying Csikszentmihalyi’s flow theory. Researchers found that the encouragement of autonomy was beneficial for cooperation among students and for social relatedness. It was suggested that by encouraging student autonomy, in addition to supporting self-efficacy and carefully balancing challenge and skill, that students are more motivated to learn mathematics. More generally, Kiefer, Alley, & Ellerbrock (2015) surveyed 209 students in a large, urban, ethically-diverse middle school and found that a combination of academic and emotional peer support with autonomy-supportive teachers promoted academic motivation, engagement, and a sense of belonging in the school.

The need for autonomy in schools cannot be disputed. However, an overwhelming majority of autonomy-related research is focused on the need for teacher autonomy rather than student autonomy (Tessier, Sarrazin, & Ntoumanis, 2008). In a study about teacher
empowerment, researcher Paula White (1992) made the point that “the correlation between degree of involvement and perceived benefits indicates the importance of involving teachers to the highest degree possible to get the greatest impact from decentralization of decision making” (p. 81). While teachers are trained professionals in teaching and students are not, a similar point can be made about adolescent students; there is an undeniable correlation between the degree of involvement and academic benefits. This study used formative assessment feedback as a tool to empower students to feel more autonomous while mastering difficult math concepts. Through this study, students learned to think more actively about their math education and to consider interventions that can be used independently for their own benefit and improvement.

Initial Beliefs About Mindset, Goal Orientation, and Autonomy

As the focus of this study was to describe how eighth-grade mathematics students respond to formative assessment feedback, it is necessary to know what dispositions and attitudes the students had prior to this study. By the eighth grade, adolescents have been shaped and influenced by 9 years of education and teachers instilling their own beliefs of learning on these impressionable learners. By this time in their education, there are students who have the range of fixed-to-growth mindsets, performance-to-mastery goal orientations, and varying degrees of autonomy.

Furthermore, mindset and goal orientation can affect attitudes towards achievement, and this face had the potential to interfere with the validity of this study. For example, Cain and Dweck (1995) asserted that “children who hold a [growth] view of intelligence – that is, who
believe intelligence is a malleable quality that can grow and improve – are more likely to respond to challenging tasks [with] a mastery-oriented style” (p. 27). These factors must be considered to accurately describe the effects of formative assessment feedback; therefore, this study’s first goal was to identify the attitudes students had about learning before their study’s onset.

Response to Formative Assessment Feedback

Traditionally, mathematics teachers were considered the providers of content that students then learned – teachers teach content and, as a result, students learn. The role of the teacher in a formative assessment-centered classroom is more of a facilitator and monitor of conceptual and procedural learning. (Keeley & Tobey, 2011, p. 12)

The role of the math teacher must be extended beyond merely providing content to include which educators also teach students strategies that can be used by children to monitor their own learning. More specifically, Hattie and Timperley (2007) stated that effective formative assessment feedback must clarify the following questions for students: a) What is the learning goal?, b) What progress is being made towards the goal?, and c) What must be done to attain the goal? More succinctly, Heritage (2010) referred to formative assessment as a means of narrowing the gap between where learners are and where they need to be.

Undoubtedly, providing frequent, timely formative assessment improves learning. In Bransford, Brown, and Cocking’s 1999 work, it was shown that formative assessment, when paired with a metacognitive approach to learning, led to increased student achievement. In a later 10-year study, Black, Harrison, Lee, Marchall, and William (2003) demonstrated that the use of formative assessment was particularly beneficial to students deemed to be low achievers.
However, the way in which formative assessment is provided is crucially important. As Kluger and DeNisi suggested, students cannot be depended on to change their behavior to meet a particular goal just because feedback has been provided; they may also choose to change the goal, abandon it altogether, or even reject the feedback entirely.

Formative assessment feedback allows teachers to make informed instructional decisions. If instruction is altered according to student needs, it follows that assessment feedback would also be altered to appropriately assess and inform students. Cain and Dweck (1995), citing an earlier study by Dweck and Leggett (1988), described the cycle of how students with a more fixed mindset than a growth mindset react to various forms of assessment feedback: a student with a more fixed mindset views assessment results as documentation of his or her static amount of intelligence rather than current ability. Therefore, this student will perceive formative assessment feedback about a learning task that was done poorly as proof of lack of intelligence. Consequently, the student will likely give up from a sense of helplessness and place blame on his or her perceived level of intelligence.

As school progresses and a teacher is able to encourage a growth mindset and a mastery goal orientation through formative assessment feedback—as well as promoting formative assessment feedback as an opportunity to increase autonomy—it is hoped that students’ mindsets and goal orientations will shift, thereby altering students’ interpretation of assessment of their performance and ostensibly leading to much better outcomes. Dweck and Leggett (1988) contrasted a growth-mindset student with the aforementioned fixed-mindset student as follows: Regardless of the formative assessment feedback, a child with a more growth mindset is most concerned with learning and improving, based on the belief that intelligence is malleable. Rather than using outcomes to document success (or lack thereof), feedback indicates which
skills have been learned and which ones still require attention. Rather than the helplessness the student with a more fixed mindset may experience as a result of feedback, a student with a more growth mindset is resilient in realizing that ability can change with continued effort.

The Effect of Feedback on Mindset, Goal Orientation, and Autonomy

Learning how formative assessment feedback is related to change in students’ mindset, goal orientation, and autonomy was this study’s primary purpose. Because formative assessment is a driving force in education, students will either be helped or hindered by it, depending on how teachers provide and present it and how students receive it. This concept was exemplified by a 2016 study that used focus groups at an elementary school in the United Kingdom; researchers Parker and Winstone determined, through extensive interviews, that students believed that they do not yet have the skills necessary to comprehend and engage in the interventions and feedback provided by their teachers. The students also expressed that their emotions greatly influenced their engagement with the feedback and learning from that time forward. Not only is it hoped that formative assessment feedback will empower students to learn content objectives before summative and standardized assessments, but it would serve students well if formative assessment feedback was used as a vehicle through which to promote a growth mindset and a mastery goal orientation. Furthermore, there is an urgency to shift the attitudes of adolescent learners because research has shown that over a school year in which students did not receive interventions, adolescents maintained their mindset beliefs, and their mastery goal orientations declined (J. A. Schmidt & Shumow, 2018).
A student’s mindset drastically influences the impact of formative assessment feedback given with the best possible delivery. This topic has received far more attention as it relates to college students than to middle school pupils. A 2017 study conducted about college undergraduates considered how a student’s disposition influences the way that feedback is received. The majority of student responses were self-defensive and failed to accept suggestions for remediation. In fact, students were more prone to exhibit self-deceptive attitudes in response to assessment feedback. Researchers Forsythe and Johnson attributed this to the very low percentage of student participants who started the study with a growth mindset.

In the medical field, a 2017 research project conducted by Andrew Perrella at a Canadian medical college found that in that high-stress environment, students responded to formative assessment feedback with resistance, self-protective responses, and so-called ego armoring. Feedback was perceived as harsh judgment and unwanted comparison in an environment already wrought with high stakes, lofty expectations, and competition. The study reveals the urgency with which students must be encouraged towards a growth mindset before their attitudes are set in stone, thereby eliminating the benefits of feedback during the most important years of their education.

Formative assessment as it relates to goal orientation has perhaps the most supportive empirical research. In a 2016 study of 191 undergraduate students, conducted at an American college by Dahling and Ruppel, participants received bogus negative assessment feedback on an ability test. Students with a more performance goal orientation reported lower self-efficacy and were not as interested in retaking the test; students with a more mastery goal orientation were less influenced by the effects of the negative feedback. The effect on students’ self-
efficacy was significantly detrimental only to those with a more performance goal orientation, thereby demonstrating the effect of goal orientation on students’ attitudes towards negative formative assessment feedback. More specifically related to mathematics and middle school, a study was conducted by Rakoz, Harks, Klieme et al of 146 ninth-grade German students. Among the study’s objectives was to determine whether the impact of feedback was influenced by a student’s goal orientation. It was found that there was a moderate effect on students with a more mastery goal orientation regarding the usefulness of formative assessment feedback and no significant effect on students with a more performance goal orientation.

Clark (2012) asserted a conclusion from his study of nearly 200 sources related to assessment: formative assessment promotes and reinforces self-regulatory learning behaviors, thereby increasing engagement, enriching educational experiences, and improving motivation for learning. He stressed the importance of students as necessary partners in the learning process and that they must be given opportunities to refine their skills of taking responsibility for and ownership of learning. However, empirical research that connects formative assessment feedback with autonomy is seemingly nonexistent. This is likely due to the notion that formative assessment is something that is provided to students by a teacher; the opportunity for autonomy does not present itself until students’ decisions regarding what to do in order to learn based on the feedback they have received. There is clearly a need for additional research regarding how formative assessment can actually be used to promote a sense of autonomy in students.

Especially in the eighth grade, it is essential for students to perceive that formative assessment is meant to be a tool for learning, that intelligence can increase with time and effort,
that progress over time is more important than competing with peers, and that formative assessment feedback is valuable information that students can use to control their achievement. As Dweck and Leggett (1988) stressed, “Those who believe intelligence is a fixed entity are more likely to pursue performance goals” (pp. 262-263). Teachers have a great opportunity to significantly influence the trajectory of student achievement; by encouraging students to change their minds, teachers can very tangibly change their lives.

Design-Research Methodology

The design-research methodology is frequently attributed to design scientist Ann Brown (Brown, 1992). This methodology is unique because it does not follow the strict requirements of a typical experiment (Cohen et al., 2011). However, this methodology is similar to an experiment in that it is focused on specific, intentional interventions. This methodology aims to improve current educational situations and is highly useful to teachers who are researchers in the classroom setting. Shavelson et al. (2003) state that the design-research methodology seeks to answer the following questions: “What is happening? Is there a systematic effect? Why or how is it happening?” (p. 28).

There are five primary features of the design-research methodology (Design-Based Research Collective, 2003). First, the research project and interventions were based on learning theory and practice. Second, the design-research methodology was cyclical; as the study continued, it improved over the course of several trials as refinements were made based on feedback from previous cycles. Third, all parties involved in the research were active contributors in the design and implementation of the study, and all findings will be reported to
both the participants and designers of the study. Researchers and participants were seen as collaborators rather than as separate entities. Fourth, the product of a design-research experiment is meant to work in authentic, real-world situations—not merely in a controlled laboratory setting. Brown (1992) stressed that design-research is “designed to inform practice… We must operate always under the constraint that an effective intervention should be able to migrate from our experimental classroom to average classrooms operated by and for average students and teachers” (p. 143). Finally, the cycles and interventions of the design-research methodology were driven by data gathered from previous cycles and were based on learning theory and practice.

This study adhered to the five components of design-research methodology, as follows. First, this study was based on mindset, goal orientation, and autonomy, all of which are sound learning theories. The interventions were based on best practices for educators. Second, the study was cyclical; each time students completed a post assessment survey, a new intervention was selected by the students to improve the learning environment. The interventions selected by the students refined teacher instruction and student learning. Third, the participants were heavily involved in the research, as they determined the interventions that were provided. On the day following each post assessment, I shared with the students which intervention was selected and how the intervention would be implemented. The students and I collaborated to determine fair stipulations for the interventions, as needed. Later, in periodic classroom discussions, the students and I candidly discussed the effectiveness of the interventions, how they could be improved, and what the students and I could do to benefit as much as possible from the interventions. Fourth, this project was done in an authentic, real eight-grade
classroom—not a laboratory. Finally, the interventions were selected by data collected with the post-assessment surveys, independent of my opinion.

Ultimately, the design-research methodology aspires to change teaching practice and to prevent static and outdated ways. Therefore, the product is not intended to be ideal but strives to be a living, ongoing process of refinement and improvement to remain current with education theories (Brown, 1992). As cited by the Design-Based Research Collective (2003, p. 8), the following are potential outcomes from the design-research methodology:

- Investigating possibilities for new and innovative teaching environments
- Developing theories of teaching and learning that are rooted in real-world contexts
- Developing cumulative knowledge of design
- Increasing capacity in humans for innovation

Limitations of this methodology are that some researchers would challenge the external validity and the lack of control groups (Sloane & Goddard, 2003). In response to this, Cobb et al. (2013) encouraged researchers to be specific regarding the purposes for study, to maintain communication with participants, and to have a thorough understanding of each intervention. Brown (1992) also warned that before conducting any research, the classroom included in a study must run smoothly to prevent as many potential problems as possible.

The focus of design-research methodology is to develop theories regarding both the learning process and the means in which it is supported (Cobb et al., 2003). Design research does not seek to refine either theory or practice but both as they influence one another. As explained by Collins, Joseph, and Bielaczyc (2004), researcher Diana Joseph studied
motivational theory in an afterschool program. In her findings, she noted that her findings were not limited to educational theory or practice but both in an integrated way. When conducting this study, it was important to be aware of how different interventions affected both educational theory and teaching practice together rather than in isolation. In this study, I aimed to form ideas about how to improve my instruction and develop new approaches to my teaching practices.

Researchers Cobb, Jackson, Smith, Sorum, and Henrick (2013) used the design-research methodology in a larger scale study. During 8 years, researchers studied four urban school districts with the goal of improving middle school math education. Each year, data were collected and analyzed, and then feedback was provided to the districts, prompting recommendations for improvement and the creation of new strategies for the following year. With each new year, only the most recent revised plan of action was implemented. In reviewing the effectiveness of the design-research methodology, the importance of establishing researcher-practitioner partnerships for the whole process was stressed. Furthermore, in commenting on the refinement and implementation stages of the process, researchers stressed the need for teachers to be open to feedback and the implementation of new teaching strategies.

In a study in which students learned about graphing, researchers found that students were valuable contributors of ideas for instruction and that well-meaning teachers were actually a hindrance to the learning process (diSessa & Cobb, 2004, p. 88). It is therefore necessary that all parties (including students) are active contributors to the design process because their contributions will feed back into the iterative refinement process.
Brown shared that her research was prompted by the following questions: “Why is it that young children do not use strategies? Is it that they do not know that such activities are useful, or that they do not care, or a little of both?” (1992, p. 146). Comprehending why students do not use strategies—or discovering why they do not utilize the tools they have—is precisely the driving force behind this study. After years of witnessing needless student failure due to lack of utilizing tools for learning—namely, formative assessments—further research is necessary to identify interventions that teachers can practically implement and strategies that students can easily use to promote motivation for learning and mastery of skills. Combining the features of design-research methodology with the promotion of a growth mindset, a mastery goal orientation, and increased autonomy might provide an example for teachers to use in equipping their students to take initiative to improve their learning.

Need for Additional Research

As previously mentioned, there has been some prior research in areas related to this study. While research on formative assessment is extensive, it is limited regarding American middle school mathematics classrooms. Mindset is currently a popular trend in education, and helpful scholarly texts are readily available to educators; however, more empirical research is needed to support mindset theory as it relates to formative assessment feedback. Goal orientation, in terms of formative assessment feedback, has been researched in depth by numerous researchers in a variety of contexts, content areas, age groups, and countries, while research that connects autonomy with formative assessment is seemingly nonexistent. Because the design-research methodology is based on participants as partners in the research, every
study is different. Additional research using the design-research methodology is needed to support the research methodology itself in addition to supporting previous research conducted in math or middle school classrooms. While previous research can connect formative assessment feedback with mindset or with goal orientation or with autonomy or with using design-research methodology or with mathematics or with middle school students, this study is different because it seeks to meld together all of these arenas into one related, holistic view. Rather than considering each relationship with formative assessment feedback in isolation, this study’s methodology investigates the intervention assuming that there is an interconnectedness between all of these arenas.
CHAPTER 3

METHODOLOGY

Setting & Participants

The setting of this study was an eighth-grade mathematics classroom in a northern Illinois small town within commuting distance to larger cities. Including the surrounding rural area that the school serves, there are nearly 10,000 residents within the school district boundaries (United States Census Bureau, 2012). Of the residents who participated in the last census, approximately 75% are White, 25% are Hispanic, and a small number are African American or Asian; about 20% of residents speak a language other than English at home. The average household size is 2.5 persons, with a median household income of $45,000-$50,000. Almost one fifth of the people are below the poverty level. In terms of education, over 80% of the residents have graduated from high school, and fewer than 20% have obtained a bachelor’s or more advanced degree.

Of these residents, approximately 575 sixth-, seventh-, and eighth-grade students attend the local middle school. According to the Illinois Report Card (IRC; 2013), average class size at the middle school is 25 students. Over half of the students met or exceeded expectations on the Illinois Standards Achievement Test (ISAT) in the 2012-2013 school year. The IRC also reports that more than 50% of the students are from low-income families (123 receive free and
150 receive reduced-price lunch), over 10% are reported to be English language learners (ELLs), and nearly 20% of the students served have disabilities. The National Center for Education Statistics (2013) reports that this school is a Title I school, and the student-to-teacher ratio is 14 to 1.

The participants were 149 students chosen by convenience sampling from my eighth-grade mathematics classroom. Three students who moved into the district and six students who moved away over the course of the study were excluded from this study. In addition, two students failed to comply with the research protocol and were also excluded, resulting in a final sample of 138 students from the six classes that participated in this study. Each class group was comprised of approximately 23 eighth-grade students. Of the 138 students, 111 were enrolled in a pre algebra class, which is the basic level for students in regular education classes in Illinois (see Table 1). The students taking the pre algebra course were performing at grade level (average) or approaching grade level (slightly below grade level). The remaining 27 students were enrolled in an algebra (accelerated) class in which students complete the same curriculum that is offered by the community high school. Students who performed significantly below grade level for mathematics and had Individualized Education Plan (IEPs) were in a self-contained class and were not included in this study.
Table 1

Percentage of Participants by Demographics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>62</td>
<td>44.93%</td>
</tr>
<tr>
<td>Female</td>
<td>76</td>
<td>55.07%</td>
</tr>
<tr>
<td>Race-Ethnicity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>74</td>
<td>53.62%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>57</td>
<td>41.30%</td>
</tr>
<tr>
<td>Black</td>
<td>7</td>
<td>5.07%</td>
</tr>
<tr>
<td>ESL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>9</td>
<td>6.52%</td>
</tr>
<tr>
<td>No</td>
<td>129</td>
<td>93.48%</td>
</tr>
<tr>
<td>IEP</td>
<td></td>
<td></td>
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<tr>
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<td>12</td>
<td>8.70%</td>
</tr>
<tr>
<td>No</td>
<td>126</td>
<td>91.30%</td>
</tr>
<tr>
<td>Free/Reduced-price lunch</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>56</td>
<td>40.58%</td>
</tr>
<tr>
<td>No</td>
<td>82</td>
<td>59.42%</td>
</tr>
<tr>
<td>Course</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre algebra</td>
<td>111</td>
<td>80.43%</td>
</tr>
<tr>
<td>Algebra</td>
<td>27</td>
<td>19.57%</td>
</tr>
</tbody>
</table>

Procedures

Student Assignment

Except students who were in the accelerated math program (algebra), students with IEPs in the separate class, and ELLs in a separate inclusion class, all students were randomly assigned to their classes. Therefore, each class had a variety of students who had exited from an English as a second language (ESL) program, students with have IEPs who were not
required to be in a separate class, and students with 504 behavior plans. Because this study was intended to enhance the learning process, it did not distract or harm the education of any special population in any way. Data from students in self-contained special education or ESL classes were not included in this study.

**IRB Approval**

Institutional Review Board (IRB) approval was obtained from Northern Illinois University before data collection began. Although there was no formal IRB process in the studied school district, the studied school’s building principal was given thorough information about this study, the data collection tools were shared with him, and he approved of the project before the beginning of the school year. Students learned about this study during the first 2 weeks of school and had the opportunity to ask questions and to voice any concerns they had. In addition, an informational letter was sent home to parents and families. During parent-teacher conferences, which were held in the first quarter of the school year, parents were permitted to ask clarifying questions. Throughout the process, I was available by phone or email to respond to any concerns. Parents were able to request a copy of the measurement tools at any time. Any student who chose to be excluded from this study participated in class as usual, but they did not complete the measures for this study.

**Design–Research Method**

Student interventions were selected because of the basic characteristics of the design-research methodology. Based on this methodology, students selected the next intervention that
they wanted to have implemented in the classroom, and then I implemented that intervention. The next time that students received formative assessment feedback, the survey completed at that time measured the effectiveness of the previous intervention as well as determined the next intervention to be introduced to the students. Cohen et al. (2011) cited numerous advantages to design-research methodology, including that the “process is [cyclical]… it focuses on the processes… the product has to work in the ‘real world’… [and] it is data driven” (p. 330). Although the authors called design-research methodology “messier” than a regular experiment (p. 331), it allowed me to respond to changes as they occurred throughout this study.

**Introduction of Study**

At the beginning of the school year, I led a class discussion about this study. Participation in this study was promoted as an opportunity for teens to have a voice in how their math class was run, as well as a chance to choose what accommodations would be made available to them. Furthermore, it was explained that this study would use a method (design-research methodology) that thrives on interaction between researcher and participant, that is fluid and changing, and regularly invites the feedback of participants. Finally, the students were made aware that the results of this study would possibly affect the school district, if the findings were significant and could prove beneficial for other content areas or grade levels.

Students were assured of their privacy by the use of student ID numbers and that their grades would in no way be affected by their participation (or lack thereof) in this study. It should be noted here that all students possessed and regularly used their ID numbers in the library, to log in to computers, and to pay for their lunches; therefore, they all knew their ID
numbers. Teachers could acquire these ID numbers, but it would be an arduous task to look up each student’s ID number and would not have advanced this study to correlate students’ responses to their surveys. The students were given the opportunity to ask questions, permissions slips were distributed with an appropriate deadline, and students were informed of their right to decline or withdraw at any time.

Data Collection

In the first week of school, the students completed the initial survey (Appendix A), which was the same as the post assessment survey (Appendix B), except the first and last statements were omitted on the initial survey. The point of this initial survey was to measure students’ general attitudes regarding mindset, goal orientation, and autonomy as related to math class without the influence of formative assessment feedback. It was stressed that honesty was crucial. Because of the amount of text and student unfamiliarity with the survey format, I read the statements aloud. Before accepting the written answers to the initial surveys, I quickly reviewed them to ensure that each survey had an ID number, that it was filled in completely, and that the circles students marked were obvious. My quick review of written answers was repeated throughout this study to ensure the highest possible completion rate and also so that I would not have to make judgments regarding students’ intended responses when compiling the data. Once reviewed, the completed initial surveys were placed in a folder.

I administered each survey because it was not practical or feasible to ask another person to administer so many surveys throughout the course of this study. Bias was avoided by
providing the same survey to each student. Students were given time and space to complete the surveys without me watching over them directly.

Each post assessment survey (Appendix B) was administered immediately after students received feedback for a formative assessment. Over the course of this study, students completed the same post assessment survey after receiving feedback for each graded formative assessment. The only difference on the repeated post assessment surveys was the last statement, where suggestions for interventions generated by students on the previous survey were added to the list of intervention options to choose from. All of the students in each class completed the surveys at the same time, except a small number of students who were absent on the day of the feedback and post assessment survey. Students completed the surveys independently, without collaborating with others. Parts of the survey statements were bolded to clarify the subtle differences between statements that students may not have perceived when each statement was read to them: for example, “Given enough time, I could master new math skills” and “Given enough effort, I could master new math skills.”

Measures

Survey

According to Cohen, Manion, & Morrison (2011), validity refers to the degree that an instrument actually measures what it claims to measure. The surveys measured the mindset of students using three of the original statements provided by Dweck (2006b, pp. 12-13). Only the three statements most related to this study were included because many of Dweck’s
statements are repetitive and unrelated to mathematics, such as statements related to special talents and sports. Furthermore, keeping the surveys concise allowed students to both receive assessment feedback and complete a survey in one class period and also helped in preventing students from experiencing survey fatigue.

Students indicated their agreement (or disagreement) with the three survey statements, using a 4-point Likert scale. These statements were (a) Given enough time, I could master new math skills; (b) Given enough effort, I could master new math skills; and (c) A person is born with a certain amount of ability to learn math skills. These statements reflect Dweck’s basic statement (2006a): Any person can always substantially change how intelligent you are. Visser (2013) conducted a study regarding the mindset of professionals in which 3,345 subscribers of a digital newsletter completed Dweck’s questionnaire as an online survey. In this study as well as the Visser study, items worded as fixed mindset statements were reverse-coded. Cronbach’s alpha for the Visser study was .80 when all 8 items were included and .83 after 2 of the items were deleted. The test-retest reliability was .82 over a 1-week and .71 over 4 weeks.

Similarly, this study’s surveys measured the goal orientation of the students through statements adapted from characteristics listed on Shumow and Schmidt’s Checklist of Goal Orientation (2013). As with mindset, only the three characteristics most related this study’s focus were used from J. Schmidt and Shumow’s (2013) original list of eight major characteristics of goal orientation. The three characteristics relate to teacher focus, student attention, and effort; the other five characteristics would be beneficial for a classroom teacher to know, but they are not as closely linked to this study.
Again, students indicated their agreement (or disagreement) with three statements using a 4-point Likert scale. These statements were (a) Learning is very important to me in math class, (b) Grades are very important to me in math class, and (c) Doing as well as other students is very important to me in math class. These three statements reflect the following two basic statements from the goal orientation checklist, which was adapted from the PALS survey (Midgley et al., 1997): (a) The teacher focuses on learning and improvement, and (b) Effort [is] inspired by gaining new knowledge (not high grades or outperforming others). Midgley et al. (2000) surveyed secondary students regarding how they perceived the purpose of engaging in academic work. The survey was adapted from PALS, as this study’s surveys were. In the Midgley et al. (2000) study, the reliability was .71 and the test-retest reliability and validity was \( a > .70 \).

Finally, this study’s surveys measured students’ levels of perceived autonomy through statements adapted from the autonomy aspect of E. Deci and Ryan’s General Causality Orientations Scale (GCOS, 2017). Students indicated their agreement (or disagreement) to three statements using a 4-point Likert scale. These statements were (a) I can control how well I learn in math class, (b) my opinions matter to my math teacher, and (c) I know how to independently study for a math assessment. Deci and Ryan conducted a study in 1985, which validates their GCOS and describes how it was developed. The GCOS was found to be reliable; the Cronbach alpha was .75, and the test-retest coefficient was .74 over 2 months.

The scoring of this study’s survey statements is included in Appendices A and B (following the student copy) and reflects values ranging from 0 to 3 points. High points (3) represent a growth mindset, goal orientation, and high levels of autonomy. Additionally, a
mean score for each category of mindset, goal orientation, and autonomy were calculated based on the statements about represent each. For every factor, a sum score from the corresponding statements was calculated for every student. Each survey statement was scored with a value ranging from 0-3; therefore, each factor had a value ranging from 0-9 where 0 represented fixed mindset, performance goal orientation, and low perceived autonomy and 9 represented growth mindset, mastery goal orientation, and high perceived autonomy (the sum score of statements that each had a point value of 0-3).

In the aforementioned study in 2007 by Dweck, Blackwell, and Trzesniewski, students completed what was referred to by the researchers as a motivational survey, including a “theory of intelligence, goals, beliefs about effort, and responses to failure” (p. 249), similar in nature to the survey used in this study. The 2007 survey also used a Likert scale and, similar to this study, the researchers used a mean score to represent the survey categories. The internal reliability of Dweck et al.’s study was .78 (N = 373) with a mean of 4.45 and a SD of .97 on a range of 1-6. The test-retest reliability over 2 weeks was .77 (N = 52). Students from the Dweck, Blackwell, and Trzesniewski study were surveyed to determine the effect of intelligence, goals, beliefs about effort, and responses to failure regarding mathematics grades over 2 years.

Cohen defined reliability as a “synonym for dependability, consistency and replicability over time, over instruments and over groups of respondents. It is concerned with precision and accuracy” (2011, p. 199). The same instruments were used throughout this study, and I oversaw the completion of each survey, thereby increasing the consistency of this study. Regarding validity, the instruments yielded accurate results as long as students treated the
surveys seriously and I was observant of any uncharacteristic behaviors from the students. I was also careful to ensure that all surveys were completely and correctly finished to prevent missing data. After the students’ responses were compiled in SPSS for analysis, the data were double-checked for precision to ensure that the results are accurate.

The post assessment survey was pilot-tested by the eighth-grade students from the 2013-2014 class, and a variety of interventions were pilot-tested with students from the 2014-2015 class. Therefore, the 2015-2016 students who contributed data this study had a fresh start and did not experience any of the preliminary survey versions or teacher interventions. The purpose of the pilots was to test the validity of the survey and the functionality of the interventions themselves, not to investigate the impact of any interventions. By administering several surveys and interventions prior to this study, I was able to clarify complex wording on the survey, prevent potential problems in administering the survey, develop a system for administering the survey efficiently, gauge time more effectively, and implement interventions smoothly. In a series of whole-class discussions and individual writing prompts, the students from the pilots were encouraged to identify parts of the survey that were unclear, provide suggestions for improvements, and suggest interventions that would be useful to future students. The developed interventions that resulted from these pilots were included on the initial survey, which were built upon over this study.

Interventions

As the academic semester began, the first 2 weeks were spent on the first set of math standards. Students received formal feedback through graded homework assignments as well
as informal feedback in general classroom activities, such as in working through classroom example questions, justifying answers with a student partner, and with me during independent practice time.

After 2 weeks, the first formative assessment (quiz) was given and the cycle of assessments, feedback, and surveys began (see Figure 1). For the first quiz, only check marks were used for incorrect answers, and a score of positive points over ten possible points written at the top of the page. Before returning the formative assessments to the students, I recorded students’ scores; students were allowed to keep their assessments. All graded formative assessments were returned during the next class meeting. The correct answers were given, explanations of questions with higher error rates were given, and students were given the opportunity to ask questions. Directly following this feedback, the were given their first post-assessment survey. The post assessment survey was scored in the same way as the initial survey. The last question of the post assessment survey was used to determine the intervention to be offered in the next class meeting, as students were asked to select what they believed to be most beneficial from a list of potential interventions; students were also encouraged to submit suggestions for future interventions.

The interventions that were offered on the first post assessment survey were (a) practice worksheets (with an answer key) to use for studying, (b) links to online games or apps to use for studying, (c) extra help before or after school, (d) homework re-grading opportunities to use to prepare for quizzes and the unit test, (e) quiz re-takes to use to prepare for the test, (f) more written feedback on homework/ quizzes, and (g) more verbal feedback on homework/ quizzes. These interventions were based on 2 years of pilot-testing interventions as well as suggestions
by veteran teachers (Wormeli, 2013). Any intervention suggestions that were provided by students on the post assessment surveys were added to the next post assessment surveys. The interventions on the first post-assessment survey were limited to only the interventions used in the pilot tests in order to provide a greater opportunity for students to suggest interventions.

The intervention that was selected most frequently by the students was the intervention that was implemented in the next class meeting. In almost all situations, one intervention was favored by a large margin, and each class chose similarly. In the one case in which the number of selections of two interventions was very close, the slightly less popular option was selected in the next post assessment survey. While it may have been ideal to individualize the interventions by student, or even by class period, it was not feasible to manage so many interventions for 138 students over a short time frame.

The second set of standards started a new cycle of teaching and providing formal and informal feedback through homework and classroom activities. During this time, the first intervention was implemented so that students could experience it before taking the next post assessment survey. The second formative assessment went much the same way as the first. I graded the assessment using check marks and wrote a total score at the top of the page. During the next class period, the formative assessments were returned and students completed their second post-assessment survey. This survey described the initial impact of the first intervention (regarding mindset, goal orientation, and autonomy) as well as generated input for the next intervention.
The cycle of teaching, formative assessments, feedback, and interventions was completed eight times 22 weeks (see Figure 1). There were no interventions presented after summative assessments because this study sought to investigate teacher feedback on formative assessment. When students were absent for formative assessment feedback, I recreated the formative assessment feedback in a way that was as close as possible to what the rest of the students had experienced. The absent student then completed the post assessment survey.

![Figure 1. Organization of teaching, assessments, feedback, and interventions.](image)

**Analysis**

I entered the data into an SPSS database from each survey that the students completed. Each post assessment survey question was a variable so that it could be compared over this course of the study. Mean scores for mindset, goal orientation, and autonomy were calculated from the three or four corresponding questions was a variable. Other variables such as gender, race, and socioeconomic status were entered for each student.
Question 1

With what level of mindset, goal orientation, and autonomy do eighth graders enter mathematics class at the beginning of a school year? This research question was answered using descriptive statistics based from data collected from students’ responses on the initial survey. Mean scores were used to describe students’ average level of mindset, goal orientation, and autonomy and standard deviations further described the variability for each of the three factors.

Question 2

How do students’ mindset, goal orientation, and autonomy change over a school semester during which they received formative assessment feedback? Do students who select interventions after receiving formative assessment feedback decline significantly in mindset, goal orientation, and autonomy during the school semester (as is the typical case in middle school classrooms)? This research question was answered using a series of two-tailed paired samples t-tests. All students completed the same survey throughout this study; therefore the same scale could be and was used for each factor (mindset, goal orientation, and autonomy). The independent variable (time—the initial versus last post assessment survey) was categorical, and the dependent variables (mindset, goal orientation, and autonomy scores) were continuous.

Question 3

Does change in students’ mindset, goal orientation, and autonomy over a school semester vary by student demographic characteristic? This research question was answered
using a one-way repeated measures ANOVA. All students completed the same survey throughout this study; therefore the same scale was used for each factor (mindset, goal orientation, and autonomy). The independent variable (pre, post) was categorical and the dependent variable (goal orientation, mindset, and autonomy scores) was continuous. The demographics tested were gender, English language proficiency, special education, race, socioeconomic status (free/reduced-price lunch), and class placement (algebra/pre algebra), which are categorical variables.

**Question 4**

*What is the teacher-researcher’s reflection on the implementation of student-selected interventions in the classroom?* This research question was answered using small focus group interviews. Four to six students were randomly selected from each class period to participate in interviews conducted by me, in which they were asked questions related to mindset, goal orientation, and autonomy. Students’ responses were coded and analyzed according to these demographic characteristics.
CHAPTER 4

RESULTS

Purpose

A purpose of this analysis is to learn how eighth-grade mathematics students responded to the process of selecting interventions after receiving formative assessment feedback, specifically related to student mindset, goal orientation, and autonomy. There were three major steps in the data analysis, each corresponding to one of the first three research questions. First, this study sought to identify the level of mindset (ranging from a fixed to a growth mindset), the level of goal orientation (ranging from performance to mastery goal orientation), and the degree of autonomy students perceive to have had upon entering eighth grade. Second, this study attempted to determine whether selecting, implementing, and evaluating interventions after receiving formative assessment feedback had a significant effect on the level of eighth-graders’ mindset, goal orientation, and autonomy and whether participating in selecting interventions (using design-research methodology) promoted the development of a growth mindset, a mastery goal orientation, and increased autonomy. Finally, this study identified which demographic of students benefited most from selecting interventions that they felt would be most beneficial.
Question 1: With what mindset, goal orientation, and level of autonomy do eighth-grade students enter mathematics class at the beginning of a school year?

The data used to respond to this research question were from an initial survey, which students completed at the beginning of this study (prior to selecting any interventions). Descriptive statistics were run for all categories (mindset, goal orientation, autonomy) to determine the mean scores and standard deviations in order to compare subsets within different populations of students: male and female (gender), ESL and non-ESL (language proficiency), IEP and non-IEP (learning ability), White/Hispanic/Black (race), free/reduced-price lunch or not (socioeconomic status), and algebra or pre algebra (course track).

Entering eighth-grade students demonstrated, on average, to be inclined towards a growth mindset, rather than a fixed mindset, with a mean score of 6.01 (SD = 1.48) on a scale of 0-9, where 0 is fixed mindset and 9 is growth mindset (see Table 3). This indicates that students generally believed that they could master new skills with time and effort and that they did not believe that a person is born with inherent skills in math. Students beginning eighth-grade were slightly more likely, on average, to identify with the mastery goal orientation, rather than the performance goal orientation, indicating that these students believed that learning was more important than grades or doing better than their peers. Students’ scores ranged from 1 to 7, with a mean score of 4.01 (SD = 1.14). As indicated by their survey scores, students starting the eighth-grade felt that they possessed more autonomy than not, meaning that, on average, these students believed that they were in control of their learning in math class, that they thought that their opinions matter to their math teacher, and that they knew how to study
independently for math assessments. Students’ scores ranged from 2 to 9, with a mean score of 5.76 (SD = 1.54).

Question 2: How do students’ mindset, goal orientation, and autonomy change over a school semester during which they received formative assessment feedback? Do students who select interventions after receiving formative assessment feedback decline significantly in mindset, goal orientation, and autonomy over the school semester (as is the typical case in middle school classrooms)?

A series of two-tailed paired samples t-tests was used to describe changes in students’ levels of mindset, goal orientation, and autonomy after students had selected interventions to be implemented in the classroom (see Table 3). The information used to answer to this research question was the difference between the initial and last post assessment survey administered to each student. The mindset, goal orientation, and autonomy scores were calculated for each student based on his or her responses to survey questions related to mindset, goal orientation, and autonomy; all students completed the same survey throughout this study; therefore the same scale could be and was used. The independent variable (time–the initial versus last post-assessment survey) was categorical, and the dependent variables (mindset, goal orientation, and autonomy scores) was continuous.

Table 4 shows a significant association between the initial and post scores for mindset and goal orientation ($p < .05$).

On average, students who participated in selecting interventions after receiving
Table 2

Means and Standard Deviations From Descriptive Statistics on Mindset, Goal Orientation, and Autonomy of Eighth-Grade Students at the Start of the School Year

<table>
<thead>
<tr>
<th>Category</th>
<th>Mindset mean (sd)</th>
<th>Goal orient. mean (sd)</th>
<th>Autonomy mean (sd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All eighth-grade students (n = 138)</td>
<td>6.01 (1.36)</td>
<td>4.01 (1.14)</td>
<td>5.76 (1.54)</td>
</tr>
<tr>
<td>Male (n = 62)</td>
<td>6.18 (1.48)</td>
<td>3.97 (1.13)</td>
<td>6.13 (1.41)</td>
</tr>
<tr>
<td>Female (n = 76)</td>
<td>5.87 (1.26)</td>
<td>4.05 (1.15)</td>
<td>5.46 (1.58)</td>
</tr>
<tr>
<td>ESL (n = 9)</td>
<td>5.88 (1.13)</td>
<td>4.13 (1.25)</td>
<td>4.38 (0.74)</td>
</tr>
<tr>
<td>Non-ESL (n = 129)</td>
<td>6.02 (1.38)</td>
<td>4.01 (1.14)</td>
<td>5.85 (1.53)</td>
</tr>
<tr>
<td>IEP (n = 12)</td>
<td>6.17 (1.75)</td>
<td>3.92 (1.0)</td>
<td>6.50 (1.51)</td>
</tr>
<tr>
<td>Non-IEP (n = 126)</td>
<td>5.99 (1.33)</td>
<td>4.02 (1.16)</td>
<td>5.69 (1.53)</td>
</tr>
<tr>
<td>White (n = 74)</td>
<td>6.28 (1.48)</td>
<td>4.01 (1.09)</td>
<td>5.99 (1.58)</td>
</tr>
<tr>
<td>Hispanic (n = 57)</td>
<td>5.67 (1.12)</td>
<td>4.02 (1.20)</td>
<td>5.40 (1.41)</td>
</tr>
<tr>
<td>Black (n = 7)</td>
<td>5.86 (1.46)</td>
<td>4.00 (1.29)</td>
<td>6.29 (1.41)</td>
</tr>
<tr>
<td>Free/Reduced-price Lunch (n = 56)</td>
<td>5.52 (1.22)</td>
<td>4.18 (1.13)</td>
<td>5.61 (1.29)</td>
</tr>
<tr>
<td>Non-Free/Reduced-price Lunch (n = 82)</td>
<td>6.34 (1.36)</td>
<td>3.90 (1.14)</td>
<td>5.87 (1.68)</td>
</tr>
<tr>
<td>Pre algebra (n = 111)</td>
<td>5.77 (1.23)</td>
<td>4.05 (1.16)</td>
<td>5.60 (1.56)</td>
</tr>
<tr>
<td>Algebra (n = 27)</td>
<td>6.96 (1.48)</td>
<td>3.85 (1.06)</td>
<td>6.41 (1.28)</td>
</tr>
</tbody>
</table>

*Note.* Values shown are means. Mindset, goal orientation, and autonomy scores ranged from 0 to 9. Low scores indicate a more fixed mindset, a performance goal orientation, and low autonomy; high scores indicate a more growth mindset, a mastery goal orientation, and high autonomy.
Table 3

Comparison of Initial and Post Scores: Paired Samples Statistics (N = 138)

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std. deviation</th>
<th>Std. error mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial mindset</td>
<td>6.01</td>
<td>1.364</td>
<td>.116</td>
</tr>
<tr>
<td>Post mindset</td>
<td>6.17</td>
<td>1.564</td>
<td>.133</td>
</tr>
<tr>
<td>Initial goal orientation</td>
<td>4.01</td>
<td>1.14</td>
<td>.097</td>
</tr>
<tr>
<td>Post goal orientation</td>
<td>4.27</td>
<td>1.212</td>
<td>.103</td>
</tr>
<tr>
<td>Initial autonomy</td>
<td>5.76</td>
<td>1.536</td>
<td>.131</td>
</tr>
<tr>
<td>Post autonomy</td>
<td>6.64</td>
<td>1.638</td>
<td>.139</td>
</tr>
</tbody>
</table>

Formative assessment feedback had a higher degree of growth mindset ($M = 6.17, SE = 0.133$) than before choosing interventions ($M = 6.01, SE = 0.16$). This difference, -0.16, 95% CI [-.41, .09], was not significant $t(137) = -1.25, p = .213$.

On average, students who participated in selecting interventions after receiving formative assessment feedback had a higher degree of mastery goal orientation ($M = 4.27, SE = 0.103$) than before choosing interventions ($M = 4.01, SE = 0.097$). This difference, -0.26, 95% CI [-.48, -.03, was significant $t(137) = -2.24, p = .027$.

On average, students who participated in selecting interventions after receiving formative assessment feedback had a greater degree of perceived autonomy ($M = 6.64, SE = 0.139$) than before choosing interventions ($M = 5.76, SE = 0.131$). This difference, -0.88, 95% CI [-1.17, -.60], was significant $t(137) = -6.11, p = .000$. 
Table 4

Initial-Post Paired Differences

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std. deviation</th>
<th>Std. error</th>
<th>95% confidence interval</th>
<th>t</th>
<th>Sig (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>Lower</strong></td>
<td></td>
<td><strong>Upper</strong></td>
</tr>
<tr>
<td><strong>Mindset</strong></td>
<td>-.159</td>
<td>1.496</td>
<td>.127</td>
<td>-.411</td>
<td></td>
<td>-.092</td>
</tr>
<tr>
<td><strong>Goal orientation</strong></td>
<td>-.254</td>
<td>1.329</td>
<td>.113</td>
<td>-.477</td>
<td></td>
<td>-.030</td>
</tr>
<tr>
<td><strong>Autonomy</strong></td>
<td>-.884</td>
<td>1.700</td>
<td>.145</td>
<td>-1.170</td>
<td></td>
<td>-.598</td>
</tr>
</tbody>
</table>

Note: p < .05. **p < .01. ***p < .001.

Question 3: Does change in students’ mindset, goal orientation, and autonomy over the school semester vary by student demographic characteristic?

**Goal Orientation**

The information used to answer this research question was the difference between the initial and last post assessment survey. The goal orientation score was calculated for each student based on his or her responses to survey questions related to goal orientation. The same questions were used throughout this study.

The data were first tested for sphericity, using Mauchly’s test of sphericity. Because the significance was less than .001 (p = .000), this indicates a violation of the assumption of sphericity. This time, because the Greenhouse-Geisser correction was greater than .75 (p = .794), the Huynh-Feldt correction was used.
The one-way repeated measures ANOVA test was used to describe whether the students’ goal orientation changed over the course of this study. The interventions were categorical, independent variables, while the goal orientation score was the continuous, dependent variable.

Table 5 indicates that, overall, there were no significant differences between the mean scores at the different times \( F(7.076, 919.871) = 1.258 \) and \( p = .272 > .05 \). At the .05 significance level, the gender, ESL, IEP, race, free/reduced-price lunch, and pre algebra/algebra, variables were found to have no significant effect on goal orientation over time. However, at the .10 significance level, the effect of race on goal orientation is marginally significant over time \( (p = <.10) \)
Table 5

Analysis of Within-Subjects Effects on Goal Orientation in Eighth-Grade Mathematics Students Over Time

<table>
<thead>
<tr>
<th></th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>time</td>
<td>6.224</td>
<td>7.076</td>
<td>.880</td>
<td>1.258</td>
<td>.268</td>
</tr>
<tr>
<td>time * female</td>
<td>5.020</td>
<td>7.076</td>
<td>.709</td>
<td>1.015</td>
<td>.419</td>
</tr>
<tr>
<td>time * ESL</td>
<td>1.372</td>
<td>7.076</td>
<td>.174</td>
<td>.27</td>
<td>.964</td>
</tr>
<tr>
<td>time * IEP</td>
<td>6.067</td>
<td>7.076</td>
<td>.857</td>
<td>1.227</td>
<td>.285</td>
</tr>
<tr>
<td>time * race</td>
<td>16.749</td>
<td>14.152</td>
<td>1.184</td>
<td>1.693</td>
<td>.051†</td>
</tr>
<tr>
<td>time * free</td>
<td>2.483</td>
<td>7.076</td>
<td>.351</td>
<td>.502</td>
<td>.835</td>
</tr>
<tr>
<td>time * prealg</td>
<td>6.101</td>
<td>7.076</td>
<td>.862</td>
<td>1.233</td>
<td>.281</td>
</tr>
</tbody>
</table>

*Note.* Using Huynh-Feldt-corrected values. †p < .10.

Table 6 indicates that the variable of free/reduced-price lunch was related to goal orientation (p = .016). The variables of gender, ESL, IEP, race, and pre algebra/algebra were not related to goal orientation.

**Autonomy**

The information used to answer this research question was the difference between the initial and last post assessment survey. The autonomy score was calculated for each student
Table 6

Analysis of Between-Subjects Effects: Goal Orientation

ONE-WAY ANOVA

<table>
<thead>
<tr>
<th></th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>female</td>
<td>.953</td>
<td>1</td>
<td>.953</td>
<td>.137</td>
<td>.712</td>
</tr>
<tr>
<td>ESL</td>
<td>2.781</td>
<td>1</td>
<td>2.781</td>
<td>.396</td>
<td>.529</td>
</tr>
<tr>
<td>IEP</td>
<td>.022</td>
<td>1</td>
<td>.022</td>
<td>.003</td>
<td>.955</td>
</tr>
<tr>
<td>race</td>
<td>7.002</td>
<td>2</td>
<td>3.501</td>
<td>.502</td>
<td>.607</td>
</tr>
<tr>
<td>free lunch</td>
<td>41.550</td>
<td>1</td>
<td>41.550</td>
<td>5.954</td>
<td>.016*</td>
</tr>
<tr>
<td>pre algebra</td>
<td>.252</td>
<td>1</td>
<td>.252</td>
<td>.036</td>
<td>.850</td>
</tr>
</tbody>
</table>

Note. †p < .10. *p < .05. **p < .01. ***p < .001.

based on his or her responses to survey questions related to levels of perceived autonomy. The same questions were used throughout this study.

Again, the data were first tested for sphericity using Mauchly’s test of sphericity. Because the significance was less than .001 (p = .000), this indicates a violation of the assumption of sphericity. The Greenhouse-Geisser correction was used for this analysis.

The one-way repeated measures ANOVA test was used to determine when students’ levels of perceived autonomy changed during the semester in which they received formative assessment feedback. As in the previous analysis of mindset and goal orientation, the interventions were categorical, independent variables, while the autonomy score was the continuous, dependent variable.
Table 7, using the Greenhouse-Geisser corrected values, indicates that there was no overall significant difference between the levels of autonomy at different times over the course of this study ($F(5.736, 745.646) = 2.068$ and $p = .058 > .05$). At the .10 significance level, however, time does have a marginally significant effect on students’ perceived autonomy ($p = .058 < .10$)

Table 7
Analysis of Within-Subjects Effects on Perceived Autonomy in Eighth-Grade Mathematics Students Over Time

<table>
<thead>
<tr>
<th></th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>time</td>
<td>17.247</td>
<td>5.736</td>
<td>3.007</td>
<td>2.068</td>
<td>.058†</td>
</tr>
<tr>
<td>time * ESL</td>
<td>9.349</td>
<td>5.736</td>
<td>1.630</td>
<td>1.121</td>
<td>.348</td>
</tr>
<tr>
<td>time * IEP</td>
<td>2.674</td>
<td>5.736</td>
<td>.466</td>
<td>.321</td>
<td>.920</td>
</tr>
<tr>
<td>time * race</td>
<td>10.509</td>
<td>11.471</td>
<td>.916</td>
<td>.630</td>
<td>.811</td>
</tr>
<tr>
<td>time * free</td>
<td>2.846</td>
<td>5.736</td>
<td>.496</td>
<td>.341</td>
<td>.909</td>
</tr>
<tr>
<td>time * PreAlg</td>
<td>8.367</td>
<td>5.722</td>
<td>1.462</td>
<td>1.270</td>
<td>.271</td>
</tr>
<tr>
<td>time * female</td>
<td>13.862</td>
<td>5.736</td>
<td>2.417</td>
<td>1.662</td>
<td>.131</td>
</tr>
</tbody>
</table>

*Note.* Used Greenhouse-Geisser-corrected values. †$p < .10$. *$p < .05$. **$p < .01$. ***$p < .001$. 
As seen in Table 8, gender was related significantly to perceived autonomy at the .05 significance level ($p = .049$). At the .10 significance level, ESL ($p = .055$), race ($p = .052$), and pre algebra ($p = .061$) had a marginally significant association with autonomy.

Table 8

Analysis of Between-Subjects Effects: Autonomy

**ONE-WAY ANOVA**

<table>
<thead>
<tr>
<th></th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>female</td>
<td>47.122</td>
<td>1</td>
<td>47.122</td>
<td>3.966</td>
<td>.049*</td>
</tr>
<tr>
<td>ESL</td>
<td>44.722</td>
<td>1</td>
<td>44.722</td>
<td>3.764</td>
<td>.055†</td>
</tr>
<tr>
<td>IEP</td>
<td>29.196</td>
<td>1</td>
<td>29.198</td>
<td>2.457</td>
<td>.119</td>
</tr>
<tr>
<td>race</td>
<td>71.693</td>
<td>2</td>
<td>35.846</td>
<td>3.017</td>
<td>.052†</td>
</tr>
<tr>
<td>free</td>
<td>1.376</td>
<td>1</td>
<td>1.376</td>
<td>.116</td>
<td>.734</td>
</tr>
<tr>
<td>pre algebra</td>
<td>42.545</td>
<td>1</td>
<td>42.545</td>
<td>3.581</td>
<td>.061†</td>
</tr>
</tbody>
</table>

*Note.* †$p < .10$. *$p < .05$. **$p < .01$. ***$p < .001$.

Question 4: What was the teacher-researcher’s reflection on the implementation of student-selected interventions in the classroom?

My reflection is based on careful repetition of design-research methodology for 2 ½ years beyond this study’s completion. Conclusions were formulated from my notes; classroom
observations; whole-class discussions (and the notes produced from them); and students’ independent, written responses. The continued implementation as well as the reflections and conclusions based upon my experience and practices are described in a section of Chapter 5. In short, I developed new thoughts and approaches to my teaching practice,
CHAPTER 5

DISCUSSION

General Findings

This study determined that students entered eighth grade with mindsets more inclined towards growth mindsets rather than fixed mindsets. It is noteworthy that, on average, the students with the lowest mindset scores, indicating a more fixed mindset, were from disadvantaged populations. Based on the findings from this study, students entered eighth-grade mathematics class with a slight disposition towards a performance goal orientation, but were largely neutral about this factor. Findings for the level of perceived degree of autonomy upon entering eighth grade were very similar to the mindset findings.

The act of selecting interventions after receiving formative assessment feedback was related to a change in students’ goal orientation mean score. Students who participated in selecting interventions after receiving formative assessment feedback had a greater degree of a mastery goal orientation at the end of this study than they had at the beginning. The act of selecting interventions after receiving formative assessment feedback was related significantly to a change in students’ levels of perceived autonomy. Students who participated in selecting interventions after receiving formative assessment feedback reported perceiving a greater degree of autonomy at the end of this study than they had at the beginning.
Student-selected interventions was related significantly to the goal orientations of students who received free/reduced-price lunch. This study showed that student-selected interventions had a significant association with the level of autonomy perceived by males as well as a marginally significant effect on non-ESL, White, and pre algebra students. Therefore, there was an association with allowing students to select interventions after receiving formative assessment feedback: students who received free/reduced-price lunch became significantly more inclined towards a mastery goal orientation, and male students made significant gains in feelings of perceived autonomy.

**RQ1:** With what mindset, goal orientation, and level of autonomy do eighth grade students enter mathematics class at the beginning of a school year?

**Mindset: Expected Results**

Previous research, such as Blackwell et al.’s (2007), has shown that adolescent students tend to experience a downward trend towards a fixed mindset over the middle school years, causing a decline in motivation and achievement. Based on the prevalence of non persistence observed in middle school, it was supposed that most middle school students in this study would enter eighth grade with a more fixed mindset.

**Mindset: Findings and Interpretation**

This study found that students entered eighth grade with mindsets more inclined towards a growth mindset rather than a fixed mindset (6.01 on a scale of 0 to 9, with a standard
deviation of 1.36). This indicates that the majority of students believed that any person can learn difficult math concepts, given sufficient time and effort. Furthermore, this shows that students have previously been influenced to accept the ideas that learning new concepts may take several attempts but that failure—even repeated failure—is not an indication of inability. Students’ confirmed these ideas during small focus group discussions; when asked if they were capable of learning difficult math concepts, their response was only in the affirmative. Even more, students elaborated that they actually believe that studying for tests would help them to perform better and that they were not just saying that to appease me. They also suggested that teachers should practice math processes constantly, use repetition “almost to the point of overkill,” and to go through material slowly and in very small pieces before moving along; the request for repetition, thorough explanations, moving slowly, and teaching small amounts of content at a time was recurrent in almost every interview. While these reflections largely relate to performance, they indicate the application of a growth mindset; students so thoroughly believe in their ability to learn difficult skills that they are able to cite strategies that would help them best. If they did not believe that they could learn, they would not be likely to have so consistently expressed these needs.

**Mindset: Implications**

Cain and Dweck (1995) found that students establish their theories of intelligence, as well as their motivational patterns, by the fifth grade. Furthermore, a child is not only affected academically by having a more fixed mindset; Dweck asserted that a person’s mindset affects the most basic qualities of his or her life, including talents and personality, in addition to intelligence (2006). Fortunately, a person’s mindset can change; this change of mindset,
however, is far easier to accomplish if it is done by the end of elementary school, when most students have solidified their mindsets. Therefore, elementary educators and parents must be continually educated about mindset, the implications of a more fixed mindset, and strategies that encourage a growth mindset. Most importantly, adults who work and live with students must first be convinced of the tenets of growth mindset themselves before they can effectively encourage these same beliefs in children. Only when students are raised with the knowledge that mistakes are normal in the process of learning, with the expectation that some concepts will require more work to master than others, and with the examples that demonstrate the malleability of the mind, will students fully embrace a growth mindset. Furthermore, students in their most formative teenage years must be supported by teachers, coaches, and peers who remind them of these tenets of a growth mindset. It is suggested that schools—elementary especially—continue to encourage students at a young age towards a growth mindset. Administrators should strongly encourage mindset education to be taught in schools, school guidance should supply information to parents, and teachers ought to continue to model a growth mindset by encouraging their students and by being transparent about their own struggles (and eventual successes) in learning.

**Goal Orientation: Expected Results**

Researchers E. Anderman and Maehr, who previously researched the goal orientations of middle school students in mathematics (1993), shared their concern regarding the drastic downturn in motivation of students in the middle grades. Their concern that students are relying on low-level learning strategies (such as rote fact memorization) and are heavily and immediately relying on the assistance of teachers when faced with difficult tasks is shared by
me and is evident in this study’s student population. It was expected that students would have an overall disposition towards a performance goal orientation.

**Goal Orientation: Findings and Interpretation**

Based on the findings from this study, students entered eighth-grade mathematics class with a slight disposition towards a performance goal orientation (3.97 on a scale of 0 to 9, with a standard deviation of 1.13) but were largely neutral in this domain. This indicates that students cared slightly more about grades than they did about learning. Furthermore, this shows that students were aware of the performance of their peers but may or may not have been concerned with how they compared to peers. These findings were supported in the small focus group discussions. In four of the six discussions, students responded unanimously that while some students noticed the grades of other students, they did not really care if others did better or worse than them. It was their own scores that they were most concerned about. However, in two discussions, students showed a stronger sensitivity about their grades being visible to other students, how they felt judged by others, and how comparisons affected their attitudes towards their own accomplishments. One student responded that she was feeling good about her score on her math test (a B) because she knew that she had put a lot of effort towards learning that content; however, when she noticed two students near her had scored higher than her, her sense of pride significantly diminished. She went on to suggest that teachers write grades more discreetly, “like, microscopically at the bottom of the page” to prevent comparisons.

Interestingly, students with the lowest goal orientation scores—those who were more inclined towards a performance goal orientation rather than a mastery goal orientation—were
students from the accelerated track for math (3.85) and were not from the free/reduced-price lunch population (3.90).

**Goal Orientation: Implications**

E. Anderman and Maehr stated over 2 decades ago that “the time for reinventing schools has arrived” (1993). The need for a culture change in schools is long overdue. There is great urgency to promote a mastery goal orientation in young students, especially before lifelong decisions are made. E. Anderman and Wolters (2006) voiced their fear that middle school students may not pursue mathematics in high school or math-related careers based on low motivation caused by a more performance goal orientation in the area of mathematics. In short, students are failing to meet their lifelong potential because of a more performance goal orientations established as adolescents. As discussed before by Shumow and Schmidt (2013a), teachers ought to support a mastery goal orientation by continuing with practices they should be doing already to support learning: using pretests and frequent formative assessment, promoting goal-setting, teaching students how to use time efficiently, and incorporating active learning activities. Further research is advised regarding goal orientation as it relates to gifted students as well as to affluent populations, because these students showed a greater tendency towards a performance goal orientation in this study. With even small changes, students likely could find that by adopting attitudes of a mastery goal orientation, they may find themselves processing new information more deeply, using strategies to persevere with difficult problems, and facing obstacles with increased creativity. Mastery goal orientation supportive teachers may keenly identify these benefits of mastery goal orientation, thereby increasing the
likelihood that students will continue expressing these habits and hopefully perpetuate a new cycle towards a mastery goal orientation and positive lifelong learning strategies.

**Autonomy: Expected Results**

Based on the inability of students to use formative assessment feedback as a tool for learning, it was supposed that students either feel a low degree of freedom to take control of their learning, that they do not have the skills or understanding about formative assessment feedback to master concepts, or that students are not motivated to exercise their autonomy to pursue learning. Anecdotally, students’ responses in focus group discussions alluded to a general frustration regarding the clarity and function of formative assessment feedback, so it was therefore expected that students would indicate a low degree of perceived autonomy at the start of the eighth-grade school year.

**Autonomy: Findings and Interpretation**

Findings for the level of perceived autonomy were very similar to those about mindset. On a scale of 0 to 9, the overall score for eighth-grade students was 6.13, with a standard deviation of 1.41, which reveals a fair amount of perceived autonomy, but with room for improvement. This score indicates that some—but not all—students felt to some degree that they could control how well they learned in math class, that their opinions mattered to me, and that they had the skills needed to prepare for a math assessment. Students who reported the lowest degree of perceived autonomy were ESL students (4.38).

Student responses in the small focus group discussions were surprisingly pessimistic in light of the findings. While students received a high score for perceived autonomy on the
survey, their verbal responses did not match. They complained that teachers pressure students to “study more” or to “bring up your grade,” but the responders expressed frustration because they simply do not know how to study, especially for assessments. When students were asked what specific actions they could take to study more there was only silence–no responses at all. After follow-up questions, a student responded, “I don’t know… look over my notes, I guess. But I never know what’s going to be on the test, and the questions are always in some weird wording that I don’t understand.” Students became even more vocal when parents contributed to the pressure to do better. One student responded,

It’s not like I want to have a D in science class. If I knew how to do better, I would. So taking away electronics and privileges is not helpful. I’m not learning this stuff any better because I don’t have my phone. I’m just learning how to not be bored in my room for a whole weekend.

When asked what teachers can do to help, students in most group discussions responded that time spent reviewing in class is helpful because the teacher provides direction about what to study. When asked if they would benefit from instruction on how to study for a math test, responses were an overwhelming yes: “Oh my gosh, YES! I mean, how have we made it this far in life and no one has taught us how to study for a math test? At least if I fail, then it will be my own fault!”

**Autonomy: Implications**

Teachers have a responsibility to not only provide appropriate formative assessment feedback but also to teach students how to use feedback to regulate their behaviors in relation to their learning. Students must be willing to accept feedback, understand how to identify skills that need to be learned, possess the study skills necessary to learn these concepts, and have the
motivation necessary to invest the time and effort in learning difficult topics. Furthermore, much more research related to autonomy in middle school mathematics is needed as well as autonomy as it relates to students rather than to educators, as recommended by Tessier, Sarrazin, & Ntoumanis (2008).

RQ2: How do students’ mindset, goal orientation, and autonomy change over the school semester during which they receive formative assessment feedback? Do students who select interventions after receiving formative assessment feedback decline significantly in mindset, goal orientation, and autonomy over the school semester (as is the typical case in middle school classrooms)?

Expected Results

For students who have already established a more fixed mindset or a performance goal orientation, it was expected that formative assessment feedback would be met with resistance. According to the previous research, it can be expected that students will engage in the self-protective responses described by Perrella in his 2017 research. By definition of a fixed mindset (Dweck and Leggett, 1985), it is likely that students with a more fixed mindset will perceive formative assessment feedback as proof of their lack of intelligence and a justification to give up on the learning task. Students have revealed in focus group discussions that they do not have the skills needed to comprehend teacher feedback or the emotional maturity to respond appropriately to constructive criticism (Parker & Winstone, 2016). Therefore, it was expected that there would be positive change in all areas—mindset, goal orientation, and
especially perceived autonomy—but that the improvement of these factors may be small and perhaps not significant.

The interventions were designed to help students, but it was not possible to determine whether the act of selecting the interventions had a significant causal effect on mindset, goal orientation, or perceived autonomy because it was not ethical for me to provide the expected benefits to only some students. Rather, only associations could be observed. Allowing students to select interventions had the most obvious effect on their sense of perceived autonomy. Students who were given the opportunity to exercise choice in the mathematics classroom by selecting interventions to promote their learning grew in autonomy across the semester. Regarding mindset and goal orientation, students were forced to consider the growth mindset and mastery goal orientation and were encouraged in these positive directions as they evaluated which strategies would help them learn best. In considering improvements for the future, it was implied that students intended to learn and master the course content by making their choices. By selecting an intervention, students were encouraged to consider how they might improve, which is consistent with a growth mindset and a mastery goal orientation. By repeating this exercise eight times over the course of a semester, it was expected that students would naturally see learning as a process. Furthermore, by utilizing the design-research methodology of implementing one intervention at a time, students and teachers as co-researchers could carefully monitor the effectiveness of each intervention and respond effectively and appropriately.
Findings and Interpretation

Mindset

Students who selected interventions after receiving formative assessment feedback had more of a growth mindset at the end of this study ($M = 6.17$) than they had at the beginning ($M = 6.01$). The act of selecting interventions after receiving formative assessment feedback was associated with a small shift in students’ mindset mean score, but the difference of 0.16 was not significant ($p = .213$).

Goal Orientation

The act of selecting interventions after receiving formative assessment feedback was related to a significant effect ($p = .027$) on students’ goal orientation meanscore. Students who selected interventions after receiving formative assessment feedback had more of a mastery goal orientation at the end of this study ($M = 4.27$) than they had at the beginning ($M = 4.01$).

Autonomy

The act of selecting interventions after receiving formative assessment feedback was related to a significant effect ($p = .000$) on students’ level of perceived autonomy. Students who selected interventions after receiving formative assessment feedback perceived a greater degree of autonomy at the end of this study ($M = 6.64$) than they had at the beginning ($M = 5.78$).
All mean scores increased over the course of this study, especially in perceived autonomy. Allowing students to select interventions to improve their learning was associated with students becoming more inclined towards a growth mindset, a mastery goal orientation, and an increased sense of perceived autonomy to some degree. Allowing students to select interventions may have had a positive impact in all areas when comparing the initial and post assessment scores.

**Implications**

As expected, there were small improvements shown over this study. It has been suggested that further improvements might occur by extending the length of time during which students receive specific formative assessment feedback. Students may experience greater results if this sort of feedback were given for a whole academic year or in all core content classes instead of only mathematics. Furthermore, this study demonstrates the point that Hattie and Timperley (2007) made: assessment feedback alone is insufficient. Students need a plan to close the gap between their current ability and the ultimate learning target. Giving feedback by itself may inspire students to believe that their brains can grow and learn despite difficulty, but feedback does not teach students specific strategies to implement in order to be successful.

It is clear that offering student-selected interventions through the design-research model was associated with improvement in the mindset, goal orientation, and level of perceived autonomy of some students. Teachers may confidently allow their students to take ownership of their own learning by choosing appropriate and effective interventions that will promote learning. If students experienced improvement in mindset, goal orientation, and autonomy in a span of one semester, it is worth considering whether choosing their interventions would be
more beneficial over the course of an entire academic year or in all core content areas. If student-selected interventions were paired with a more specific means of teaching students how to create feasible plans for academic improvement, along with perhaps a plan for accountability, it is supposed that formative assessment feedback, along with providing interventions according to the design-research model, might have an even greater positive effect. Further research will need to assess this possibility.

RQ3: Does change in students’ mindset, goal orientation, and autonomy over the school semester vary by student demographic characteristics?

Expected Results

While E. L. Deci and Ryan (2000) suggested that all students’—regardless of demographic—academic satisfaction will increase through improving the learning climate, this study suggests that certain subgroups may benefit more than others from selecting interventions to use in the classroom. The Blackwell, et al. (2007) study exemplified this assertion by showing that students identified as at-risk excelled in learning self-regulatory skills, thereby improving their mathematics achievement. It was therefore expected that students of disadvantaged demographics would make the greatest gains in moving towards a growth mindset, a mastery goal orientation, and increased feelings of perceived autonomy.

Specific to goal orientation, it was shown in the Martinek and Williams study (1997) that students who initially were more inclined towards a mastery goal orientation moved further in that direction, as contrasted to their growth-mindset counterparts who continued ego-protective behaviors over the course of the study. These findings were further supported by the
Steuer et al. (2013) study. Therefore, it was expected that students who initially indicated a greater mastery goal orientation would move further in that direction, while their peers with a more performance goal orientation may be more resistant to change.

Finally, because of limitations that ELLs often face due to language barriers, it was likely that these students would enthusiastically take advantage of the opportunity to participate in this study to take control of their learning, thereby experiencing related increases in feelings of perceived autonomy. Similarly, it was likely that students with IEPs would be motivated to consider which strategies most benefit their unique learning needs and to participate in the interventions offered. Therefore, it was expected that they, too, may experience related growth in mindset and feelings of perceived autonomy.

Findings and Interpretation

Goal Orientation

Student-selected interventions were significantly associated with growth in a mastery goal orientation of students who received free/reduced-price lunch ($p = .016$).

Autonomy

This study showed that males reported greater perceived autonomy after participating in the intervention than they reported prior to participating. There was marginally significant changes among non-ESL, White, and pre algebra students at the .10 level ($p = .055, .052, .061$, respectively). It is also noteworthy that throughout this entire study, females, students with
IEPs, and algebra students reported lower perceived autonomy scores than their counterparts at all points throughout this study.

While mean scores increased in mindset, goal orientation, and perceived autonomy, significant growth was only observed for goal orientation and perceived autonomy. Specifically, by allowing students to select their interventions after receiving formative assessment feedback, students who received free/reduced-price lunch were significantly more inclined towards a mastery goal orientation and male students made significant gains in feelings of perceived autonomy as compared to their preintervention levels. Interestingly, marginally significant increases in perceived autonomy were received by students with IEPs and students in the algebra (accelerated) math class, but not the regular math class.

Implications

In addition to providing students with formative assessment feedback, teachers might want to include students in the process of deciding how to respond to the feedback and how to use it to close the gap between where they are and where they need to be in their mathematics education (Hattie and Timperley, 2007). As a result, students might suggest innovative and effective interventions that they are more likely to take advantage of than if suggested by the teacher. When students were challenged to think critically about how they learn and what will help them to learn most effectively, they participated in setting mastery goals and reported feeling in more control of their learning.

When this study ended, there were numerous interventions yet to be employed. Therefore, some students had yet to see their ideas implemented in the classroom. More time to consider student suggestions on how to improve learning might also have generated even
more creative and useful ideas. It might be valuable implement this study across an entire school year.

RQ4: What is the teacher-researcher’s reflection on the implementation of student-selected interventions in the classroom?

Continuing Research

After having implemented formative assessment feedback in the way that I did, I could not justifiably return to teaching in the same way that I had been doing before conducting this study. Although implementing the interventions chosen by the students consumed time and energy, it was apparent that these efforts were not in vain but in fact were an investment in my effectiveness as an educator and in the students’ motivation. Furthermore, new administrators in our building adopted the phrase, “What more can WE do to help our students?” as a way to push educators to continue working to be innovative in providing helpful tools for learning. While I once spent hours agonizing over what I might do to help my students, I have found it far more productive to go straight to the source in asking students directly and regularly what they need in order to learn better. Even though I am a qualified, veteran teacher, I am decades removed from my experiences as a teenager, and while I may have great perspective based on the outward behaviors of students, I do not truly know what is going on in the minds of today’s youth. Therefore, a modified version of this study has continued in my classroom after conducting this study, and it has completely transformed how I teach and how my students learn.
This poststudy implementation of interventions continued to follow the basic tenet of design-research methodology. Students–equal stakeholders in the learning process–are given opportunities after each unit of study to voice their opinions regarding the effectiveness of the instruction as well as to provide suggestions for improvement. Then, the strongest suggestions are implemented until the completion of the next unit. At that time, the effectiveness of the previously selected interventions are discussed, new suggestions are made, and a plan for moving forward is made.

To be clear, these conversations are not platforms for students to openly disrespect any teacher’s instruction or to suggest ridiculous interventions that would otherwise be forbidden by school policies. At the beginning of each school year, students are guided through their first reflective discussions regarding how to give helpful, respectful, specific, appropriate, honest, and fair feedback. The students who would often be expected to take the opportunity to make disrespectful comments are often the ones who contribute the most insightful and useful feedback; without a doubt, students thrive on the opportunity to share their learning preferences with their teachers.

More specifically, there is a routine that the students follow at the completion of each unit test:

1. Students receive graded tests.
2. I discuss how points were calculated.
3. I share correct answers.
4. I share observations regarding trends found in grading, which could either be from formal item analysis or simple observations.
5. Students ask clarifying questions.
a. Before finishing the test, students answer these questions:

   i. Was the test fair?

   ii. Was the test predictable?

(6) I distribute a test redo practice packet.

(7) Students receive an updated grade report for the class.

(8) I conduct whole-class discussion.

(9) Students write a personal, written reflection to be shared privately with me.

(10) Students file their old notes and homework in their cumulative folders to give themselves a fresh start.

These steps are typically accomplished within one class period. However, if the class discussion lasts a long time, students have completed the written response for informal homework and then compiled their cumulative folders on the next day. While some of these steps are not pertinent to this study, they are mentioned here to show how it has been interwoven into the regular classroom administrative tasks.

The basic structure of the classroom discussion centers around four questions:

(1) What is going well?

(2) What is not going well?

(3) What can the teacher do to help support learning?

(4) What can students do to support their own learning?

Before this conversation, I share notes from previous class discussions to remind students which suggestions had been made previously; this also provides accountability for both them and me. I do not intervene or steer the discussion—even when students’ perceptions of the teacher are unfair or skewed—unless the conversation loses focus or is no longer constructive. Students
are able to hear and to be heard without being disrespected and without multiple students talking all at once. Students in some classes raise their hands and wait to talk, while others build on one another in a more fluid way. During these conversations, I quietly take notes of students’ comments. After each conversation is complete, I read the notes for the whole class to see to ensure that students have been understood correctly. Then, I take a few moments to make my observations of the class in general and make my suggestions for student and teacher improvement. Finally, the students and I decide which suggestions would be most effective in supporting learning. These notes are kept to be revisited during the next class discussion. For the first discussion (or two), these conversations start more hesitantly because students are unsure of how to appropriately offer candid feedback to a teacher. Eventually, these classroom discussions become so popular and inspiring that they are a highlight of the class; in the middle of the school year, these are robust and passionate discussions about how students are empowered most in learning. By the end of the academic year, these group conversations tend to dwindle because most of the suggestions for teacher action have been implemented and the students must consider more deeply how they can more fully take advantage of all that has been offered to them.

Specific plans to implement interventions are not made until students have had an opportunity to write their personal reflections. Typically, the quality of these written responses tends to be better when students have completed them in class, as opposed to completing them outside of class and bringing them back the next day. Students are asked the same questions as in the group discussions with the addition of (5) Is there anything that I [as the teacher] need to know about? This single question has yielded numerous responses: students not being able to see from their assigned seats (poor vision or obstructions), students not having necessary
supplies for class, students being distracted in their assigned seats (by other students, windows, hallways), students who cannot hear or comprehend instruction (especially ELLs), students with personal issues that distract them from learning, students who feel overwhelmed and hopeless, students who feel bored and not challenged enough, students who are not getting adequate sleep or food daily, students who are too shy to ask questions in class, students who need clarification of classroom procedures, and so on. Students write their names on these responses. These responses are read carefully, individual changes and accommodations are made when possible, and when appropriate I will write a response to the student. At times, these responses have been shared with other teachers and counselors on the eighth-grade team to communicate issues that thwart students.

Having these reflective experiences after each chapter or unit test would seem to be summative assessment feedback, which would contradict this study about formative assessment feedback. However, a teaching practice has been implemented so that students can continue to learn and improve after the chapter or unit test has been completed. Furthermore, the grading periods no longer apply to this class, as authorized by the school principal. This means that students can continue to improve on previous lessons throughout the whole school year—not just until the end of the chapter or the grading cycle. This is perfectly logical; if the content is important enough to teach, it is important enough for students to invest the time and energy into learning regardless of the time constrictions that previously limited them. This principal approval is further justified by the fact that students learn at different speeds, and some children require more time than others to learn difficult concepts. Especially in mathematics, students must understand the foundational skills that are introduced at the beginning of the school year to be successful for the rest of the year and in the future. By students being allowed to learn
these concepts after a particular interim date has passed, students better understand the importance of learning material thoroughly. This further supports the factors of a growth mindset, a mastery goal orientation, and increased perceived autonomy because students are shown that they can learn difficult skills with time and effort, that mastering a skill is more important than earning a particular grade, and that students have greater control of their learning. Now, students can use their grades as a way to identify which concepts they need to practice more, rather than as a measure of their ability or worth as learners.

**Permanent Student-Suggested Interventions**

Several other student-suggested interventions have been implemented permanently. Students are now able to contact their teacher by email any time after school hours. Previously, students were frustrated that they were unable to have their questions answered during the school day because of other assignments competing for their study hall time. Because of after school commitments, many students are not able to stay after school for help from a teacher. Furthermore, students often do not know during the school day which questions they may have as they are doing their homework late at night. Students can now take a picture of their homework questions so that a teacher can see what problems they are working on and to see if they have successfully and accurately started to solve the problems. In response to those emails, I will either verify that what they have done is correct, provide a similar problem to use as a guide, give the first step to help students get started, refer students to a specific place in their notes, or create a short video explanation on YouTube. Most students have email addresses and cell phones with which to communicate, but are also welcome to contact me through their parents’ accounts. All correspondence is copied, pasted, and saved to the
school’s information system for accountability and propriety. Students have expressed deep gratitude for having this option. Furthermore, there is now a much lower incidence of students coming to school with unfinished homework due to confusion and questions they had while doing homework. By offering this intervention, students are encouraged to take time to persist in learning difficult skills, are more likely to master math concepts, and feel a much greater sense of autonomy in their learning.

Similarly, quarterly workshops are now being offered for students to attend. Many students voiced the frustration that they needed a quiet and focused place to study with the support of their teacher as well as a dedicated time and space in which to accomplish larger tasks and make more significant gains in learning. These workshops have been created to be warm, inviting, supportive, and inclusive rather than punitive and uncomfortable. Students are provided with a large space in which to spread out their materials, they are welcome to bring refreshments, they are permitted to listen to music (through ear phones), and they are allowed to work with partners as needed. In this extended time, a teacher continually circulates around the room to answer questions, provide clarification, spot-check assignments, and help students prioritize and organize. Students leave these workshops mentally exhausted, while simultaneously feeling accomplished, refreshed, and inspired to work towards improvement again in the future.

One intervention that I was more hesitant to implement was typing notes and listening guides for my students; I firmly believed this would enable my students to become even lazier and that students would be less engaged by not having to actively take as many notes. I also knew that it would take a tremendous amount of my time, especially considering all of the special math symbols required for the content that I teach. However, the students continually
made this suggestion until I was forced to attempt it to demonstrate to the students that I would take their suggestions seriously. After just one trial, the instant improvement in the attention and participation of my students was undeniable. Because students were not frantically writing their notes from scratch on lined paper, they were more free to pause and consider the new content being presented to them. My lessons yielded much richer conversations and higher-level questioning than ever before! I had no choice but to continue providing notes to my students, and, while it was time consuming, I finally finished the entire algebra curriculum. By having the notes and homework typed in a presentable fashion, I feel more comfortable making copies of my notes to provide to students who are absent for lessons, whereas before I was too ashamed to send home copies of my handwritten notes. I have also found that my students take more complete notes now that they do not have to write as much; I do not face as many students who try to take shortcuts to alleviate the burden of writing. Students thereby have better resources to refer to when they need them.

Related to this, an even more significant intervention implementation began this year. It is perhaps a more difficult undertaking than teaching mathematics the very first year. I have agreed with my students that it would be beneficial to completely rewrite a formalized pre algebra curriculum. For a variety of reasons, our district has chosen to not purchase a published math curriculum. The result of this choice is that math teachers are expected to pull high-quality material from a variety of sources and then fill in the gaps with teacher-made materials. The result of this process, in my experience, was a disjointed, hodge-podge of seemingly unrelated worksheets that have no apparent structure or organization with each other. Rewriting the curriculum from scratch required me to divide each performance descriptor into individualized and specifically numbered objectives and then gather all related
information to then draft a complete and concise lesson for each objective, including teacher notes, student listening guides, student homework assignments, homework redo options, and answer keys for all homework options. Each lesson is a minimum of eight pages and takes 4 to 6 hours to write. These lessons use the same template, are numbered, and cite the corresponding learning objectives and common core standard(s). The students have received these lessons with overwhelming enthusiasm. Students have shared that they appreciate the predictability and familiarity of a consistent format, that they benefit by having their lessons numbered, and that they are helped by having a concise reference for each section. These lessons have become the students’ so-called text book, especially since they suggested that their copies be hole-punched in order to fit them into 3-ring binders. Again, because students’ suggestions were valued and implemented, they have been enabled to learn efficiently, enjoy the process of learning, are unhindered by needless hurdles, and have been given greater ownership of their mathematics education.

**Simple Interventions**

Not every intervention has been as difficult to implement as rewriting a math curriculum. For example, students revealed—almost exclusively in the personal writing activity—that they do not have the necessary supplies for class, specifically pencils, lined paper, calculators, and binders for organizing papers. In the past, I (like other teachers) have attempted to enforce all kinds of borrowing programs in an effort to promote responsibility and to prevent a huge financial cost in providing basic supplies. I tried everything—organizers to hold students’ agendas to borrowed calculators, taping obnoxious plastic spoons to borrowed pencils, grading the completeness of math binders to ensure they were being maintained—and
every strategy failed. The result was constant frustration because students stole supplies every day. In looking back on this, I see now that the majority of my students need supplies for a legitimate reason. Most students simply cannot afford basic school supplies. Others were simply victims of unfortunate, normal teenage circumstances, such as losing their math binders on the school bus, accidentally breaking their calculators in the bottom of their backpacks, having their pencils stolen by other students, etc. Thirteen-year-old students do not have transportation or funds to go to a store to purchase replacement school supplies when parents will not provide them. None of the students were intentionally losing their supplies or maliciously stealing; they were just trying to get by. Coincidentally, last year the school purchased numerous cases of lined paper, hundreds of pencils, 30 calculators, and several binders, all of which are freely offered to students with no questions asked. There is a designated place for students to take as many pencils or as much paper as they need, to take calculators to use as long as necessary, and opportunities to take binders as needed. At the end of the first year of making supplies readily available, I was astonished to find that students remembered this demonstration of grace, and without prompting, students would donate unused materials to my classroom at the end of the school year, thereby replenishing the initial supply. Fewer calculators were stolen, simply because students are no longer treated like criminals when they need to borrow one; this thereby increases the likelihood that the calculators would be returned. While this seems unrelated to mindset, goal orientation, and perceived autonomy, it supports students who want to continue to learn despite not having the necessary supplies and provides a greater degree of perceived autonomy to students who would otherwise be constricted by their unmet need.
Another simple intervention that was suggested by my students (and that I never would have thought of) was related to the work that students were assigned on days when they had a substitute teacher. On these days, I would typically leave something easy for students to do (and for substitute teachers to teach), which was usually a math puzzle or review worksheet. I justified this as additional practice of the skills that students were currently learning. In truth, these puzzles insulted my students because they were repetitive and not challenging enough. In short, students knew that these puzzle worksheets were being used as a so-called babysitting tool. In response, the students suggested that a normal lesson be provided by prerecorded video. So, whenever I am not in my classroom, I prepare the lesson ahead of time by videoing myself talking through the notes. The video is uploaded to YouTube, and the substitute teacher plays it so that my students can watch and take notes, stopping as needed to provide clarification. This also frees the substitute teacher to circulate around the room to prevent misbehavior and enables any substitute to work in my room regardless of his or her math competency. At the end of the videoed lesson, I get the students started on their homework (by video) so that they can use the remaining class time on homework. The students have shared that they greatly prefer this to so-called busy work. While this intervention requires more effort than simply photocopying worksheets, this is also beneficial to me because my students do not fall behind because of my absence.

While students may take advantage of some discussions to make ridiculous suggestions, this is an extremely rare occurrence. Students have the best perspective for their own preferences about how they learn best. Eighth-grade students encounter a minimum of eight teachers each day, and they make observations about the effectiveness of each teacher—not to mention teachers they have had previously in middle school. Students new to the school have
also been valuable contributors regarding suggested interventions. Often, the students make suggestions to improve areas in which a teacher has already been considering making changes. For example, it was becoming apparent that the relationships within one class period were promoting a great deal of off-task behavior during instruction. A new seating arrangement would likely help, but I was hesitant to make one because changing seating charts is a time-consuming, frustrating process that often leads to more problems rather than fewer ones. However, because the students took control of their own learning and made mature decisions regarding who they should (and should not) sit by, as well as their proximity to the white board, there was far less objection to the new seating arrangement that separated friendship groups. Rather than showing irritation with me for imposing new seats on them, students showed compliance and satisfaction in having made responsible decisions that help them learn better.

It has been discovered that some interventions may not be suitable for all students and that they may only be short-term experiences that expire after just a few uses. For example, students suggested that they would feel motivated to turn in what is referred to in class as improvements (missing work, homework redos, practice packets) in exchange for a chance in a drawing to sit at my desk, the so-called place of comfort and spaciousness. Students even dubbed the intervention “The Game of ThRones,” merging my name with the popular television series. This intervention was met with great enthusiasm and in the first two rounds, generated over 300 improvements from 160 students each time. The third time we played the game, participation was greatly reduced in the pre algebra classes, and students have not asked for another round since. Participation eventually dwindled in the algebra classes as well, and now the intervention is a mere memory of an incentive that we tried, benefitted from, and then retired. Of course, there are reasons why this specific intervention lost its effectiveness; it was
not a support for learning but an incentive to generate work. One might even argue that this intervention was detrimental because it promoted a performance goal orientation in that it encouraged tasks completed rather than learning accomplished. Ultimately, however, it was a positive experience for no other reason than it was suggested by the students, their input was validated by having the intervention implemented, and it was useful for encouraging students to get caught up in their classwork.

**Lasting Change**

After 4 years of repeating this cycle of generating and implementing interventions to promote learning, it is evident that the investment is paying off exponentially. Two years ago, I was able to pilot a new algebra class for students who were not from the district’s usual accelerated track. These students were referred to as so-called bubble kids, those who were not being challenged sufficiently in regular math classes but did not meet the requirements for being in the accelerated (algebra) math class. These students were grouped to form a new algebra class, and it was an overwhelming success. Students were so appreciative of the challenge and the district’s belief in them that they dedicated themselves fully to the more difficult class, knowing that if they did not pass the high school’s objective placement test at the end of the year that they would have to take algebra all over again as freshmen. In the first year, all but three students were successful! Last year, 58 students were placed in geometry as freshmen, instead of the typical 30 of previous years. The pilot was so successful that the seventh-grade teacher has now also replaced a regular math class with an accelerated one to meet the needs of the bubble kids 1 year earlier, which of course will improve student success in eighth grade.
Another way that the results of this informally continued study have caused lasting improvements is that far fewer students fail math class than before, which significantly decreases the rate of eighth-grade retention for students typically at risk of academic failure. Because students are now permitted – and encouraged – to improve in math throughout the year, students are able to eventually show mastery to a degree that is sufficient for passing on to high school. Last academic school year, there were 157 F grades given in math class among four quarters and six class periods, or approximately 6-7 students per class, per quarter. By the end of the school year, all but 23 of those F’s had been raised to passing grades—less than one student per class, per quarter. The aim of this study is certainly not good grades but to promote a growth mindset, a mastery goal orientation, and increased perceived autonomy, thereby increasing learning and subsequently having a positive impact on students’ grades. When students see a way to escape failure, they will graciously accept additional opportunities to improve. After students have witnessed their own improvements, it has been demonstrated to them that they really can accomplish difficult tasks with time and effort, that they can eventually learn and master new skills, and that they can take control of their own learning in the future. These are lessons that apply to life, not just math class. This approach has also decreased apathy and disruptive behavior in the classroom, which has improved the learning environment for other students as well.

Implications

Teachers must stop limiting themselves to their own efforts in their attempts to invent new ways to motivate and educate their students. While these attempts are based on the best intentions, and at times do result in creative and helpful strategies, the students we teach have
the most valuable perspectives about how they learn, their preferences in learning, and insight into what best motivates their peers to learn. In a group discussion, a student said in a direct way,

These teachers, I just get so embarrassed for them. They do these things that they think are so cool, and I just wanna say stop. Just stop. Maybe in the 80s, or if I were like a little kid, but no. And they went to so much work, and spent money, and I feel bad, but no. I’m not going to do that thing so that you’ll give me a pencil. Please, do NOT give me a smiley face pencil in front of all of these people! You give me a pencil, and I’m never doing your homework again. But if you’d just ask me, I’d say I’ll do just about anything if you let me listen to music [with headphones]. There’s probably a ton of swear words in it, but what do you care if you can’t hear it and I’m getting my work done?

Children thrive on the opportunity to share their opinions, as their perspectives are so infrequently solicited by adults in their lives and at school. Furthermore, students are far more likely to welcome to educational interventions that they have suggested, even if the interventions would have been offered by teachers anyway.

Teachers must also resist the temptation to create once-and-for-all curricula and procedures. The process of establishing a high-quality curriculum and an efficient classroom is exhausting, but a teacher’s job is never done. Trends, technology, and student interests are constantly changing, and a practice that worked once will not necessarily be effective the following school year, let alone in the next 5-10 years. Furthermore, teachers cannot assume that if a particular program or intervention works for one individual or group of students, it will work for all students. This requires teachers who are willing to do the work of staying relevant and engaged in students’ current interests, flexible and open to change, and able to relinquish control over aspects of teaching and classroom management when it is appropriate and advantageous in harnessing student interest in learning and improving.
Limitations

I conducted this study in my own classroom. Because of this, the results are not representative of every eighth-grade mathematics student; the results may more accurately represent 8th grade mathematics students in an American, midwestern, rural, low SES, public school classroom. The results may be more likely to apply to students who are general education students and less likely to apply to students with IEPs and 504 plans.

Next, the definition of formative assessment varies by teacher and district. While the core elements of formative assessment are constant in all classrooms, the findings from this study cannot be generalized to apply to schools that do not conduct formative assessment in the same way that this study utilized.

Third, this study used self-reported data. Because of this, the study depends on perceptions reported by adolescents. There may be variation in how students used the rating scales. Furthermore, the validity of the surveys relies on students’ willingness to respond honestly, accurately, and appropriately to the surveys.

Fourth, because the research method was the design-research methodology, and not a traditional experiment, there was no control group for comparison. Therefore, there could be no tests for causality.

This study is involved a very specific population of students of a largely low-socioeconomic class in a suburban school. Because schools vary widely, this same study may not feasibly be replicated in other settings, and the conclusions found in this study may not hold true in different, or even the same, contexts.
This study was constrained to be conducted during one academic semester. By extending this study to a full academic year, or to several years, additional data may be found that would be valuable in demonstrating how formative assessment feedback can be used more effectively to promote motivation for learning. Furthermore, it would be beneficial to repeat this study with a different group of students in the same school and with the same teacher to see if results are similar.

This study was conducted by a single teacher-researcher (me). While students were reassured that their names would not be matched with their responses, it would not be surprising that adolescents do not trust this, and some may have altered their responses to fit what they perceived I wanted, rather than to reflect their true feelings. Similarly, students who have not yet developed maturity and respect for research may have presented incorrect responses intentionally for the purpose of causing inaccuracies. When students are entrusted with providing data regarding their opinions, inaccuracies can be prevented through reassurance and vigilance of the teacher, but cannot be eliminated completely.
REFERENCES


Kierfer, S., Alley, K., & Ellerbrock, C. (2015). Teacher and peer support for young adolescents’ motivation, engagement, and school belonging. *RMLE Online: Research in Middle Level Education, 38*(8).


Wormeli, Rick. (2013). *The collected writings (so far) of Rick Wormeli.* Westerville: Association for Middle Level Education.


APPENDICES
APPENDIX A

INITIAL SURVEY
### INITIAL SURVEY

<table>
<thead>
<tr>
<th></th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
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<tbody>
<tr>
<td>Given enough <strong>time</strong>, I could master new math skills.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Given enough <strong>effort</strong>, I could master new math skills.</td>
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<td>○</td>
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<td>A person is born with a set amount of ability to learn math skills.</td>
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<td><strong>Learning</strong> is very important to me in math class.</td>
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<td>○</td>
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<td>○</td>
<td>○</td>
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<td><strong>Doing as well as other students</strong> is very important to me in math class.</td>
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<td>○</td>
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<tr>
<td>I can control how well I learn in math class.</td>
<td>○</td>
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</tr>
<tr>
<td>My opinions matter to my math teacher.</td>
<td>○</td>
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<td>I know how to <strong>independently</strong> study for a math assessment.</td>
<td>○</td>
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**INITIAL SURVEY - SCORING**

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<tr>
<th></th>
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<th>Strongly Disagree</th>
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<td><strong>Mindset Questions</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Given enough <strong>time</strong>, I could master new math skills.</td>
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<td>2</td>
<td>1</td>
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</tr>
<tr>
<td>Given enough <strong>effort</strong>, I could master new math skills.</td>
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<td>2</td>
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<td><strong>Goal Orientation Questions</strong></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>Learning</strong> is very important to me in math class.</td>
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<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td><strong>Grades</strong> are very important to me in math class.</td>
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<td>2</td>
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<td>2</td>
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<td><strong>Autonomy Questions</strong></td>
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<td></td>
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</tr>
<tr>
<td>My opinions matter to my math teacher.</td>
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<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>I know how to <strong>independently</strong> study for a math assessment.</td>
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APPENDIX B

POSTASSESSMENT SURVEY
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<th>Statement</th>
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<th>Strongly Disagree</th>
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<tbody>
<tr>
<td>I understand why my answers on the quiz were correct or incorrect.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Given enough time, I could master new math skills.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Given enough effort, I could master new math skills.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>A person is born with a set amount of ability to learn math skills.</td>
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<td>○</td>
<td>○</td>
<td>○</td>
</tr>
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<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
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<td>○</td>
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</tr>
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</tr>
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<td>○</td>
<td>○</td>
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</tr>
<tr>
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<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
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<td>I know how to study for a math assessment.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>If I were taught strategies to learn these skills, I would independently study before the unit test.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

TURN OVER
What would be the most helpful thing that the teacher could provide to help students learn these skills before the unit test? (ie What would you be most likely to participate in or benefit from?)

<table>
<thead>
<tr>
<th></th>
<th>Practice worksheets (with an answer key) to use for studying.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Links to online games or apps to use for studying. (Note: Students use own technology)</td>
</tr>
<tr>
<td></td>
<td>Extra help before or after school. (Note: Students’ responsibility to arrange with teacher)</td>
</tr>
<tr>
<td></td>
<td>Homework re-grading opportunities to use to prepare for quizzes and for the unit test.</td>
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<tr>
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<td>Quiz re-takes to use to prepare for the unit test.</td>
</tr>
<tr>
<td></td>
<td>More written feedback on homework/quizzes. (ie Write in correct steps and/or answers for some problems)</td>
</tr>
<tr>
<td></td>
<td>More verbal feedback on homework/quizzes. (ie Explain common problems to the whole class)</td>
</tr>
<tr>
<td></td>
<td>Other: ________________________________________________________________</td>
</tr>
<tr>
<td>Mindset Questions</td>
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<tr>
<td>-------------------</td>
<td>---</td>
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</table>

<table>
<thead>
<tr>
<th>Goal Orientation Questions</th>
<th></th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
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<td>Grades are very important to me in math class.</td>
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<td>2</td>
<td>3</td>
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<tr>
<td>Doing as well as other students is very important to me in math class.</td>
<td></td>
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<table>
<thead>
<tr>
<th>Autonomy Questions</th>
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</tr>
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<td>I can control how well I learn in math class.</td>
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<td>3</td>
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</table>

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- Practice worksheets (with an answer key) to use for studying.
- Links to online games or apps to use for studying. (Note: Students use own technology)
- Extra help before or after school. (Note: Students’ responsibility to arrange with teacher)
- Homework re-grading opportunities to use to prepare for quizzes and for the unit test.
- Quiz re-takes to use to prepare for the unit test.
- More **written** feedback on homework/ quizzes. (ie Write in correct steps and/or answers for some problems)
- More **verbal** feedback on homework/ quizzes. (ie Explain common problems to the whole class)
- Other: _____________________________________________________________
1. (MINDSET) What are the best ways for you to learn difficult math skills?

2. (MINDSET) What do you attribute your grades to?

3. (GOAL ORIENTATION) How do you react to incorrect answers on math assessments?

4. (GOAL ORIENTATION) What parts of math learning are in your control?

5. (AUTONOMY) What happens when you offer an opinion to your teacher about math class?

6. (AUTONOMY) What strategies do you use to independently study for math tests?
Formative assessment = quiz  Summative assessment = unit test

Timeline:

1. Explain study
   a. Empowers teens – opportunity to have a voice
   b. Not linked to grades at all – use of ID# for privacy
   c. Use student ID (students know and use this number for lunch & library)
   d. Something I would like to do even if not in PhD program
   e. Opportunity to ask questions
   f. Permission slips
      i. Opportunity to decline/withdraw at any point

2. Initial survey
   a. Aligned with post-assessment survey
   b. Removed from quiz feedback situations
   c. Measures mindset, goal orientation, autonomy
   d. Honesty & neatness crucial
   e. Consider reading through with students
   f. Not just “yes” and “no” to eliminate confusion and to ensure correct answers
   g. “Yes” or “no” to encourage students to select what is most true for them (no middle ground)
   h. Check for ID #, completion, clear circling
   i. Scoring
      i. All “a” responses score 1 point. All “b” responses score 0 points.
      ii. Variables
         1. Each question as its own variable
         2. A total (out of 3) for mindset, goal orientation, and autonomy as additional variables
         3. A total (out of 27) as a combined score

3. Teach first set of standards
   a. 1-2 weeks
   b. Students are given formal feedback through graded homework assignments (not just participation points) and informal feedback through classroom activities
   c. During this time, begin data entry for mindset, goal orientation, and autonomy questions from initial survey

4. First formative assessment
   a. Grade with only check marks and positive points over 10 listed at the top
      i. Record student scores over 10 points for future comparison
      ii. All graded formative assessments returned the next class day
      iii. First formative - no intervention, no explanation
1. Simulates what many teachers would typically do
   iv. First post-assessment survey
      1. Baseline for no intervention
      2. Generate input for first intervention
      3. Scored in the same way as the initial survey
         a. Compile results of initial survey to determine the intervention to be offered with the feedback for the next quiz
            i. Take most popular selection (majority)
            ii. Add “write in” suggestions for use in future post-assessment surveys

5. Based on first formative assessment scores, re-teach as normal, if necessary.
   a. Mini-lesson
   b. Bell-ringers (openers)
   c. Additional lesson – rare

6. Teach second set of standards
   a. 1-2 weeks
   b. Students are given formal feedback through graded homework assignments (not just participation points) and informal feedback through classroom activities
   c. Make sure first intervention is ready to go
   d. During this time, continue to record data from first post-assessment survey (mindset, goal orientation, autonomy)

7. Second formative assessment
   a. Grade and return according to intervention determined by the post-assessment survey information gathered from the previous quiz
      i. Record student scores over 10 points for future comparison
      ii. All graded formative assessments returned the next class day
         1. Deliver first intervention
      iii. Second post-assessment survey
         1. Describes impact of first intervention
         2. Generates input for second intervention

8. Based on first formative assessment scores, re-teach as normal, if necessary.
   a. Mini-lesson
   b. Bell-ringers (openers)
   c. Additional lesson – rare
   d. During this time, compile results of the post-assessment survey to determine the intervention to be offered with the feedback for the next formative assessment
      i. Take most popular selection (majority)
      ii. Add “write in” suggestions for use in future post-assessment surveys
9. Short unit review – 1 or 2 class periods
   a. Provides time for students to utilize second intervention
   b. During this time, continue to record data from the second post-assessment survey (mindset, goal orientation, autonomy)
10. Repeat steps 1-9 for at least 8 interventions (one semester / 18 weeks)
    a. NOTE: Some units may have 3 formative assessments, in which steps 6-8 would be repeated for a third set of standards
11. Spring semester
    a. Additional cycles of teaching/formative assessment/surveys, if needed
APPENDIX E

SAMPLE DATA COLLECTION
<table>
<thead>
<tr>
<th>Student</th>
<th>INITIAL time</th>
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<th>INITIAL time effort</th>
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<th>INITIAL GOAL</th>
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APPENDIX F

STUDENT-SELECTED INTERVENTIONS
Interventions are listed in the order in which they were selected. The student popularity ranking (1-8, 1 being least popular) is listed after each intervention.

**Pre Algebra**
1. Provide practice worksheets, along with a worked-out answer key that students can use for checking work. (3)
2. Allow students to eat mints while taking assessments. (1; note that a previous teacher from 7th grade strongly and frequently encouraged this. Ironically, the school underwent a permanent “food ban” the week after this intervention was selected)
3. Allow students to retake formative assessments, provided that they first complete a short practice activity. (5)
4. Replace formative assessment scores if the corresponding summative assessment score is higher (so that overall grade more accurately reflects ability). (8)
5. Allow students to view formative and summative assessments for 3-5 minutes the day before the assessments are given; students are not allowed to take notes during this time. (7)
6. Reward the highest-scoring class with a “free day.” (2)
7. Allow notes to be used for formative assessments – not summative assessments. (6)
8. Allow students to “cram” for five minutes before assessments are distributed. (4)

**Algebra**
1. Provide practice worksheets, along with a worked-out answer key that students can use for checking work. (2)
2. Allow students to complete alternate assignments to be re-graded; the higher of the two grades will be kept – not an average. (5/6 – tied)
3. Allow students to retake formative assessments, provided that they first complete a short practice activity. (7)
4. Allow students to view formative and summative assessments for 3-5 minutes the day before the assessments are given; students are not allowed to take notes during this time. (5/6 – tied)
5. Provide an extra credit question on each formative assessment; extra credit will not exceed 10% of the score. (3)
6. Replace formative assessment scores if the corresponding summative assessment score is higher (so that overall grade more accurately reflects ability). (8)
7. Allow students to complete formative assessments during homeroom, granting students the opportunity to review notes and return to the assessment without as much time constraint. (4)
8. Review earlier topics as a class – both from the current chapter and previous ones – rather than students doing so independently or the class doing this at the end of a chapter. (1)
APPENDIX G

STUDENT-GENERATED INTERVENTIONS (NOT IMPLEMENTED)
These interventions were suggested by students but not selected within the time frame of the formal research project. Interventions are listed in order of popularity (first was most popular), based off the last survey completed.

Students pick their own groups for class work
Play soft music during assessments
Students study with a partner of their choice the day before an assessment
No individual work – only group work (anything not done in class becomes homework)
Play a tossing game, where a student asks a question, tosses a ball to another student to answer
Use individual white boards to review the day before quiz or test
Teacher provide pre-tests
Provide more notes
Play math games in class
More group work
Help on homework that is due the first 10 minutes of class
Links to online games or apps to use for studying; students use own devises
Extra help before and/or after school
More written feedback on homework and quizzes
More verbal feedback on homework and quizzes
More detail about how to complete math assignments
Assign more homework
Make flash cards that partners can use to study
Give the students the answer keys