DEVELOPMENT OF PERSEVERANCE IN MATHEMATICS CLASSROOMS THROUGH THE ADVANCEMENT OF A GROWTH MINDSET

by
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PERSEVERANCE IN MATH CLASSROOMS

Abstract

The impact of behaviors and attributes, such as perseverance, on student achievement and success in school is becoming more widely accepted. However, perseverance in students is not being developed and supported in high school mathematics classrooms. A review of the literature and a needs assessment conducted in a high school in the Northeast United States determined this lack of development was in part due to student and teachers’ beliefs of learning and mathematics. This study sought to determine if an online growth mindset intervention could be utilized within the context to alter students’ beliefs of learning and mathematics, thus increasing their academic perseverance. Ninth grade students who had traditionally underachieved in mathematics completed three 40-minute sessions through an online medium. A significant difference was seen between treatment and comparisons participants’ beliefs of mathematics after the intervention. Additional research is suggested on conducting the growth mindset intervention in a blended learning environment to increase student engagement. Findings also suggest that a consistent growth mindset message may be necessary for students to begin converting their beliefs into actions.

Keywords: mathematics education, perseverance, problem solving, reform
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Dedication

I would like to dedicate this to my family. To my parents Alice and Artie Bifulco Jr. for always supporting, loving, and pushing me, through which you prepared me for this journey. I love you both so much and then some. My grandparents, Lillian and Artie Bifulco Sr., whose consistent and unwavering pride throughout my life always motivated me to ensure it was not misplaced.

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# Table of Contents

Abstract ............................................................................................................................... ii  
Dedication .......................................................................................................................... iv  
Acknowledgments ................................................................................................................v  
Table of Contents ............................................................................................................... vi  
List of Tables ..................................................................................................................... xi  
List of Figures ................................................................................................................... xii  
Executive Summary .............................................................................................................1  
Chapter One- Introduction of the Problem of Practice ......................................................8  
  Overview of the Problem of Practice .............................................................................8  
  Literature Review ..........................................................................................................9  
    Theoretical Framework ...............................................................................................9  
  Synthesis of Literature ..............................................................................................11  
Conclusion .....................................................................................................................20  
  Statement of the Problem ...........................................................................................21  
Chapter Two- Needs Assessment ..................................................................................23  
  Context of the Study ....................................................................................................23  
    Description of the Context & Stakeholders ..............................................................23  
    Goals and Objectives ...............................................................................................24  
Methodology .................................................................................................................25  
  Participants ..................................................................................................................25  
  Instrumentation ..........................................................................................................27  
Variables ......................................................................................................................29
PERSEVERANCE IN MATH CLASSROOMS

Procedure .............................................................................................................33

Needs Assessment Findings ................................................................................35

  Initial Findings From Students .........................................................................35
  Initial Findings From Adults ...........................................................................39

Discussion .........................................................................................................41

Limitations and Implications ..........................................................................43

  Barriers to Data Collection ............................................................................44
  Implications .....................................................................................................44

Conclusion .........................................................................................................45

Chapter Three- Intervention Literature Review ...........................................46

  Conceptualizing Perseverance .......................................................................46
  Underlying Causes and Factors .....................................................................49

Needs Assessment Results ..............................................................................51

Data Collection and Methods .........................................................................54

  General Approach ..........................................................................................54
  Inclusion and Exclusion Criteria ....................................................................54
  Theoretical Framework ....................................................................................54

Review of the Literature .................................................................................56

  Converting to a Reform-Based Classroom .....................................................57
  Mindset Interventions ......................................................................................61

Proposed Intervention ......................................................................................71

Chapter Four- Intervention Procedure and Program Evaluation ..................75

  Purpose and Research Questions ....................................................................75

vii
<table>
<thead>
<tr>
<th>Chapter Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clarification of Terms</td>
<td>77</td>
</tr>
<tr>
<td>Research Design</td>
<td>77</td>
</tr>
<tr>
<td>Inputs</td>
<td>78</td>
</tr>
<tr>
<td>Activities</td>
<td>79</td>
</tr>
<tr>
<td>Outputs</td>
<td>81</td>
</tr>
<tr>
<td>Outcomes</td>
<td>81</td>
</tr>
<tr>
<td>Process Evaluation</td>
<td>83</td>
</tr>
<tr>
<td>Outcome Evaluation</td>
<td>85</td>
</tr>
<tr>
<td>Method</td>
<td>89</td>
</tr>
<tr>
<td>Sample and Participant Selection</td>
<td>89</td>
</tr>
<tr>
<td>Instrumentation and Measures</td>
<td>92</td>
</tr>
<tr>
<td>Teacher Fidelity Measure &amp; Learning Management System Data</td>
<td>92</td>
</tr>
<tr>
<td>Student Focus Group</td>
<td>94</td>
</tr>
<tr>
<td>Perseverance, Intelligence, and Beliefs Inventory</td>
<td>94</td>
</tr>
<tr>
<td>Procedure</td>
<td>98</td>
</tr>
<tr>
<td>Intervention Description</td>
<td>98</td>
</tr>
<tr>
<td>Data Collection</td>
<td>100</td>
</tr>
<tr>
<td>Data Analysis</td>
<td>101</td>
</tr>
<tr>
<td>Conclusion</td>
<td>104</td>
</tr>
<tr>
<td>Chapter Five- Results and Discussion</td>
<td>106</td>
</tr>
<tr>
<td>Research Questions</td>
<td>106</td>
</tr>
<tr>
<td>Findings</td>
<td>107</td>
</tr>
<tr>
<td>Implementation Fidelity</td>
<td>107</td>
</tr>
</tbody>
</table>
PERSEVERANCE IN MATH CLASSROOMS

Appendix J: Parental Consent and Student Assent for Intervention.........................184
Appendix K: Growth Mindset Intervention Teacher Fidelity Measure.........................188
Appendix L: Student Focus Group Protocol................................................................190
Appendix M: Students’ Perseverance Observation Instrument....................................191
Appendix N: Student Pre and Post-Tests....................................................................192
Appendix O: Summary Matrix of Intervention Evaluation............................................196
Appendix P: Timeline of Intervention Activities..........................................................197
PERSEVERANCE IN MATH CLASSROOMS

List of Tables

Table 2.1. Student Participants’ Present Level of Mathematics Class ..................................................26
Table 2.2. Mathematics Teacher Participant Characteristics .....................................................................27
Table 2.3. Descriptive Statistics of Student Variables ...............................................................................36
Table 2.4. Descriptive Statistics of Time to Complete Homework Problem and Considered Impossible .................................................................37
Table 2.5. Correlation Values Between Various Student Variables ..........................................................38
Table 2.6. Influences on Teachers Choices of Instructional Practices ......................................................40
Table 5.1. Student Participant Recruitment Frequencies (Attrition) of Teachers ..............................108
Table 5.2. Demographics & Mathematics Level of Treatment ($n = 12$) & Comparison Participants ($n = 17$) ...........................................................................................................110
Table 5.3. Participant Mean (SD) Engagement and Interest in Intervention Workshops ($n = 10$) ........................................................................................................................................111
Table 5.4. One-Way Analysis of Variance of Student Engagement and Interest by Treatment Room ....111
Table 5.5. Descriptive Statistics of Student Participation ($n = 10$) in the Intervention ................................113
Table 5.6. Reliability of Variables ...........................................................................................................117
Table 5.7. Tests for Normality and Homogeneity of Variance of Post-Scores of Variables ..................119
Table 5.8. Means (SD) of Post Intervention Measures of Treatment and Comparison Conditions .................................................................................................................................120
Table 5.9. Changes in Academic Perseverance for Each Treatment Participant .................................122
List of Figures

Figure 4.1. Logic Model of Mindset Intervention .............................................................78

Figure 4.2. Theory of Treatment for Proposed Growth-Mindset Intervention ...............84

Figure 5.1. Logic Model Map Showing Challenges and Needs During Recruitment and Implementation ....................................................................................................107

Figure 5.2. Screenshot of Session 1 Activities From the LMS and Their Requirements .................................................................................................................................113

Figure 5.3. Scatterplot of Assignment Variable and Participants’ Academic Perseverance at Post ......................................................................................................................................115

Figure 5.4. Histogram with Imposed Normal Curve and Q-Q Plot of Factor 3: Beliefs About Mathematics as Learnable Subject for Treatment and Comparison ........118
Executive Summary

Perseverance in High School Math Classrooms

It has become clear to many that success is not due to intelligence alone, but to non-cognitive factors as well such as mindsets, learning strategies, social skills, and perseverance (Farrington et al., 2012; Shechtman, DeBarger, Dornsife, Rosier, & Yarnall, 2013). Duckworth, Peterson, Matthews, and Kelly’s (2007) research demonstrated that individuals with higher levels of perseverance performed better within the National Spelling Bee and West Point Academy than individuals who exhibited less perseverant related behaviors. Perseverance was found by Strayhorn (2014) to be positively correlated to grades of Black male students within a primarily White college. These studies denote the increasing evidence of the importance of perseverance in academic achievement.

Perseverance is considered vital for 21st century citizens (Partnership for 21st Century Skills, 2015), as well as for students who engage and do mathematics (NCTM, 2014), yet goes undeveloped in mathematics classrooms where it is essential (Hiebert & Grouws, 2007; Schoenfeld, 1989). Learning standards have begun to recognize the importance of perseverance and require mathematics teaching to “support productive struggle in learning mathematics” (NCTM, 2014, p. 10). A student is unable to work through this struggle without perseverance- the willingness and determination to strive through a challenge. However, the development of perseverance is not being attended to as teachers mainly adopt show and tell instructional methods within mathematics classrooms (Hiebert & Grouws, 2007).

Understanding the Drivers of This Problem
**Review of the literature.** A review of the literature was undertaken to understand the drivers of this problem: Why is perseverance not being developed or supported in high school mathematics classrooms? There are various interconnecting factors that are preventing this from occurring such as teacher choices of instructional practices that either support or hinder students’ productive struggle and perseverance (NCTM, 2014). This is in turn driven by teachers’ acceptance of their role (Henningsen & Stein, 1997), their beliefs (Cross, 2009) and external factors such as testing (Vogler & Burton, 2010). Student beliefs about mathematics (Schoenfeld, 1989), self-regulation, motivation (Sussan & Son, 2004), and confidence (Bénabou & Tirole, 2002) can also be linked to students’ acceptance of these practices in developing perseverance. It becomes essential that students feel they are capable of success in mathematics (Schunk & Richardson, 2011).

**Needs assessment.** A review of the literature revealed a plethora of drivers impacting the development of perseverance in mathematics. To understand which of these drivers was prominent within a public high school in the Northeast, a mixed-methods needs assessment was conducted in the Spring of 2015. Teachers reported using a mix of instructional practices within their classrooms. Teachers noted that they are utilizing methods in their classrooms that they feel are the best instructional practices. Interactions with colleagues and ensuring students are able to graduate also greatly influenced teachers’ choices of instructional practices. Student beliefs of mathematics including their beliefs about the role of the teacher and mathematics as a discipline lean more toward those associated with a traditional mathematics classroom where productive struggle is not emphasized. While the students surveyed had high perseverance, teachers,
the mathematics supervisor and the literature all pointed to lower achieving students
lacking and needing the development of perseverance. Survey results also revealed
students had fixed mindsets (Dweck, 2015) in which they felt that achievement in
mathematics was more greatly influenced by ability than hard work and effort.

**Developing an Intervention**

The needs assessment findings and a review of the literature pointed to the beliefs
of students and teachers hindering the development of perseverance in high school
mathematics classrooms. These beliefs include those about learning mathematics, such as
valuing process over consistently getting the correct answer, the role of the teacher, and
what attributes to success in mathematics. Drawing on the literature once more, I found
development of reform-based mathematics classrooms (Boaler, 2006; Hodges & Kim,
2013; Mason & Scrivani, 2004) and mindset interventions (Aronson et al., 2002;
Blackwell et al., 2007; Donohoe et al., 2012; Paunesku et al., 2015; Yeager et al., 2014)
offer two paths for a proposed intervention. This study focused on a mindset intervention
due to the stronger methodology and greater transparency of methods and specific
activities utilized within the literature, instead of attempting to alter the
sociomathematical norms of mathematics classrooms. Time and resource restrictions also
made a mindset intervention more plausible within the context. The convenience and low
cost of a mindset intervention adds to the perceived advantageousness of the intervention,
which would increase the rate of diffusion (Rogers, 2003).

Mindset interventions discussed in the literature include growth (Blackwell et al.,
2007; Good et al., 2003), sense of purpose (Yeager et al., 2014), or combinations of the
two (Paunesku et al., 2015). Given that the combination of interventions did not increase
PERSEVERANCE IN MATH CLASSROOMS

the impact on students’ academic achievement (Blackwell et al., 2007; Good et al., 2003; Paunesku et al., 2015), and considering the time and cost restrictions, the selection of one mindset intervention to focus upon within the context was reasonable. The needs assessment demonstrated that students hold strong fixed mindset beliefs where they believe achievement in mathematics is based on innate ability and cannot be accomplished through hard work and effort. Students’ perseverance is negatively impacted by beliefs that they are not intelligent enough to succeed in mathematics (Schunk & Richardson, 2011). It is also important to note that a range of resources are available to aid students in developing a growth mindset through Carol Dweck’s website (https://www.mindsetworks.com) as well as Stanford’s Mindset Kit (https://www.mindsetkit.org/), and Jo Boaler’s site through Stanford University which focuses more on the implications of a growth mindset in mathematics (https://www.youcubed.org). Therefore, a growth mindset intervention was conducted within the focus high school.

The two main mediums through which the mindset interventions were carried out within the literature is through direct delivery by an instructor (Blackwell et al., 2007; Good et al., 2003) and via online delivery (Paunesku et al., 2015; Yeager et al., 2014). The focus school has the technology already in place to make online delivery simple, therefore given study resource restrictions and concerns about fidelity implementation, and online implementation was planned. Blackwell et al. (2007) noted the importance of completing mindset interventions with students who were undergoing a transition such as ninth grade students moving into high school. Teachers within the focus school and the literature (Ader, 2013; Cross, 2009; Lynch & Star, 2014) pointed to lower achieving
students needing the development of perseverance. Ninth grade students who have historically underachieved in mathematics have therefore been the focus of this study.

Implementing the Intervention

Directed by the literature and the needs assessment, an online growth mindset intervention was designed and implemented. The intervention consisted of three 40-minute workshops in which students learned about the malleability of the brain, the growth and fixed mindset, how these beliefs impact achievement and success, and these beliefs in mathematics specifically. A mixed methods approach was chosen because a single quantitative strand would not provide the information and context sought to adequately answer the research questions as developed. The following research questions directed the evaluation of this study:

1. Is at least 80% of the intervention implemented as planned?

2. Do at least 80% of eligible participants complete at least 80% of the activities designed within the mindset intervention?

3. What is the difference in underachieving students’ theories of intelligence between those who participated in the growth mindset intervention and the comparison group?

4. What is the difference in underachieving students’ beliefs of mathematics between those who participated in the growth mindset intervention and the comparison group?

5. What is the difference in underachieving students’ academic perseverance between those who participated in the growth mindset intervention and the comparison group?
The intervention was implemented in the fall of 2016. Sixteen students consented to participate in the treatment and 19 students consented to participate within the comparison condition with 12 treatment participants and 17 treatment participants completing all requirements.

**Results and Discussion**

While there were differences between the means of treatment and comparison participants at post for many of the outcome variables the only statistically significant difference was for factor 3 beliefs about mathematics as a learnable subject. This finding was interesting as the beliefs of mathematics factor 3 is closely aligned with the general implicit theories of intelligence (mindset), where a significant difference was not seen. Focus group findings suggest this could be due to students finding the workshop focused on growth mindset beliefs in mathematics more engaging. Treatment participants found the workshops useful and interesting, but they rated their engagement in the sessions as less than both the usefulness and their interest. Individuals can also hold different levels of growth mindset beliefs about different areas or subjects (Dweck, 2015b).

While no significant difference between treatment and comparison participants’ academic perseverance on the self-reporting measure was found, a teacher cited four of the treatment participants as exhibiting increased effort and perseverance in mathematics classrooms. Academic perseverance was conceptualized as a medium-term outcome but it may be a long-term outcome, which is why differences were not detected within this study. The growth mindset intervention began to alter student’ beliefs about mathematics, but additional time may then be needed for this to impact their actions. Considering the social cognitive perspective, Bandura (1986) stresses the importance of the role of
environmental factors in student behavior. The limited resources of the current study permitted a focus on students only, but the literature and theory are pointing to the need for students to experience these growth-mindset messages throughout the school environment. This implies to the need for professional development for teachers and staff within schools so that a consistent growth mindset messages can be transferred to students.
CHAPTER 1- INTRODUCTION OF THE PROBLEM OF PRACTICE

This chapter contains a review of the relevant literature to determine the factors impacting a pertinent problem within an educational context. First, the theoretical framework on which the review was conducted will be explained. The literature will then be studied and synthesized. Limitations of the studies reviewed will be taken into consideration. Lastly, based on the findings of the review of the literature, the goals and focus of the needs assessment to be conducted within the high school of interest will be stated. To begin, the problem of practice that will be the focus throughout this dissertation will be defined.

Overview of the Problem of Practice

It has become clear to many that success is not due to intelligence alone, but to non-cognitive factors as well such as mindsets, learning strategies, social skills and perseverance (Farrington et al., 2012; Shechtman, DeBarger, Dornsife, Rosier, & Yarnall, 2013). Duckworth, Peterson, Matthews, and Kelly’s (2007) research demonstrated that individuals with higher levels of perseverance performed better within the National Spelling Bee and West Point Academy than individuals who exhibited less grit related behaviors. Perseverance was found by Strayhorn (2014) to be positively correlated to grades of Black male students within a primarily white college. These studies denote the increasing evidence of the importance of perseverance in academic achievement.

Historically, a strong focus has been placed on mathematics achievement and success (Schoenfeld, 2004) as studies such as an economic analysis completed by Rose and Betts (2004) revealed that mathematics courses taken in high school strongly predict earnings even 10 years after graduation. With this focus comes the indecision on whether
PERSEVERANCE IN MATH CLASSROOMS

Mathematics teachers should focus on the basics of mathematics or the process to improve learning and achievement (Schoenfeld, 2004). The process of mathematics and problem solving are now considered essential for students’ success in their personal and professional lives (Partnership for 21st Century Skills [P21], 2015), and the National Council of Mathematics Teachers (NCTM, 2014) explain that it is necessary for students to “acquire conceptual knowledge as well as procedural knowledge” (p. 9).

Problem solving and deep conceptual understanding is demonstrated by a student deciding how to solve a problem, monitoring their own process, and being able to judge if this is indeed a correct method to find a solution to the problem or if a new strategy needs to be attempted (Schoenfeld, 1992). Curriculum reforms have focused on processes such as in the Standards of Mathematical Practice (Common Core State Standards Initiative [CCSSI], 2010), which include what Schoenfeld (1992) describes as the “executive aspects of mathematical behavior” (p. 366). One such aspect is “make sense of problems and persevere in solving them” (CCSSI, 2010, p. 1). NCTM (2014) requires mathematics teaching to “support productive struggle in learning mathematics” (p. 10). A student is unable to work through this struggle without perseverance- the willingness and determination to strive through a challenge. However, the development of perseverance is not being attended to as teachers mainly adopt show and tell instructional methods within mathematics classrooms (Hiebert & Grouws, 2007). Teachers must begin to design learning environments including a focus on process and productive struggle to foster perseverance in the classroom.

Literature Review

Theoretical Framework
The notion that mathematics education is greatly impacted by beliefs of teachers and students is becoming more accepted within the research community (Leder, Pehkonen, & Törner, 2002). Bandura (1986) explains how from a social cognitive perspective behavior, environmental and cognitive aspects such as beliefs interact to determine a person’s behavior. These beliefs include those about mathematics as a discipline, the learning of mathematics and what Schunk and Richardson (2011) refer to as an individual’s self-efficacy. Self-efficacy are the beliefs a person holds about what they are able to learn or accomplish (Schunk & Richardson, 2011). A person’s self-efficacy can affect perseverance since as Alexander, Schallert, and Reynolds (2009) suggest, “learning can be resisted” (p. 178), with this resistance possibly triggered by false beliefs (Bandura, 1986).

The situated learning and cognitive perspectives can also impact the instructional strategies used within mathematics classrooms. NCTM (2014) encourages the use of rich tasks, which “…promote mathematical reasoning and problem solving and allow multiple entry points and varied solution strategies” (p. 10). The use of these rich tasks should naturally encourage the development of perseverance within the mathematics classroom, and also necessitates the need for teachers to act as the facilitator of learning (NCTM, 2014). Brown, Collins, and Duguid (1989) contend that students must engage in authentic activities of mathematics and learn through cognitive apprenticeship, where enculturation of students allows them to work in genuine mathematical practice and the teacher is needed to take on the role of the expert. Bransford, Brown, and Cocking (2000) explain the vast differences in the methods used by experts versus novices in solving problems. Through modeling the behavior of expert problem solving, teachers instruct students on
how to organize and solve a problem, leading to greater confidence and perseverance (Bransford et al., 2000). These various theoretical perspectives will become essential as a review of the literature is used to determine the driving factors relating to the lack of development and support of perseverance in mathematics classrooms.

Synthesis of Literature

Before considering the literature several key terms must be defined. Problem solving stemming from the sociocultural theory and the work of Resnick (1987) and Gee (2008) includes students being able to use a variety of strategies and tools to solve non-routine problems or rich tasks where the method may not be immediately clear (NCTM, 2014). The Merriam-Webster online dictionary definition of perseverance is the “continued effort to do or achieve something despite difficulties, failure, or opposition” (“Perseverance,” n.d., para 1). Farrington et al. (2012) differentiated between perseverance and what they define as academic perseverance which focuses on a student’s tendency to complete school work completely and on-time “despite distractions, obstacles, or level of challenge” (p. 9). Grit is very often used as a synonym for perseverance, but Duckworth et al. (2007) add that grit entails the perseverance for long term goals. The completion of short terms goals within a mathematics classroom leads students to the long-term goal of mathematical competence and completion of a class. Challenge and difficulty are important inclusions within the various definitions. Perseverance is developed through the use of problems that promote productive struggle where students face difficulty but have the ability to move ahead within a task (NCTM, 2014). A variety of variables affect how teachers support or hinder the development of perseverance in their classrooms (Spillane, Reiser, & Reimer, 2002).
**Teacher roles.** Education reform has changed the roles of both teachers and students (NTCM, 2014), whereas the teacher is now seen as a facilitator of learning instead of the dispenser of knowledge whose main task is to engage and guide students in discovery and ensure students are challenged and encouraged to persevere through solving problems (CCSSI, 2010; NCTM, 2014). Meanwhile, the student is an active participant and as such expected to be responsible for their learning, and a doer of mathematics (NCTM, 2014). The development of productive struggle in the classroom fosters a disposition to persevere in students (Hiebert & Grouws, 2007). The determination of the location of productive struggle will depend upon the individual student and their zone of proximal development (Vygotsky, 1978).

Providing these opportunities for students to struggle with mathematics can be difficult for teachers. Clarke (1997) completed a qualitative case study of two sixth grade mathematics teachers who were given resources and professional development for a reform-based unit. Observations of lessons and meetings, and interviews with teachers documented the first teacher’s greater comfort and acceptance of his new role as expert guide within the classroom, and the second teacher’s continued hesitance. The second teacher demonstrated that while her beliefs in the teaching and learning of mathematics included the new positioning of the teacher, she wanted to ensure that her students did not face complications. In this example, eliminating the challenge eliminated the opportunity for students to demonstrate and develop perseverance.

An important piece of the teacher’s role as facilitator becomes the selection of high-level mathematical tasks, in which students can exercise and develop their perseverance (NCTM, 2014). Henningsen and Stein (1997) explored the factors that
affected students’ completion of high level mathematical problem solving during rich
tasks and activities within four middle school mathematics classrooms. The sample taken
from a larger study included 58 lessons that were identified as rich tasks in which
students would be expected to actively participate in mathematical endeavors. Two
factors found to degrade the higher cognitive levels of a task were the elimination of
difficult aspects of the task and shifts in lesson goals from conceptual understanding to
getting the correct answer (Henningsen & Stein, 1997). Similar to situations described by
Clarke (1997), the teachers would eliminate pieces of a task or would take over a section
of the task deemed too challenging for the students (Henningsen & Stein, 1997).
Although both Clarke’s (1997) and Henningsen and Stein’s (1997) samples of teachers
were small, the studies demonstrate teachers’ hesitation in allowing students to struggle
through a problem. Students and teachers were also seen to become very preoccupied in
some cases with finding the answer instead of ensuring a deep conceptual understanding
of the topic (Henningsen & Stein, 1997). It suggests that teachers and students believe
the correct solution is the most important outcome of problem solving in mathematics.

*Teachers’ beliefs.* Ernest (1989) suggests teacher beliefs of the learning of
mathematics, and mathematics as a discipline greatly impacts their selection of
instructional practices. These beliefs can determine if a teacher runs a reformed or
traditional classroom, the latter being the most prevalent in mathematics classrooms
(Banilower, Boyd, Pasley, & Weiss, 2006). Lynch and Star (2014) completed a study of
teachers’ conceptions about the instruction of multiple strategies, considered essential in
the reform classroom and in cultivating students’ problem solving abilities (NCTM,
2014). A total of 92 Algebra I teachers from 70 Massachusetts schools were surveyed
before the start of a voluntary professional development session designed to prepare them to implement curriculum materials. Almost half of the teachers felt time constraints hindered their decision to teach multiple methods and 36 percent were concerned that low-achieving students would become confused if more than one method to solve a problem was introduced (Lynch & Star, 2014).

Cross (2009) attempted to examine the relationship between teacher beliefs and their instructional practice through a study of five high school Algebra I teachers using interviews in conjunction with lesson observations to understand the teachers’ thinking and intentions. Three out of the five teachers viewed mathematics as procedural and computational, and their lessons tended to be teacher-directed, which do not allow for student opportunities in productive struggle and the development of perseverance. These teachers also voiced the belief that low-achieving students were not capable of higher level thinking and needed concrete procedures and formulas, which was also articulated by teachers within Lynch and Star’s (2014) research. The much smaller sample in Cross’s (2009) study may be the reason that a greater portion of the sample expressed these views. However, it is interesting to note that more than half of the teachers interviewed by Lynch and Star (2014) were middle school teachers where Algebra I would be considered an accelerated path for students. These teachers would not be hindered by the belief that lower achieving students are not capable of rich tasks as they are teaching higher achieving students.

Beswick (2012) conducted a case study of two secondary school mathematics teachers in Australia in order to answer similar questions to Cross (2009). The first teacher believed the discipline of mathematics to be oriented around problem solving but
when questioned on the nature of mathematics responded with connections to school mathematics and curriculum. Beswick (2012) theorized that this teacher had conflicting beliefs about the nature of mathematics and the education of mathematics, which allowed her to hold varying beliefs even when some of these beliefs diverged from her instructional practice. While the teachers within Cross’s (2009) study demonstrated that their beliefs closely aligned with their choices of instructional practices, a teacher within Beswick’s (2012) investigation demonstrated that a teacher can carry beliefs about mathematics that do not coincide with their instructional practices.

**Instructional time.** While the beliefs of teachers can be a determinant in their acceptance of their new role within the classroom and guide or hinder their development of perseverance, the politics of education cannot be ignored if allowing for a fair and full accounting of barriers (Schoenfeld, 2004). Vogler and Burton (2010) distributed a survey instrument to all Algebra I teachers in 55 participating school systems in Mississippi and 53 in Tennessee. An average of three-quarters of the teachers noted they spend time preparing their students for the state’s high-stakes tests. The teachers defined some of the factors influencing their instructional practices as ensuring students pass to graduate from high school and ensuring that their school has good results on these tests (Vogler & Burton, 2010).

Barksdale-Ladd and Thomas (2000) interviewed and conducted focus groups from 59 K-8 teachers and saw that teachers felt increasing pressure to teach to the test and ensure good student results, leading to the discontinuation of activities meant to improve teamwork, independence and higher order thinking. Ader (2013) completed an ethnographic study of three teachers within two schools in the United Kingdom to
determine factors underpinning teachers’ development of metacognition in their middle school mathematics classrooms. Metacognition is simply seen as thinking about how one thinks (Flavell, 1979) and instructional activities seen to develop metacognition also develop perseverance (Hiebert & Grouws, 2007). Ader (2013) found the teachers’ choice of instructional activities were due in part to beliefs that for lower ability students, cognitive processes and content knowledge were more important to ensure that they were prepared for high stakes exams. While both Vogler and Burton’s (2010) and Barksdale-Ladd and Thomas’s (2000) studies demonstrate teachers’ increasing preoccupation with high stakes assessment, Ader (2013) would suggest that this pressure is not bound by culture but educational politics. Henningsen and Stein (1997) found that the appropriate amount of time to complete a mathematical task was crucial in ensuring the high cognitive demand of rich tasks. The inappropriate allocation of time on tasks to promote mathematical discourse, struggle, and therefore perseverance, could be linked to teachers’ perceived pressure to “get through” content and ensure students are prepared for tests. While all these studies are with relatively small samples of teachers, the similarities in results indicate the presence of perceived stress to ensure good student results on high stakes exams is felt keenly by teachers internationally and impacts their instructional practices.

The language here is not intended to say that curriculum should not be adhered to or teachers’ concerns about preparing students for these high stakes tests such as the Partnership for Assessment of Readiness for College and Careers (PARCC), which is currently being implemented in many states throughout the country are not valid. These studies suggest, however, that some teachers do not understand the necessary role of non-
PERSEVERANCE IN MATH CLASSROOMS

cognitive factors in the teaching and learning of mathematics, viewing their development and the teaching of content as conflicting rather than symbiotic, even as they proclaim the need and support of reform classrooms.

Student roles. Students also carry beliefs about their role within the classroom, beliefs of mathematics and dispositions that hinder their development of academic perseverance and push them to revolt against their role as active participant (Leder & Forgasz, 2002). Henningsen and Stein (1997) saw a teacher within their study would diminish the cognitive demand of a task at the insistence of the students. Schoenfeld (1989) attempted to determine student beliefs about mathematics using a survey instrument administered to 230 high school students in New York, and observations of classes to corroborate results and aid in explaining findings. In general the students felt memorization is very important and that one needs to know the “rules” to be able to solve problems in mathematics. Schoenfeld (1989) saw that real world problems in classes were few and far between and students believed any problem should be able to be completed in one to two minutes using a set procedure. While effort is deemed important by students, it is possible students consider effort to be more about putting in the time. Perseverance goes beyond just putting in the time to complete an assignment but pushing through even when difficulties arise. It is possible that students may not understand the difference between effort and perseverance. Understanding student beliefs becomes imperative as they determine students’ actions in, and reactions to, their classroom.

Students’ self-control, motivation and confidence. A student’s self-control is seen as the ability to stay focused to complete short-term tasks such as studying for a test or finishing a project (Farrington et al., 2012). Sussan and Son (2014) asked 113 ninth
grade biology students to bet if they would be able to answer questions correctly on a set of various topics on a subsequent test. The study allowed students to decide how long to study a topic before answering the questions and was conducted with a control group of students who did not bet (Sussan & Son, 2014). The research demonstrated that students who bet did have higher intentions of studying, although the attainment on the final test was very similar for students who bet and those who did not bet (Sussan & Son, 2014). Students who made bets on topics had better goals of studying but not the self-control or motivation to follow through. It is important to note that the incentive of a prize may not have seemed significant enough for students to follow-through with their study plan.

Bercher (2012) hypothesized that accurate self-monitoring would improve students’ performance on exams in college Anatomy and Physiology I labs. A self-assessment evaluation was completed by all 77 students at the end of a lab for students to self-assess their mastery of different learning objectives and to develop a study plan. Students who claimed that the self-assessment tool had a “definite impact” or had “a great impact” (Bercher, 2012, p. 29) on their test preparation achieved a higher average score on the exams than students who did not find the tool helpful. Bercher’s (2012) study demonstrated that at least some students were able to accurately assess their understanding of the course material and adjust their strategies to ensure their success.

This difference in results from Bercher’s (2012) study to Sussan and Son’s (2014) may be due to the effort being too great given the possible rewards (Alexander et al., 2009). Students in Sussan and Son’s (2014) investigation were offered an undefined prize for the highest score while the perceived “reward” for the college students in Bercher’s (2012) study could be considered higher grades. There is also the possibility that the age of the
students in college compared to the high school freshmen affected their self-control and motivation. Sussan and Son (2014) also suggest the possibility that overconfidence could have affected the accurate self-assessments of the 9th grade students’ understanding.

The beliefs of students also extend to the beliefs about their capabilities or their self-efficacy (Schunk & Richardson, 2011). Schunk and Richardson (2011) declare that students need to believe that they are capable of success and therefore have the confidence to take part in mathematics. Learning can be defined if “…the likelihood of success [is] deemed too risky for learning to be pursued” (Alexander et al., 2009, p. 179). Confidence is seen by society as a positive attribute, but while under-confidence can tempt students to not attempt a problem, over-confidence can also be detrimental. Over-confidence can make one think that they understand a concept when in fact the person does not. Bénabou and Tirole (2002) used an economic analysis to help understand some irrational behaviors seen by psychologists that attempt to preserve or enhance a person’s self-confidence. Links were seen between confidence and self-beliefs to perseverance. While positive belief in one’s ability can lead one to persist in the face of difficult tasks, over-confidence can lead to inaccurate self-assessments (Bénabou & Tirole, 2002). Perseverance can be deemed unnecessary when a student inaccurately judges the wholeness of their learning. It becomes imperative that a person use their metacognitive skills to recognize that their self-knowledge is very open to distortion and for teachers to ensure students are able to balance their ego and their doubts to reflect an accurate estimate of their abilities, thus ensuring an accurate level of perseverance (Bénabou & Tirole, 2002). These results could suggest a teacher’s perception of a student’s lack of self-control or motivation could in fact be due to overconfidence.
Limitations. This review gains strength from the variety of perspectives that are included but weaknesses are also present. A great amount of research on perseverance and the factors relating to the development of perseverance were discovered while working in elementary school grades, but it has been determined that age can effect a person’s perseverance (Duckworth et al., 2007), and therefore middle school through college was used to more closely resemble the high school context. A great number of the studies used survey instrumentation or interviews to determine teacher and student beliefs and instructional practices. This methodology can result in limited reliability since flawed self-assessment can easily distort results (Bénabou & Tirole, 2002), and information reported by teachers may not coincide with their instructional practices (Spillane et al., 2002). Methodologies that include lesson observations to support self-reported information are highly valuable but were not widely used within the research.

Since higher achievement is positively correlated with motivation in students (Tavani & Losh, 2003), the use of higher achieving students may have skewed the results of some of the studies. For instance, Schoenfeld (1989) surveyed high school students on a college track with almost half in pre-calculus or calculus courses, typically viewed as advanced level. Yet teacher beliefs consistently pointed to low achieving students as lacking in content knowledge and ability to persevere through rich mathematical tasks (Ader, 2013; Beswick, 2012; Lynch & Star, 2014). This would indicate a need for research to focus on these middle to low achieving students and the ability to build their perseverance in mathematics classrooms.

Conclusion
While prominent education theorists and mathematics education researchers agree that students should be given the opportunity to persevere through solving problems (Bransford et al., 2000; Schoenfeld, 1992), there are various interconnecting factors that are preventing this from occurring discussed in this chapter. One factor is teacher choices of instructional practices that either support or hinder students’ productive struggle and perseverance (NCTM, 2014). This is in turn driven by teachers’ acceptance of their role (Henningsen & Stein, 1997), their beliefs (Cross, 2009) and external factors such as testing (Vogler & Burton, 2010). Student beliefs about mathematics (Schoenfeld, 1989), self-regulation, motivation (Sussan & Son, 2004), and confidence (Bénabou & Tirole, 2002) can also be linked to students’ acceptance of these practices in developing perseverance. For example, if a student feels that they are not capable of doing well in mathematics, they may decide it is not beneficial for them to study or put forth the effort. These feelings are an aspect of their metacognitive knowledge, confidence, and beliefs and may cause a student to be less capable to evaluate oneself and his or her need to study. It becomes essential that students feel they are capable of success in mathematics (Schunk & Richardson, 2011). Research must begin to focus on the development of perseverance in high school mathematics classrooms and classroom practices that will foster perseverance. Next, the problem and the project objectives will be defined in preparation of the following chapter, which will explain the needs assessment conducted at the focus school.

Statement of the Problem

Perseverance is a concept frequently discussed in mathematics education research and education reforms but are also qualities that have held the interest of researchers in
other fields such as psychology (Duckworth et al., 2007). The research at this point has dealt mainly with trying to measure and account for variations in achievement due to non-cognitive factors, and is just beginning to determine the extent to which schools can affect these (Farrington et al., 2012). Perseverance is considered vital for the 21st century citizen (P21, 2015), as well as for students to engage and do mathematics (NCTM, 2014), yet goes undeveloped in mathematics classrooms where it is essential (Hiebert & Grouws, 2007; Schoenfeld, 1989).

**Project objectives.** Although the concepts have become more prominent in research and education reforms, within a high school in the Northeast of the United States “I give up” is still a common statement heard in mathematics classrooms, by the researcher, as perseverance gives way to doubt and learning is resisted. The literature revealed a plethora of drivers impacting this problem. The primary objective of this study is to aid students in developing perseverance and teachers in supporting this perseverance within the mathematics classroom. Ultimately this can then increase success within mathematics courses and prepare students to become productive citizens within the 21st century (P21, 2015).
CHAPTER 2- NEEDS ASSESSMENT

The last chapter detailed the main findings of a review of the literature pertaining to the factors impacting the development of the perseverance within high school mathematics classrooms. This chapter will explain the needs assessment conducted within the focus school to determine the specific drivers of the problem within the context. First, a description of the context and stakeholders will be provided and the goals of the needs assessment clarified. Next, the methodology including participants, variables, instrumentation and procedures will be explained in detail. Thirdly, the results of the needs assessment are provided. A discussion of the findings as they relate to each of the research questions will follow. Lastly, the limitations and implications of the results will be discussed.

Context of the Study

Description of the Context & Stakeholders

The development of perseverance in high school mathematics classrooms of a suburban high school in the Northeast of the United States is the focus of this study. This school has an enrollment of 1686 students of whom 26% qualify for free or reduced lunch. The student population is comprised of 56% Caucasian, 28% Hispanic, 11% Black and five percent documented as Asian or other. The mathematics department is comprised of four male and 12 female teachers with a varying range of experience and teaching styles. Of these 16 teachers 19% are Hispanic and 81% are Caucasian. The development of 21st century skills, which includes problem solving and creative thinking (P21, 2015) has been defined as a school wide objective. The Common Core Curriculum has been adopted as required by the state, which include these skills of problem solving
PERSEVERANCE IN MATH CLASSROOMS

and creative thinking (CCSSI, 2010). These skills are fostered through productive struggle and perseverance (NCTM, 2014).

The key stakeholders are teachers and students, however given the nature of the problem a wider view is possible. This need for the development of perseverance in students ensures that parents who feel a strong connection to their child’s success and school administrators who feel the pressure of greater policy control on schools and school achievement will also be bound to this problem and its solution (Schoenfeld, 2004).

Goals and Objectives

This needs assessment looked to determine not only the actual level of perseverance of students within the school, but how student beliefs about mathematics learning and mathematics as a discipline and their motivation, interact with students’ perseverance. The literature also pointed to teacher beliefs and instructional practices supporting or hindering the development of perseverance in students, and therefore it becomes imperative to define this as a secondary goal of the study. To determine how these intermingling factors affect the problem the following research questions were developed:

1. What instructional practices are teachers using in the classroom to foster perseverance?
2. How do the beliefs of teachers influence their choices of instructional practices within their classrooms?
3. How do students’ beliefs of mathematics influence their motivation, confidence and perseverance?
PERSEVERANCE IN MATH CLASSROOMS

4. Do students and teachers believe perseverance, motivation and confidence are necessary in the learning of mathematics?

Determining the factors within a particular context becomes essential so that an appropriate intervention can be ascertained. Given these objectives, the methodology of the study will be explained.

Methodology

Participants

Student participants. Sixteen out of 32 homerooms were selected based on convenience, and the anticipated support from the teachers of those homerooms including eight sophomore and eight junior classrooms. Homeroom teachers were emailed individually and asked to aid in the collection of data. All of these homeroom teachers were given a short paragraph to read (seen in Appendix A) detailing the objectives of the investigation, the possible benefits that findings could have on mathematics instruction within the school, and the process by which the survey would be completed. Students were also reminded that participation was voluntary, there were no potential risks and no incentives were offered. Letters of Informed Consent (seen in Appendix B) were distributed to students by homeroom teachers, which were also available in Spanish for parents as needed. Students were asked to return the Letters of Consent within two days.

A total of 30 students returned the Letters of Consent and completed both portions of the survey. Due to the need for a larger sample size a second round of sampling was completed at the end of May and beginning of June. While the original study was based on 10th and 11th grade students, seniors were asked to participate in the second round.
Four 12th grade homerooms were asked to participate and this additional round of
surveying added an additional 11 students to the sample.

Table 2.1

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two Courses Above Grade Standard</td>
<td>9</td>
<td>22.0</td>
<td>22.0</td>
</tr>
<tr>
<td>One Course Above Grade Standard</td>
<td>21</td>
<td>51.2</td>
<td>73.2</td>
</tr>
<tr>
<td>Course at Grade Standard</td>
<td>10</td>
<td>24.4</td>
<td>97.6</td>
</tr>
<tr>
<td>One Course Below Grade Standard</td>
<td>1</td>
<td>2.4</td>
<td>100</td>
</tr>
</tbody>
</table>

Of the total 41 participants, 34% \( (n = 14) \) were in grade 10 and 39% \( (n = 16) \) were
in grade 11 and 26% \( (n = 11) \) were in grade 12, similar to the population proportions. The
percentage of male and female participants did not match as closely with the population
proportions. The sample contained 29% \( (n = 11) \) male and 71% \( (n = 19) \) female. As
shown in Table 2.1, over 73% of the sample is made up of students who are taking at
least one course above the standard mathematics course for their grade level.

**Adult participants.** Mathematics teachers were surveyed, and one key informant,
the mathematics supervisor within the organization, was interviewed. All 16 mathematics
teachers, including three special education and two bilingual mathematics teachers, were
asked to participate in the study. They were emailed (seen in Appendix D) with some
brief information of the research, assured that confidentiality would be maintained, and
told that letters of consent (seen in Appendix E) would be placed in their school mailbox.
Teachers were asked to sign and return the letter if they agreed to complete the survey.
Eleven teachers returned the letter of consent and 10 completed the online survey (seen in
Appendix F). Six of the 10 teachers were female and the sample consisted of a range of teaching experience and highest degrees earned as shown in Table 2.2.

Table 2.2

Mathematics Teacher Participant Characteristics

<table>
<thead>
<tr>
<th>Length of Teaching</th>
<th>Highest Degree Earned</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bachelor's degree</td>
</tr>
<tr>
<td>First Year</td>
<td>1</td>
</tr>
<tr>
<td>2-6 years</td>
<td>2</td>
</tr>
<tr>
<td>7-9 years</td>
<td>-</td>
</tr>
<tr>
<td>15-19 years</td>
<td>1</td>
</tr>
<tr>
<td>20-24 years</td>
<td>-</td>
</tr>
<tr>
<td>30 years or more</td>
<td>-</td>
</tr>
</tbody>
</table>

The mathematics supervisor within the organization was asked to participate due to their knowledge of the school, faculty, and students, and was given the same letter of consent given to teachers (seen in Appendix E). The individual’s role within the school was such that they have intimate knowledge of the planned and enacted curriculum within mathematics classrooms. Before beginning the interview, the key respondent was reminded that confidentiality would be maintained and participation could be withdrawn at any time. Questions relating to the perseverance of students within the school and development of perseverance within mathematics classrooms were asked (seen in Appendix G). The interview was recorded using the app AudioNote and later transcribed.

Instrumentation

Student survey. The Attitude Towards Mathematics Inventory [ATMI]
PERSEVERANCE IN MATH CLASSROOMS

developed by Tapia and Marsh (2004) has been shown to measure students’ self-confidence, enjoyment, perceived value and motivation in doing mathematics (Chamberlin, 2010; Tapia & Marsh, 2004). The original instrumentation was 40 items, but due to concerns about length, eight items were eliminated (Lim & Chapman, 2013) and this shorter version was utilized for this study.

To determine the level of student perseverance the Short Grit Scale, developed by Duckworth and Quinn (2009) was used. Student beliefs of mathematics as a discipline and the learning of mathematics, which are mentioned in the third and fourth research questions, necessitated the inclusion of some additional questions. Schoenfeld’s (1989) survey instrument was designed to determine student beliefs and attitudes and 11 items were chosen to include within the student survey. Some of the language of the questions was changed to more accurately reflect current use of words (Chamberlin, 2010). Three additional items were added including the level of mathematics course participants were taking, their grade and gender. These acted as demographic variables, but were also important because perseverance has been seen to depend upon age and education level (Duckworth et al., 2007). The combined survey, including parts one and two, can be seen in Appendix C.

Teacher survey. Existing instrumentation used in Vogler and Burton’s (2010) study was utilized to determine teachers’ instructional practices and teacher-identified factors that influence their choice of instructional practices. Similar to Vogler and Burton’s (2010) questioning, respondents were then asked if they prepared students for the Partnership for Assessment of Readiness for College and Careers (PARCC) examination and given choices of yes, no or does not apply as some teachers do not teach
PARCC assessed courses. Skip logic was then used to either have respondents define the length of instructional time they spend preparing students for PARCC if they replied yes to the previous question.

The literature also pointed to teacher beliefs about the nature of mathematics and the learning of mathematics, and therefore several open ended questions similar to those designed by Lynch and Star (2014) and Cross (2009) were included in the instrumentation. Questions ask teachers to describe mathematics using four words to aid in understanding their beliefs of mathematics as a discipline. The use of metaphors to understand beliefs has become more popular in methodology (Noyes, 2006). The last three open-ended questions focused on teacher perceptions of student levels of perseverance they witness in the classroom, and groups of students that would benefit from the development. All teachers were asked demographic information including gender, length of time teaching and highest level of education attained.

**Mathematics supervisor interview.** To capture tacit knowledge about the perceived support of perseverance within mathematics classrooms, a semi-structured interview with the mathematics supervisor informant was designed to more deeply understand the state of the problem within the context. Some questions on the development of perseverance in the classrooms, and the necessity of perseverance in the learning of mathematics were asked. The full interview schedule can be seen in Appendix G.

**Variables**
A range of variables were employed due to the extensive nature of the factors impacting the problem and were operationalized with the aid of the literature discussed above.

**Student variables.** In order to answer the third and fourth research questions it became essential to determine students’ current levels of perseverance, motivation, confidence, and their beliefs about mathematics. The items used to measure self-confidence, value, enjoyment, and motivation were taken or adapted from Tapia and Marsh’s (2004) ATMI instrumentation. To measure a student’s self-confidence in doing mathematics or their perception that they are capable of mathematics 12 items loaded into the variable. This variable could also be considered a student’s self-efficacy (Chamberlin, 2010). A sample item that loaded into the self-confidence variable was “I am able to solve mathematics problems without too much difficulty.” Six out of the 12 items were reverse scored such as “studying mathematics makes me feel nervous.” The variable of value was conceptualized as students’ perceived value in mathematics and its application in the real world. Seven items load into value including “I can think of many ways that I use math outside of school”. Students’ enjoyment in doing mathematics was based on nine items such as “I really like mathematics”. Enjoyment also included one reverse scored item: “Mathematics is dull and boring.” Motivation is a student’s inherent motivation or interest in doing mathematics and is constructed from four items such as “The challenge of math appeals to me.” The variables of self-confidence, value, enjoyment, and motivation were all measured using a 5 point Likert scale ranging from 1 which denoted “strongly disagree” to 5 denoting “strongly agree” as in Tapia and Marsh’s (2004) ATMI instrument. Higher values of these variables denoted a
participant’s higher self-confidence in doing mathematics or greater perceived value in doing mathematics.

Perseverance can be operationalized as a disposition or as a set of processes (Shechtman, et al., 2013). For the purpose of this needs assessment perseverance is considered a disposition. Duckworth and Quinn’s (2009) Short Grit Scale included two sub-scores of Consistency of Interests and Perseverance of Effort. All four items that loaded into Consistency of Interests were reverse scored such as “I often set a goal but later choose to pursue a different one” (Duckworth & Quinn, 2009). “Setbacks don’t discourage me” is an example of an item that loaded into Perseverance of Effort (Duckworth & Quinn, 2009). A 5 point-Likert scale was used for both scores where 1 was “not at all like me” and 5 “very much like me.” The combination of these two subscales was then used to determine perseverance. A higher score would denote a higher level of student perseverance.

The variable of the Role of the Teacher is operationalized as student’s perception of the part of the teacher within the classroom (Schoenfeld, 1989; NCTM, 2014). A higher value would denote a student’s perception of the teacher as expert guide, while a lower score would denote the perception of the teacher as the dispenser of knowledge as seen in the traditional classroom. Two items loaded into the variable of students’ perception of the role of the teacher including “Good math teachers show students lots of different ways to look at the same question” and the reverse scored item “Good math teachers show you the exact way to answer the math questions you’ll be tested on.” Role of the teacher was measured using a 4 point Likert scale ranging from 1 which denoted “Not at all true” to 4 denoting “Very true”. Additional short response questions were
asked including the amount of time they felt a typical homework problem should take and the time they felt they would spend on a problem before knowing it was impossible. These two questions were also asked by Schoenfeld (1989) in order to aid in determining students’ beliefs about mathematics as a discipline. All answers were converted into minutes before uploading data to SPSS. Student belief that achievement is based on ability or effort was assessed using one question “Some people are good at math and some just aren’t” with the same Likert scale as the Role of the Teacher variable. It was reverse scored so that a higher value of this variable would thus mean that students believe hard work more than natural ability determines achievement. Students were asked the mathematics class they were currently enrolled in which was defined as the Class Level variable. This variable had a value of zero if the student was in a standard mathematics class for their grade, for instance a tenth grader in Geometry or an eleventh grader in Algebra 2. Negative one would denote a student behind a class for their grade and positive one would mean one class ahead such as a tenth grader taking Algebra 2. Additional demographic information includes grade and gender.

**Teacher variables.** Instructional practices were broken into two variables of Standards Based Instruction and Traditional Instruction. Standards Based Instruction, which Vogler & Burton (2010) and Schoenfeld (2004) define as instruction focusing on problem solving, communication of thought processes, and reasoning, are practices designed to invoke productive struggle and perseverance (NCTM, 2014). Traditional instruction is teacher centered and includes direct instruction, and a focus on content over process (Vogler & Burton, 2010). These types of activities do not support perseverance within the mathematics classroom. Teachers were asked to rate on a 5 point Likert scale
the amount they used various instructional practices, and resources in their classroom from 1 denoting they “do not use” to 5 denoting the use of that instructional practice “four to five days per week on average”. Six items loaded into the Traditional Instruction variable including the use of textbook based problem sets and lecturing. Twenty-two items loaded into the Standards Based Instruction variable including the use of computers, educational software, calculators, and mathematics problems that could be solved in many ways. A higher value of the variable would denote the greater use of the instructional practices.

To answer the second research question on the influences of instructional practices 12 items were designed although due to the nature of the variable were not averaged as one score. The 12 items each refer to a different influence on instructional practices including personal desire or interactions with colleagues. They were each then labeled as Influence on Practice one through twelve. The variable was measured using a 5 point Likert scale ranging from 1 “Strongly Disagree” to 5 “Strongly Agree.” Therefore a high value of the variable denotes a greater influence of that item on a teacher’s choice of instructional practices. Additional demographic variables including gender, length of time teaching, and highest level of education were also included.

Procedure

Data collection. Teacher and student surveys were completed using Google Forms. The first round of students who had returned their Letters of Consent were emailed the links to both portions of the survey. Homeroom teachers were given assigned participant numbers to distribute to students, which students were asked to enter in the beginning and at the end of both parts of the survey. The students completed the first part
of the survey on the first day in homeroom and the second part of the survey on the second day. Procedures for data collection within the second round of sampling were largely the same. The main difference being the investigator introduced the study and handed out the Letters of Consent to twelfth grade students within their homerooms. Students willing to participate were permitted to hand in the signed Letter of Consent at this time if they were 18 years of age or older.

Once mathematics teachers had returned the Letter of Consent, a link to the survey was emailed to the teacher with a requested completion date of one week. All teachers were emailed after one week and asked to complete the survey if they had not done so already. The mathematics supervisor was chosen for their in-depth knowledge of the school and asked in person to participate in an interview. Upon agreeing and signing the Letter of Consent the researcher completed the interview. Initial notes and thoughts were hand written by the researcher during the interview and the entire interview was recorded and later transcribed.

**Data analysis.** Raw data was downloaded as an Excel file from Google Forms. Student data was coded as seen in the description of the variables above and uploaded into SPSS 22 for storage and analysis. Basic descriptive statistics including mean, median, and frequencies of all numeric variables was determined. Outliers within some of the items made the median a better indicator then the mean since high numbers can impact the mean significantly. Independent sample t-tests were used to determine if there were differences in the means of various variables between males and females, and also between different grades within the sample. Bivariate correlations were also used to
determine connections between students’ beliefs of mathematics and their motivation, confidence and perseverance.

Raw data from teacher surveys was downloaded as an Excel file from Google Forms where it was split into two files for quantitative and qualitative analysis. All numeric variables including nominal and interval variables were stored and analyzed using SPSS 22. Basic descriptive statistics including mean, median, and frequencies of all numeric variables was determined in SPSS. Open ended questions were copied into a separate Word document and separated by question with a wide right margin to write notes and codes as suggested by Saldaña (2008). Each response was labeled by the order in which participants responded such as Respondent 1, Respondent 2, etc. The responses were read through once to look for themes and then read again, and assigned initial codes. Saldaña (2008) suggests reading through qualitative data several times to check coding, and recode as necessary, and therefore the researcher completed this an additional two times. A similar process was then used on the interview conducted with the mathematics supervisor.

**Needs Assessment Findings**

**Initial Findings From Students**

An initial analysis of data demonstrated that student value, confidence, enjoyment, motivation, and perseverance are quite high, all around 3.5, as seen in Table 2.3. The medians of these variables are also very close to the means. Recall that student consistency of effort and student perseverance of effort loaded into the variable of student perseverance. They have been included because of the 0.83 difference between their means. This demonstrates that while the students’ perseverance is high their perseverance
PERSEVERANCE IN MATH CLASSROOMS

of effort in completing tasks and assignments is higher than their consistency in
completing long term goals. Duckworth et al. (2007) defined grit as the perseverance
toward long term goals, although for the purposes of this needs assessment within a
school, perseverance of effort becomes more integral.

Table 2.3

Descriptive Statistics of Student Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Median</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students' perceived value in mathematics</td>
<td>3.95</td>
<td>4.00</td>
<td>.67</td>
</tr>
<tr>
<td>Students' confidence in mathematics</td>
<td>3.36</td>
<td>3.42</td>
<td>1.06</td>
</tr>
<tr>
<td>Students' enjoyment of mathematics</td>
<td>3.26</td>
<td>3.22</td>
<td>1.02</td>
</tr>
<tr>
<td>Student motivation</td>
<td>3.39</td>
<td>3.50</td>
<td>1.07</td>
</tr>
<tr>
<td>Student perseverance</td>
<td>3.37</td>
<td>3.38</td>
<td>.62</td>
</tr>
<tr>
<td>Student consistency of effort</td>
<td>2.95</td>
<td>3.00</td>
<td>.76</td>
</tr>
<tr>
<td>Student perseverance of effort</td>
<td>3.78</td>
<td>4.00</td>
<td>.73</td>
</tr>
<tr>
<td>Student belief of math as a discipline</td>
<td>2.47</td>
<td>2.50</td>
<td>.48</td>
</tr>
<tr>
<td>Student beliefs of role of teacher</td>
<td>2.72</td>
<td>2.50</td>
<td>.51</td>
</tr>
</tbody>
</table>

Student beliefs of mathematics as a discipline and the role of the teacher are both
at slightly higher than the middle of the scale, demonstrating students have mixed
feelings and beliefs about mathematics. The students see mathematics as a process and
problem solving, while also holding beliefs of mathematics as memorization and
procedural. They see the role of the teacher including aspects of an expert guide, but also
as a traditional mathematics teacher. The variable of student belief of determinant of
success in mathematics has a mean of 1.59, a median of 1.00 and a standard deviation of
0.71. This denotes that students believe quite strongly and consistently that achievement
PERSEVERANCE IN MATH CLASSROOMS

in mathematics is based on ability and cannot be accomplished through effort and hard work.

Table 2.4

*Descriptive Statistics of Time to Complete Homework Problem and Considered Impossible*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Median</th>
<th>Std. Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to complete a homework problem (in minutes)</td>
<td>4.68</td>
<td>3.00</td>
<td>5.83</td>
<td>0.30</td>
<td>25.00</td>
</tr>
<tr>
<td>Time until problem is considered impossible (in minutes)</td>
<td>93.24</td>
<td>15.00</td>
<td>452.67</td>
<td>2.00</td>
<td>2880.00</td>
</tr>
</tbody>
</table>

The values of how long students felt a mathematics problem should take to complete and how long they would persist until they felt a problem was impossible, were also very telling about their beliefs of mathematics as a discipline. The descriptive statistics associated with these two variables are seen in Table 2.4 and it should be noted that one student did not answer these questions. The mean time to complete a homework problem was 4.68 minutes while the median was 3.00 minutes. Looking at the mean level of perseverance of students above, it was expected that this length would have been larger, but it demonstrated that the students hold beliefs about the procedural aspects of mathematics, and do not feel perseverance is necessary in mathematics as Schoenfeld (1989) also saw within his study. The large standard deviation of the time students felt they would spend before feeling a problem was impossible hints at the large range of values provided by students with the median being 15.0 minutes.
Moderate positive correlations significant at the 0.01 level were also discovered between student beliefs of mathematics as a discipline and their motivation, confidence, enjoyment, and perceived value in mathematics as seen in Table 2.5. Moderate positive correlations were also seen between student beliefs about the role of the teacher and student motivation, perseverance of effort and confidence seen in Table 2.5. This indicates that a student who has stronger beliefs of the teacher as a facilitator generally has greater perseverance. While only moderate positive correlations between student beliefs of mathematics as a discipline and confidence and motivation, it does demonstrate that there is a connection between the variables as asked in the third research question.

Table 2.5

*Correlation Values Between Various Student Variables*

<table>
<thead>
<tr>
<th>Variable</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Student’s motivation in doing mathematics</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Student’s enjoyment in doing mathematics</td>
<td>.89*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Student's perceived value in mathematics</td>
<td>.69*</td>
<td>.67*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Student beliefs about the role of the teacher</td>
<td>.47*</td>
<td>.34*</td>
<td>.36*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Perseverance of Effort</td>
<td>.34*</td>
<td>.34*</td>
<td>.44*</td>
<td>.35*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Student's confidence in doing mathematics</td>
<td>.83*</td>
<td>.86*</td>
<td>.65*</td>
<td>.50*</td>
<td>.56*</td>
<td></td>
</tr>
<tr>
<td>7. Student beliefs of math as a discipline</td>
<td>.55*</td>
<td>.55*</td>
<td>.46*</td>
<td>.20</td>
<td>.30</td>
<td>.48*</td>
</tr>
</tbody>
</table>

*Note. N = 41; ** p < 0.01, two tailed; * p < 0.05, two-tailed*

Interestingly there was also a high positive correlation between motivation and confidence, and between motivation and confidence as seen in Table 2.5. A high positive correlation of 0.89 at the 0.01 significance level was also discovered between students’
motivation in doing mathematics and their enjoyment of mathematics. Students who have a greater enjoyment of mathematics tend to see greater value in the learning of mathematics. Independent sample t-tests demonstrated that there were no significant differences between the level of perseverance in males and females, or between grade levels.

**Initial Findings From Adults**

An analysis of the results from the surveys completed by teachers demonstrated that teachers are using a mix of instructional practices. Standards based instruction resulted in a mean of 2.97 with a standard deviation of 0.40, and traditional instructional practices had a mean of 3.37 with a standard deviation of 0.50. No significant correlation was determined between standards based instruction and traditional instructional practices. The close proximity of the means would suggest that teachers are using a mix of instructional practices, some which promote perseverance and some which do not. The mathematics supervisor who noted when asked if perseverance was being developed in mathematics classrooms corroborated this finding saying that “the groundwork was being laid” (Mathematics Supervisor 1). Traditional instruction such as lecture is still very prevalent in classrooms, which does not promote perseverance.

The data suggests that various factors affect teachers’ choices of instructional practices within the classroom as seen in Table 2.6. Beliefs they are the best instructional practices, interactions with colleagues and ensuring students have scores that allow them to graduate are the influences with the highest means. The format of the PARCC exam was quite low and may be due to this being the first year of PARCC testing within the school and scores not determining whether students are able to graduate or not. Of the
eight teachers who teach PARCC tested courses, seven said they do spend instructional
time preparing students for the test. Out of the seven teachers who said they spend time,
40% said they spend two to four days preparing students and 10% said they spend one
week to nine days.

Table 2.6

<table>
<thead>
<tr>
<th>Influence</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beliefs these are the best instructional practices</td>
<td>10</td>
<td>4.50</td>
<td>.71</td>
</tr>
<tr>
<td>Format of the PARCC examination</td>
<td>10</td>
<td>2.20</td>
<td>1.23</td>
</tr>
<tr>
<td>Interest in helping my school improve PARCC exam scores</td>
<td>10</td>
<td>2.60</td>
<td>1.26</td>
</tr>
<tr>
<td>Interest in helping my students attain test scores that will allow them to graduate high school</td>
<td>10</td>
<td>4.20</td>
<td>.92</td>
</tr>
<tr>
<td>Interest in avoiding sanctions at my school</td>
<td>10</td>
<td>2.00</td>
<td>1.15</td>
</tr>
<tr>
<td>Interactions with school principal</td>
<td>10</td>
<td>2.50</td>
<td>1.27</td>
</tr>
<tr>
<td>Interactions with colleagues</td>
<td>10</td>
<td>4.10</td>
<td>.57</td>
</tr>
<tr>
<td>Personal desire</td>
<td>9</td>
<td>4.11</td>
<td>0.93</td>
</tr>
<tr>
<td>Staff development in which I have participated</td>
<td>10</td>
<td>3.70</td>
<td>.67</td>
</tr>
<tr>
<td>Interactions with parents</td>
<td>10</td>
<td>2.90</td>
<td>1.10</td>
</tr>
</tbody>
</table>

A qualitative analysis of the open ended questions indicated that teachers felt
mathematics was logical such as one respondent who said “I think that math makes sense,
that it’s step-by-step and built on logic” (Teacher Respondent 4). Teachers in general see
there is high value in mathematics such as one teacher who said “there are so many
applications of mathematics” (Teacher Respondent 2). Challenging was also a common
theme seen in responses and also patterns which teachers saw as “understanding the
rules” or as one teacher specified “much of the time a problem can be solved by
PERSEVERANCE IN MATH CLASSROOMS

following the algorithm related, or uncovering the pattern in it” (Teacher Respondent 7). The responses were indicative of teachers’ beliefs that the learning of mathematics and the teaching of mathematics are quite different as seen within Beswick’s (2012) study. Responses to the question about their mathematics education revealed the teachers had been taught mathematics in school with the use of mostly traditional instructional practices. Responses to this question did not vary with the length of time teaching. One teacher defined her mathematics classes as “chalk and talk” (Teacher Respondent 9). Open ended questions also provided a good deal of information useful in assessing the research questions pertaining to student levels of perseverance, and student beliefs. One teacher responded “they do not have a lot of perseverance because they know they are in lower levels and have already been told that they are not good at math” (Teacher Respondent 1). The mathematics supervisor also verbalized this notion including that students can begin to believe they are not capable of mathematics because their parents were not good at mathematics. This variation in perseverance and belief of ability to persevere depending on the level of student was seen in the literature as well (Ader, 2013; Beswick, 2012; Lynch & Star, 2014). When asked what particular students would benefit from the development of perseverance, three of the teachers mentioned those with low motivation and a different teacher also mentioned students with low confidence. This would suggest that teachers do understand the necessity of motivation, confidence and perseverance in the learning of mathematics.

Discussion

The first research question that guided this needs assessment asked what instructional practices teachers are using in the classroom to foster perseverance. As
mentioned a mix of instructional practices were reported as being utilized by teachers in their classrooms. This mix may be the reason there was no correlation detected between the two as all teachers are using some traditional and some standards based instructional methods, with none of the teachers using predominantly one or the other. It is important to note that all of the instructional methods were self-reported and while items such as the use of calculators is considered standards based instruction, this can depend on how the teacher is actually utilizing the calculators within instruction.

The connection between beliefs of teachers and their choice of instructional practices were investigated to answer the second research question. Teachers noted that they are utilizing methods in their classrooms that they feel are the best instructional practices. Interactions with colleagues and ensuring students are able to graduate also greatly influenced teachers’ choices of instructional practices. Seven out of eight teachers who teach a PARCC tested course spend instructional time preparing students. This highlights the importance that teachers place on results, preparing students for the test and ensuring their ability to graduate. Qualitative data from teachers indicated that understanding rules or algorithms are essential for success in mathematics. These are not practices that would support the development of perseverance in mathematics classrooms.

Next, the results of student surveys are considering, beginning with the third research question. Perseverance was positively correlated to students’ beliefs of the role of the teacher meaning that students who felt a teacher’s role was that of a dispenser of knowledge had lower perseverance. Lastly, considering the fourth research question, the data demonstrated students and teachers understand the need for perseverance,
motivation and confidence, but their beliefs about the learning of mathematics would not support the development of perseverance within the classroom. Student beliefs of mathematics including their beliefs about the role of the teacher and mathematics as a discipline lean more toward those associated with a traditional mathematics classroom where productive struggle is not emphasized. While the students surveyed had high perseverance, teachers, the mathematics supervisor, and the literature all pointed to lower achieving students lacking and needing the development of perseverance.

Another important and surprising finding was that about students’ attributions of success or failure. The low score denoted that students felt that achievement in mathematics was more greatly influenced by ability and is interesting in a society where children are taught that hard work assures victory. While the sample was primarily students taking classes above their grade level, this is very important especially if it is a belief held by those throughout the school culture. This type of fixed mindset has been shown to correlate to lower motivation and achievement, especially for lower achieving students (Blackwell, Trzesniewski, & Dweck, 2007). The combination of a fixed mindset and beliefs that support a traditional mathematics classroom, would not aid lower achieving students to fully accept those reform based practices seen to develop perseverance within the mathematics classroom.

**Limitations and Implications**

These findings must be taken with a grain of salt, as restrictions do exist. The main limitation seen within this study is the small sample size of students. The demographics of the sample also greatly limit the validity of the results. Seventy-three percent of the sample was composed of students who were one to two courses ahead of
the normal level for their grade, which could arguably be considered to be higher achieving students. This would not be representative of the population and since higher achievement is positively correlated with motivation (Tavani & Losh, 2003) and perseverance (Farrington et al., 2012) this high percentage quite possibly skewed the results. Another limitation was the self-reporting nature of all of the instruments, as some students or teachers may not have strong self-assessment capabilities.

**Barriers to Data Collection**

Unfortunately the small sample size of students greatly limits the generalizability of the results. This limited sample was due to a variety of barriers including time constraints due to the timing of the school’s spring break and PARCC testing. Four hundred letters of consent were distributed, but only 30 were returned in the first round of testing. A second round of surveying did not minimize this constraint as intended, only adding an additional 11 respondents.

**Implications**

Taking these limitations into account, this needs assessment does imply that the factor most hindering the support and development of perseverance within the mathematics classrooms of the focus high school are the beliefs of students and teachers. The role of beliefs in teachers’ support of perseverance and student acceptance of this development was also seen within the literature (Beswick, 2012; Henningsen & Stein, 1997; Schoenfeld, 1989). These beliefs include those associated with mathematics as a discipline, the role of the teacher and student, and the learning of mathematics. The literature also demonstrated the strong links between teacher beliefs and student beliefs. The beliefs of teacher were seen to determine instructional practices (Lynch & Star,
PERSEVERANCE IN MATH CLASSROOMS

2014), which in turn create a classroom and sociomathematical norms in which students understand and develop their own beliefs about learning and mathematics (Schoenfeld, 1989). It becomes clear then that no intervention could be completed with only students. The involvement of both teachers and students would be necessary to begin to alter the beliefs of both in order to ensure that perseverance is developed and supported within mathematics high school classrooms.

Conclusion

This chapter utilized the review of the literature conducted in the previous chapter to design a needs assessment to determine the prominent factors impacting the limited development of perseverance within high school mathematics classrooms within the focus school. The objectives, procedure, and methodology of the needs assessment conducted within a high school in the Northeast of the United States have been elucidated. An explanation and discussion of the results was included. The next chapter will determine possible interventions to implement within the focus school in an attempt to correct one of the factors impacting the problem through a review of the literature.
CHAPTER 3- INTERVENTION LITERATURE REVIEW

This chapter will provide a review of the literature to aid in determining possible solutions to the problem in relation to the limited development of perseverance in high school mathematics classrooms. Initially, a more concrete definition of perseverance as it pertains to learning mathematics will be examined. Second, a discussion of the underlying factors associated with this problem seen in the literature and results from a needs assessment conducted in the Spring of 2015 within a large suburban high school in the Northeast are reviewed to understand the problem in context. Third, it will continue with a discussion of the social cognitive perspective that aided in constructing the theoretical foundation, and directed the review of the literature. Fourth, review the research involving two interventions for developing perseverance in mathematics classrooms by altering student and teacher beliefs of mathematics and learning: reform-based classroom environments and mindset interventions. Finally, the proposal of a growth mindset intervention within the context of the focus high school in the Northeast will be discussed.

**Conceptualizing Perseverance**

Upon completion of the needs assessment, greater clarification was deemed necessary on the use and operationalization of the term perseverance. The definition of perseverance varies throughout the literature and several other terms are used as synonyms including tenacity, grit, resiliency, and persistence. Dweck, Walton, and Cohen (2011) define academic tenacity as the skills and mindsets that aid students’ perseverance through challenges and over longer lengths of time. This is similar to grit, which Duckworth et al. (2007) define as the perseverance for long-term goals. Resilience is
another term that can overlap with perseverance, but focuses on students’ ability to recover from severe trauma (Shechtman et al., 2013). A student’s self-control is also mentioned frequently within the literature connected to perseverance and is related to a student’s ability to remain focused on short-term requirements instead of moving on to more enjoyable activities (Duckworth et al., 2007; Dweck et al., 2011). Persistence is defined as the continuation toward the achievement of a goal despite obstacles, but Peterson and Seligman (2004) suggest that perseverance cannot be measured by simply measuring the length a person spends on a given task. Most people can persist when they deem a task enjoyable or fun, but true perseverance is demonstrated when an individual continues toward a goal despite significant challenges (Peterson & Seligman, 2004). Farrington et al. (2012) focus on the impact of non-cognitive factors on student achievement including what they define as academic perseverance. Academic perseverance is stated as a student’s tendency to complete schoolwork completely and on-time “… to the best of one’s ability despite distractions, obstacles, or level of challenge” (Farrington et al., 2012, p. 9).

The various definitions of perseverance can lead to confusion when using the term for research. For the purpose of this study, it becomes important to determine what perseverance looks like in the mathematics classroom. Does it entail persisting through difficulties even when the answer is wrong or persisting until the correct answer to a problem is achieved? Bransford et al. (2000) explain the benefits and need of fluency when learning, but warn that it does not automatically develop by focusing on accuracy. A teacher who emphasizes the importance of acquiring the correct answer does not guarantee that a student will be fluent in adding fractions for instance. The development
of perseverance within students is mentioned throughout NCTM’s Principles to Actions (2014). It is explained how the majority of authentic problem solving cannot be completed in a matter of minutes (NCTM, 2014) as so many students believe it can (Schoenfeld, 1989). Some students may require longer amounts of time and it is important for teachers to support students without denying them the challenge needed to develop perseverance (NCTM, 2014). While there are differences between the various definitions, the inclusion of ‘challenge’ and ‘difficulty’ are important shared features (Duckworth et al., 2007; Dweck et al., 2011; Farrington et al., 2012). Perseverance is developed through this challenge with the use of problems that promote productive struggle (NCTM, 2014). Productive struggle is referring to students experiencing challenge and difficulty during the process of learning or completing a task, but still having the ability to make progress (NCTM, 2014). Teachers within the needs assessment conducted at the focus school also acknowledged students’ limited frustration level, wanting to finish as quickly as possible and wanting them to show greater perseverance in their normal day-to-day work.

Mathematics achievement is very dependent upon previous understanding and learning due to the constant building on prior knowledge. NCTM (2014) and mathematics teachers within the needs assessment mentioned the need for students to persevere in the face of difficulty, placing less value on obtaining a correct answer. Indeed, cognitive apprenticeship perspectives now push for the goal of authentic problems in classes where a correct solution may be subjective (Boaler, 2006; Brown et al., 1989). Farrington et al.’s (2012) focus on academic perseverance as a student’s persistence to the best of their ability seems to be the most in line with the direction of the
current study although the other terms will be taken into consideration. Perseverance will therefore be operationalized as academic perseverance, which is a student’s tendency to complete schoolwork completely and on-time “… to the best of one’s ability despite distractions, obstacles, or level of challenge” (Farrington et al., 2012, p. 9). Both terms, perseverance and academic perseverance will be used interchangeably throughout the remainder of the study.

**Underlying Causes and Factors**

A review of the literature uncovered a number of potential factors or drivers resulting in a lack of development and support of student perseverance in high school mathematics classrooms. These factors related to both teachers and students individually, but also had a great amount of interplay between the various factors, for instance teachers’ choices of instructional practices impacting student beliefs. Those drivers impacting teachers’ decisions to implement instructional techniques designed to support perseverance in students will be discussed first, and then those influencing students’ acceptance of these classroom activities.

NCTM (2014) suggests that teachers’ choice of instructional practices that either support or hinder a student’s opportunity of working through productive struggle governs the level of perseverance being developed in mathematics classrooms. A teacher-centered learning environment where lecture or drill and kill techniques and students use algorithms taught by the teacher to complete all similar problems, will not provide students with the opportunity to flex their perseverance. On the other hand, the use of rich tasks where students can work collaboratively on problems that have multiple entry points and answers, give students the chance to persevere (Boaler, 2006). Henningsen
and Stein (1997) suggest that the selection of instructional practices is in turn driven by teachers’ acceptance of their role as a facilitator instead of the traditional knowledge distributor in the classroom. Teachers’ beliefs of learning mathematics and mathematics as a discipline can also impact classroom decisions (Cross, 2009). For instance, a teacher who believes that lower achieving students are not interested in learning was seen to develop a teacher-centered classroom environment as the most appropriate method for teaching these students (Cross, 2009). External factors such as the pressure to ensure good student results on high stakes tests also impact teachers’ decisions about instructional practices (Vogler & Burton, 2010). Teachers who feel the pressure of ensuring good results on these high stakes tests may utilize the drill and kill techniques in order to quickly guarantee students are prepared for the problems normally seen on the test.

While teachers’ beliefs impact their selection of instructional practices, students’ beliefs about mathematics can be linked to students’ acceptance of these practices in developing perseverance (Schoenfeld, 1989). Students, who hold beliefs that mathematics problems should be completed in a few minutes and obtaining a correct answer is the most important aspect of problem solving, do not understand why perseverance is necessary in mathematics (Schoenfeld, 1989). These students can push back against activities designed to support productive struggle by insisting their teacher offer greater assistance and direction (Henningsen & Stein, 1997). Students’ self-regulation and motivation also play a role in determining their actions to student-centered learning environments (Sussan & Son, 2004). A students’ self-control that allows them to stay focused and persist even when faced with difficulty or a more enjoyable activity (Sussan
& Son, 2004) is key for developing perseverance. Given the quantity and range of factors associated with the problem, it is not plausible that all underlying causes can be targeted. In order to determine the factors within the target high school most predominantly impacting the problem, a needs assessment was conducted.

**Needs Assessment Results**

A mixed methods study was conducted in the Spring of 2015 included surveying 10th, 11th, and 12th grade students (N = 41) (Bifulco, 2015). The purpose of this study was to determine the particular drivers impacting the lack of support and development of student perseverance within high school mathematics classrooms within the context, so that a directed intervention could be determined. Mathematics teachers (N = 10) were also surveyed using a different instrument to explore their choices of instructional practices and the factors that influence these choices. Convenience sampling techniques were employed during this study. The surveys completed by teachers included some open-ended questions focused on measuring their beliefs of mathematics and their perceptions of students’ levels of perseverance demonstrated in their classrooms. An interview with the mathematics supervisor, a key informant within the organization, was also conducted to offer insight on some of the findings (Bifulco, 2015). Student surveys included: the Attitude Towards Mathematics Inventory developed by Tapia and Marsh (2004) to measure students’ self-confidence, enjoyment, perceived value and motivation in doing mathematics (Chamberlin, 2010); the Short Grit Scale, developed by Duckworth and Quinn (2009) to determine participants’ level of perseverance; and eleven items from Schoenfeld’s (1989) survey instrument were also included to establish student beliefs and attitudes. Teacher surveys included questions from Vogler and Burton (2010) about their
PERSEVERANCE IN MATH CLASSROOMS

instructional practices and reasoning behind these practices. Open-ended questions completed by teachers focused on their perceptions of student levels of perseverance witnessed in the classroom, and groups of students they felt would benefit from perseverance development (Bifulco, 2015).

Students surveyed demonstrated relatively high perseverance \( M = 3.37 \) as measured using a five point Likert-type scale (Bifulco, 2015). However, mathematics teachers, the mathematics supervisor, and the literature all pointed to lower achieving students lacking and needing the development of perseverance (Lynch & Star, 2014; Schoenfeld, 1989). Student beliefs of mathematics had a mean of 2.47 on a scale of four and beliefs of the role of the teacher had a mean of 2.72. Both slightly higher than the middle of the scale, demonstrates that students have mixed feelings and beliefs about mathematics, seeing mathematics as a process and problem solving, while also holding beliefs of mathematics as memorization and procedural. The students also see the role of the teacher including aspects of an expert guide, but also as a traditional mathematics teacher whose task is to bestow knowledge on them. Moderate positive correlations were also seen between student beliefs about the role of the teacher and student motivation, perseverance of effort and confidence (Bifulco, 2015). This denotes that students who felt a teacher’s role was that of a dispenser of knowledge had lower perseverance.

The variable of students’ attributions of success or failure was determined using one item: ‘Some people are good at math and some just aren't’. The variable of student belief of determinant of success in mathematics had a mean of 1.59, a median of 1.00 and a standard deviation of 0.71 (Bifulco, 2015). This denotes that students believe quite strongly and consistently that achievement in mathematics is based on innate ability and
cannot be accomplished through effort and hard work. This type of fixed mindset has been shown to correlate to lower motivation and achievement, especially for lower achieving students (Blackwell et al., 2007).

Students and teachers understand the need for perseverance, motivation and confidence, but their beliefs about the learning of mathematics would not support the development of perseverance within the classroom. Student beliefs of mathematics lean more toward those associated with a traditional mathematics classroom where productive struggle is not emphasized. If teachers choose the reform-based practices that support productive struggle, students’ beliefs that they are not capable of success in mathematics could prevent them from fully engaging in the instructional activities. The students may feel that if innate ability determines success, there is no purpose in exerting effort and persevering through difficulty. The combination of a fixed mindset and beliefs that support a traditional mathematics classroom, would hinder students in fully accepting those reform based practices seen to develop perseverance within the mathematics classroom.

It becomes important then to first alter student beliefs of mathematics and learning. While all of these factors discussed are entwined, the foundation of student beliefs must be reinforced first to support later reforms. The focus of the current research was on changing student beliefs of intelligence and mathematics to increase perseverance in mathematics classrooms. A review of the literature was therefore undertaken to determine possible interventions to alter student beliefs of mathematics and learning in an effort to increase student perseverance in high school mathematics classrooms. First, the
criteria for inclusion and exclusion of articles within the literature review will be explained and the theoretical framework discussed.

Data Collection and Methods

General Approach

In order to identify and select relevant articles for this synthesis several steps were undertaken. Searches were conducted in various databases to locate applicable peer-reviewed articles including ERIC, JSTOR, Education Full Text, MathSciNet and PsycINFO. Articles were limited to the last ten years to ensure greatest relevancy.

Databases were explored using the following search terms: perseverance, grit, math*, education, teacher role, problem solving, intervention, math beliefs, developing productive struggle, attitudes towards mathematics, mindset and math dispositions.

Reference lists of articles obtained through these searches and Internet searches also resulted in some older, seminal and/or theoretical articles and studies.

Inclusion and Exclusion Criteria

All included articles had to be published in English and data had to be collected in the United States, Europe, Canada, Australia or New Zealand. Research must have been conducted in middle school, considered to be fifth through eighth grade, through college level students and/or teachers. High school level is the context of this investigation, and middle school and college level were deemed close in age and experience to high school. All research must have detailed their instrumentation and methodology in order to ensure rigor. If studies had used the same datasets only the study that used the most rigorous methodology was included.

Theoretical Framework
The social cognitive perspective creates a strong theoretical foundation for this work. Bandura (1986) explains how human behavior is in part guided by a person’s self-reflective capabilities where people will analyze their thoughts and actions. These metacognitive activities (Flavell, 1979) can lead to decisions about the amount of effort they put forth and “…how long to persevere in the face of disappointing results” (Bandura, 1986, p. 21). Within the social cognitive perspective a person’s behavior is determined by triadic reciprocal determinism (Bandura, 1986). Behavior, environmental and personal factors including cognitive aspects interact with varying influence determining a person’s behavior (Bandura, 1986). Bandura (1986) warns that beliefs can trigger defensive or avoidant behavior in individuals that can be difficult to correct through environmental factors. This behavior is counterintuitive to the concept of perseverance. An example of such beliefs of mathematics is that problems have only one correct answer and there is only one method to achieve this answer (Schoenfeld, 1992). One learns this method through a demonstration of a similar problem completed by a teacher (Schoenfeld, 1992). If a student believes that they do not know the method to solve the problem it will impact their behavior when faced with an option to quit or persevere. In other terms, if a student does not have a rule to complete a problem, why persist in trying to solve it?

Schunk and Richardson (2011) found that self-efficacy, a person’s perceptions or beliefs of what they are able to learn, predicts a student’s perseverance during problem solving. If a student feels like they are not intelligent enough to succeed in mathematics, their perseverance and motivation will be negatively impacted (Schunk & Richardson, 2011). Students will often see mistakes as an indication of their low intelligence, and
therefore Boaler (2013) contends that students should be given challenging work, such work designed to promote productive struggle, and in which mistakes will occur. If the risk of failure is determined to be too great by a student they may also resist even attempting a task (Alexander et al., 2009). Bransford et al. (2000) assert that learning must be student centered and teachers must acknowledge the impact of these student beliefs on their learning. Dweck and Leggett (1988) describe two patterns of behavior, the first being the ‘helpless’ response where the avoidance of difficulty and struggle results in lower achievement. The second is the ‘mastery-oriented’ pattern where an individual will persevere even when faced with failure and embrace difficulty (Dweck & Leggett, 1988). These patterns are connected to student beliefs of theories of intelligence such that those holding an entity theory of intelligence demonstrate a helpless response and a mastery-oriented response is seen within those holding an incremental theory of intelligence (Dweck & Leggett, 1988). An entity theory or fixed mindset is where a person believes their intelligence is set and unchanging (Dweck, 2015). The incremental theory or growth mindset is the belief that intelligence and the brain are malleable and therefore effort can enhance learning (Dweck, 2015). Neuroscience research has demonstrated that the plasticity of the brain, or its constant ability throughout life to change in learning, does imply that intelligence is indeed flexible (Hardiman, 2012).

**Review of the Literature**

Farrington et al. (2012) and Shechtman et al. (2013) suggest that there have not been a sufficient number of interventions that have focused on directly trying to develop perseverance in students, but have been concerned with changing student attitudes and beliefs to instill greater persistence in students. Altering student beliefs has been
attempted indirectly through the conversion to reform-based classrooms where students engage in problem solving and there is a greater focus on process. Problem solving stemming from the sociocultural theory and the work of Resnick (1987) and Gee (2008) includes students being able to use a variety of strategies and tools to solve non-routine problems or rich tasks where the method to solve may not be immediately clear (NCTM, 2014). Problem solving and the promotion of productive struggle are essential components of reform classrooms (NCTM, 2014). Students can balk at the necessity of this struggle as their beliefs of mathematics including that mathematics is procedural, problems should be completed quickly, and their role within the classroom is not one of active participant, do not justify a need for perseverance (Henningsen & Stein, 1997; Schoenfeld, 1989). Students’ beliefs about mathematics as a discipline and learning are developed through those sociomathematical norms practiced by teachers and students within the classroom (Cobb, Gresalfi, & Hodge, 2009). Sociomathematical norms are those which develop in the classroom where students understand what constitutes a valid mathematical argument and justification, a sophisticated answer versus a simple or incorrect one, and the mathematical difference between various answers (Yackel & Cobb, 1996). In an attempt to change students’ beliefs of mathematics as procedural and sociomathematical norms, researchers tested interventions focused on transforming traditional mathematics classrooms to ones in line with problem and discovery based reform classrooms.

**Converting to a Reform-Based Classroom**

Mason and Scrivani (2004) undertook an empirical study involving 86 fifth grade students in Northern Italy to determine the beliefs held by these students and if an
intervention to change a classroom into a problem based learning environment could alter these beliefs. Two classes engaged in 12 one hour and a half sessions over three months where rich tasks and problem solving were focused upon. The interspersed sessions dedicated to the intervention activities could be found more acceptable by teachers and may act as a type of scaffolding as they become accustomed to their, and the students’, changing roles within the classroom. A statistical analysis of pre and posttests demonstrated that the beliefs of students who engaged in the novel learning environment had evolved into those compatible with an inquiry mathematics practice while a control group did not (Mason & Scrivani, 2004). An additional variable not accounted for in the analysis develops from the second researcher actually conducting all the intervention sessions as the teachers declined this role (Mason & Scrivani, 2004). The impact of the researcher conducting the sessions instead of the normal classroom teachers cannot be determined. The teachers instead preferred to use the sessions as an opportunity to observe the modeling of appropriate facilitation and the role of the teacher within this new environment (Mason & Scrivani, 2004). Proper facilitation is essential to ensure the intended environment is developed in which to “support productive struggle in learning mathematics” (NCTM, 2014, p. 10). While the author’s decision to facilitate the intervention is understandable, teacher acceptance and participation is essential in designing a long-term solution with greater generalizability. The majority of current mathematics teachers within the focus high school underwent training on the use of rich tasks in classrooms a few years ago, so it is possible they would feel comfortable to facilitate a problem-based learning environment. However, current professional
development would be needed if such an intervention were to be attempted during the current study.

Hodges and Kim (2013) designed an intervention with the purpose of changing students’ attitudes toward mathematics in a college level algebra course. Attitudes were considered to be the students’ beliefs, feelings and motivation about and towards mathematics (Hodges & Kim, 2013). The study consisted of a small convenience sample where students were randomly assigned to either a treatment \((n = 22)\) or control \((n = 19)\) condition. The authors designed a video intervention, and pre and post-tests demonstrated there were statistically significant differences between the intervention and control groups’ attitudes toward mathematics (Hodges & Kim, 2013). These two interventions were completed with fifth grade students (Mason & Scrivani, 2004) and college students (Hodges & Kim, 2013), which may limit the level of implication for a high school context. The small samples within the two studies call into question the generalizability, but both demonstrated that it is possible to alter student beliefs through converting to an inquiry-based mathematics classroom (Mason & Scrivani, 2004) and a short video demonstrating the relevance of mathematics in life (Hodges & Kim, 2013). Modifying student beliefs to be more in line with a reform-based classroom would allow them to be more accepting of instructional practices shown to promote productive struggle, and therefore develop perseverance in mathematics.

Becker (2012) conducted a mixed methods study within a central Texas high school to determine if the Advancement Via Individual Determination (AVID) program impacted students’ beliefs of intelligence and which practices of the program resulted in these changes. AVID is a national program in which students who are not obtaining their
PERSEVERANCE IN MATH CLASSROOMS

potential can voluntarily participate. The program includes students’ enrollment in college preparatory level courses, an AVID class which focuses on writing and problem solving strategies, tutoring, and various other supports (Becker, 2012). Dweck’s (1999) perception of intelligence instrument was utilized to determine the mindsets of 54 AVID students and 43 non-AVID students within the school. The control group was comprised of students demographically similar to those students sampled within AVID (Becker, 2012). Descriptive statistics and analyses of variance were completed to determine if there were any differences between AVID students and the comparison group. An ANOVA was also used to determine if AVID students’ mindsets who had been within the program at least two years differed from the control group (Becker, 2012). Within the embedded sequential design this quantitative data was then utilized to determine which AVID students demonstrated a growth mindset (Becker, 2012). These participants then completed an additional qualitative section to determine if any influences connected with the AVID program were the reasons for this growth mindset (Becker, 2012).

The quantitative analysis showed no statistically significant difference between the mindsets of AVID and non-AVID students (Becker, 2012). However, Becker (2012) claims that qualitative results indicate students within the AVID program feel that some part of the curriculum had aided in developing a growth mindset. A theme seen within the responses to open ended questions was students’ increased understanding of the benefits of rigor in their academic career and the benefits of putting in more effort. Both of these messages are associated with Dweck’s (2015) definition of a growth mindset. Becker (2012) notes that there is no particular element within the AVID curriculum that teaches about the growth mindset, but the messages being received by students are aligned with
Dweck’s theories of fixed versus growth mindsets. The conflicting results from the qualitative and quantitative strands make it difficult to understand the true impact of the program on students’ mindsets. These findings suggest that while a program could logically change students’ beliefs of intelligence implicitly through the use of collaborative problem solving in class, students may need explicit instruction on theories of intelligence.

Schunk and Richardson (2011) suggest that changing the practices and sociomathematical norms in a classroom will begin to alter student beliefs, but it is also important to ensure that students understand the need and benefit of effort in learning. While the mathematics research community has become increasingly aware of the role of beliefs in the learning of mathematics (Leder et al., 2002), collaboration with psychologists has resulted in the use of mindset interventions to alter students’ beliefs of the process of learning and their attributions of success and failure (Boaler, 2013; Dweck, 2015).

**Mindset Interventions**

Mindset interventions within education are becoming more popular as students’ beliefs have been shown to have a significant impact on their performance and achievement (Leder & Forgasz, 2002). For instance, Blackwell et al. (2007) found students holding an incremental theory of intelligence tended to have a positive trajectory in mathematics achievement during middle school, while students with an entity theory predicted a horizontal path in achievement. Initial investigations of the impact of mindset interventions developed through a desire to reduce the effect of stereotype threat on students’ achievement. Steele and Aronson (1995) suggest people can experience
stereotype threat when they feel they may confirm a negative stereotype about a group of people that they are associated with. Stereotype threat has been seen to negatively impact test score performance (Steele & Aronson, 1995).

Aronson, Fried, and Good (2002) created a pen pal program for 79 black and white undergraduate students at Stanford University. One-third of these students were told they needed to write letters to at risk middle school students and ensure that the students understood that intelligence is expandable (Aronson et al., 2002). Another third wrote the letters but were instructed to advise students of the different types of intelligence- if they are not good at one thing, they will most likely be good at another- while the last third acted as a control condition and did not participate at all in the pen pal program (Aronson et al., 2002). The two groups acting as pen pals completed their tasks within three one-hour sessions. Students within the growth mindset pen pal condition created and advocated a change in their own thinking of intelligence (Aronson et al., 2002). Surveys to determine pre and post intervention beliefs about the malleability of intelligence were completed and demonstrated that participants within the pen pal condition did embrace beliefs more in line with a growth mindset after the intervention. Approximately five weeks after the end of the intervention participants completed a phone interview where they verbally answered the same Likert scale questions on intelligence and some other questions on enjoyment of academics and their experiences with stereotype threat (Aronson et al., 2002). Transcripts were obtained from the registrar at the end of the semester as a measure of academic achievement (Aronson et al., 2002). Post-test results included higher grades and increases in self-proclaimed enjoyment of academics within students within the treatment condition compared to those students in
the control condition (Aronson et al., 2002). This impact was seen in all students within the condition, not just those at risk for stereotype threat (Aronson et al., 2002). These findings are important for the current research project as they demonstrate that student beliefs can be altered. The researchers stressed the importance of ensuring that students had the chance to not only learn the material, but also to embrace these beliefs, taking them on as their own. The participants within Aronson et al.’s (2002) study had this opportunity by mentoring younger children on a growth mindset, and while this exact activity may not be possible within the current study, time needs to be provided to allow participants to truly infuse a growth mindset within their current beliefs.

In a similar study, Good, Aronson, and Inzlicht (2003) analyzed the impact of a mentoring program that encouraged an incremental view of intelligence in seventh grade students prone to stereotype threat on academic achievement. One-hundred and thirty-eight students were provided with college mentors who taught one of four conditions: (a) an incremental view of intelligence; (b) the idea that an adversity can be overcome; (c) a combination of the first two conditions; or (d) the effect of drug use (Good et al., 2003). The fourth condition acted as the control condition (Good et al., 2003). Participants were mentored throughout the school year through two face-to-face meetings and in between through email communication. Participants created webpages to aid in their deep understanding of the content the mentors were teaching them (Good et al., 2003). A quantitative analysis was conducted on achievement based on student reading and mathematics scores on the Texas standardized assessment demonstrated that students within all three conditions outperforming students from the control group (Good et al., 2003). This is an important finding when deciding which mindset message to focus on.
during the present research. Combining interventions does not have a greater impact on student achievement and therefore to limit the complexity of the current study it would be best to choose one mindset message to focus upon. These initial studies demonstrated that the benefits of instilling a growth mindset in students are not limited to those at risk for stereotype threat (Aronson et al., 2002; Good et al., 2003). This is also important, as the all participants within the current study will not be minorities prone to stereotype threat.

Designed without the intention of combating stereotype threat, Blackwell et al. (2007) studied the impact of introducing an incremental theory of intelligence to seventh grade students on mathematics achievement. The second in a two-part study introduced an intervention conducted over eight weeks, 25 minutes each week, with 99 seventh grade students in a public school in New York City (Blackwell et al., 2007). Sixteen undergraduate students were recruited and trained to conduct the intervention sessions. The intervention consisted of lessons on brain plasticity, incremental theory, and the negative impact of stereotypes through readings, activities and discussions. The control group completed all the same lessons, except they exchanged the material on incremental theory of intelligence for general information on memory (Blackwell et al., 2007). Pre and post surveys were used to determine student beliefs of intelligence, with additional questions in the post survey to determine student comprehension of the content within the sessions (Blackwell et al., 2007). Through the use of a 2 by 2 ANOVA, the authors found a significant change in the students’ beliefs within the experimental group to more closely coincide with an incremental theory of learning compared to the control group (Blackwell et al., 2007). A qualitative analysis of teacher responses to their perceptions about changes in students’ motivation showed teachers cited 27% of students within the
treatment condition had showed positive change while only 9% of the students within the control condition had demonstrated this change. An analysis of the trajectory of grades in mathematics from 6th grade through and after the intervention was utilized and the authors found the negative trajectory of grades commonly seen during a transition from elementary to middle school, was halted for the treatment but not control group (Blackwell et al., 2007). This is a significant study, which subsequent projects pulled methodology, analysis and content from. The detail in which the intervention sessions and instrumentation were designed provides a strong foundation for future research such as the current project to continue and expand their findings.

Yeager and colleagues (2014) completed several studies focusing on the use of a self-transcendent purpose for learning or sense-of-purpose instead of an incremental theory of learning. Sense-of-purpose is when students are motivated to accomplish goals in order to obtain some benefit for themselves, but also to have an impact on the wider world (Yeager et al., 2014). The authors theorized the intervention would improve students’ achievement through promoting self-regulation particularly in subjects normally found to be tedious by students. The first study included 1,364 twelfth grade students from 17 urban high schools who all completed an online survey on their motivation, sense of meaningfulness in school, grit, and self-control (Yeager et al., 2014). Participants also completed a diligence task online where they were given the option of completing some arithmetic problems or watching a short video or playing a game. The authors then examined correlations between these constructs and student persistence after the fall semester of their first year of college (Yeager et al., 2014). It was observed that a self-transcendent view within high school seniors was moderately positively correlated to
both greater persistence on a task and self-regulation (Yeager et al., 2014). The second study included conducting a purpose for learning intervention with 338 ninth grade high school students within a suburban district. The materials were delivered to students through one online session that took approximately 20 to 30 minutes to complete. It was determined that the intervention impacted achievement as measured by GPAs in STEM courses several months after the intervention was completed with participants (Yeager et al., 2014). Like Aronson et al.’s (2002) study, participants were blind to the true purpose of the intervention (Yeager et al., 2014). Control groups and verified instruments greatly increase the validity of the research, but while the authors assert the first study was conducted within urban school districts, 99% of the sample related that they were planning on going to college (Yeager et al., 2014). It seems plausible that the selection of eight out of the ten schools being charter schools, did not allow for similar characteristics to typical urban school districts and therefore limits the generalizability of their results.

While both Good et al. (2003) and Blackwell et al. (2007) demonstrated that mindset interventions could positively impact student beliefs and demonstrated levels of achievement, Paunesku et al. (2015) attempted to determine if such an intervention could be scaled-up to have the greatest widespread effect. The investigation included 13 high schools, about 1,500 students and the use of a growth mindset intervention similar to that used by Blackwell et al. (2007) and Good et al. (2003), but material was covered during two 45-minute online sessions (Paunesku et al., 2015). The second intervention tested was the sense-of-purpose intervention seen within Yeager et al.’s (2014) study, with the third then being a combination of these two interventions (Paunesku et al., 2015). Linear regressions analysis indicated that the intervention had a statistically significant positive
PERSEVERANCE IN MATH CLASSROOMS

effect on students at risk for dropping out of high school (Paunesku et al., 2015). At-risk students who completed the intervention showed a significant increase in successfully completing courses compared to the control group (Paunesku et al., 2015). The geographically and socioeconomically diverse sample provides greater evidence that mindset interventions can be successful in a wide range of schools. The use of technology does not weaken the effect of the intervention (Paunesku et al., 2015; Yeager et al., 2014), and could allow for a more economical solution to the problem of altering students’ beliefs of learning and intelligence.

The studies surprisingly discovered that combining the growth mindset condition and the sense of purpose condition did not increase the positive impacts (Blackwell et al., 2007; Good et al., 2003; Paunesku et al., 2015). Paunesku et al. (2015) suggested that this could be due to the two theories not being clearly interwoven in the intervention. It seems plausible as well that perhaps the students receiving adult guidance in the form of the intervention, are now working within their zone of proximal development (Vygotsky, 1978) and therefore the combined condition is offering additional scaffolding that the student cannot make use of. Especially within subjects such as mathematics where content is continually based on previous material, while a combined intervention may promote greater motivation and effort, academic gains may be limited by the lack of understanding of previous mathematics content. The effect of mindset interventions on academic achievement may be bounded by additional variables and conditions, such as a student’s understanding of prior material.

While results of mindset interventions have been overall positive, the sustainability of their impact on student beliefs and achievement is unclear (Blackwell et
al., 2007). Donohoe, Topping, and Hannah (2012) attempted to determine if the Brainology online intervention designed by Dweck and Blackwell could provide lasting changes to students’ beliefs and resiliency. A sequential explanatory mixed methods design was carried out in a large secondary high school in Scotland with 33 students equivalent to grade seven in the United States (Donohoe et al., 2012). Participants consisted of one class of middle set English students who received the treatment ($n = 18$) and a second class ($n = 15$) who acted as the control condition (Donohoe et al., 2012). All participants completed a survey to evaluate their theories of intelligence and their resiliency using verified measures and six students from the treatment condition were randomly selected to participate in a focus group. The treatment group completed four sessions of the online Brainology program lasting approximately 40 minutes each (Donohoe et al., 2012). Fidelity of implementation was assessed using videotaped sessions and as the researcher who was also the teacher of the treatment class, discussions were posed at the beginning of each session to determine students’ comprehension of material (Donohoe et al., 2012). All participants completed the post-intervention survey and another focus group was completed with the same students. A follow-up was completed three months after the intervention to determine the sustainability of the messages received in the intervention. A statistically significant increase was seen in the intervention group’s theories of intelligence, absent in the control condition, however no change was seen in the participant’ resiliency from pre to post test (Donohoe et al., 2012). Follow-up data then demonstrated that students had reverted to previous mindsets within the space of three months (Donohoe et al., 2012). Exam performance a year later of both
treatment and comparison groups showed no significant difference between the two groups (Donohoe et al., 2012).

Resiliency is considered a synonym of perseverance, although the conceptualization of perseverance discussed here is slightly different than resiliency, which is concerned with how students recover with traumatic events (Donohoe et al., 2012). The similarities between the two constructs of perseverance and resiliency make the lack of impact on resiliency within this study worrisome, however this could be due to the instruments utilized in measuring resiliency. The authors utilized a self-reported measure to determine students’ resiliency (Donohoe et al., 2012), the results of which can be questioned due to individuals’ difficulties with accurately assessing themselves (Bénabou & Tirole, 2002). The use of informant reports and a self-reporting measure for the current study will increase the reliability of measurements of students’ academic perseverance (Farrington et al., 2012). The follow-up finding that students had reverted back to their previous beliefs of intelligence is significant for the current study. Although not plausible for the current study, an extension of the current investigation could include a follow-up a year later to determine if participants’ views of intelligence had changed back to previous beliefs.

The various studies discussed here have demonstrated that student beliefs of intelligence are malleable (Blackwell et al., 2007; Good et al., 2003; Paunesku et al., 2015), however this last study questions the sustainability of these new ideas (Donohoe et al., 2012). This is a concern that Dweck (2015) herself has raised. Growth mindset and its associated messages have now been seen in mainstream through the publishing of Carol Dweck’s books. Mindsets including the growth mindset are described as an essential
element of personalized learning and it is suggested that students are taught about how
the brain functions and how learning occurs (Zmuda, Curtis, & Ullman, 2015).
Personalized learning has become a focus within the school district of interest through the
leadership of a new superintendent. Yeager and Walton (2011) warn that social-
psychological interventions can be powerful, but are dependent on the context and
environment in which they are delivered. Bandura (1986) also stresses the importance of
the role of environmental factors in student behavior within the social cognitive
perspective. Zmuda et al. (2015) discuss how mindset interventions are only one singular
cog in the network that needs to be in place in order for the impact of reform on student
achievement to be seen. These interventions are not a replacement of educational
reforms, but will serve to make the changes occurring within education more effective
(Yeager & Walton, 2011).

Validated instruments developed by leaders within the field of mindset
interventions such as Dweck (1999) were utilized in several of the mindset interventions
(Blackwell et al., 2007; Paunesku et al., 2015). All of the mindset intervention studies
discussed here also included the use of control or comparison groups, greatly increasing
the statistical validity of their results (Creswell & Plano Clark, 2011). However, the
interventions utilized different measures of academic achievement including mathematics
grades (Blackwell et al., 2007), student scores on standardized tests (Good et al., 2003),
and student GPA (Yeager et al., 2014). So while many of these studies demonstrated that
mindset interventions increased student achievement, comparing the advantageousness of
the various protocols becomes difficult given that the same instruments were not used to
evaluate the same constructs.
PERSEVERANCE IN MATH CLASSROOMS

The studies also demonstrated that mindset interventions can be implemented within a variety of grade levels and socioeconomic distributions within schools, and clearly demonstrate that the ability to alter student beliefs about mathematics and learning is plausible (Blackwell et al., 2007; Paunesku et al., 2015). Paunesku et al.’s (2015) study also saw that mindset interventions are scalable through the use of an online medium to allow for an impact on a large population. An online medium was still a valid means to teach students about the brain and mindset interventions (Paunesku et al., 2015).

Proposed Intervention

Development of reform-based mathematics classrooms (Boaler, 2006; Hodges & Kim, 2013; Mason & Scrivani, 2004) and mindset interventions (Aronson et al., 2002; Blackwell et al., 2007; Donohoe et al., 2012; Paunesku et al., 2015; Yeager et al., 2014) offer two paths for a proposed intervention. This study will focus on a mindset intervention due to the stronger methodology and greater transparency of methods and specific activities utilized within the literature, instead of attempting to alter the sociomathematical norms of mathematics classrooms. Time and resource restrictions also make a mindset intervention more plausible within the context. The conversion into a reform-based classroom would require teacher professional development (NCTM, 2014), increasing time needed and cost of such an intervention. The convenience and low cost of a mindset intervention adds to the perceived advantageousness of the intervention, which would increase the rate of diffusion (Rogers, 2003).

Mindset interventions discussed in the literature include growth (Blackwell et al., 2007; Good et al., 2003), sense of purpose (Yeager et al., 2014), or combinations of the two (Paunesku et al., 2015). Given that the combination of interventions did not increase
impact on students’ academic achievement (Blackwell et al., 2007; Good et al., 2003; Paunesku et al., 2015), and considering the time and cost restrictions, the selection of one mindset intervention to focus upon within the context is reasonable. The needs assessment demonstrated that students hold strong fixed mindset beliefs where they believe achievement in mathematics is based on innate ability and cannot be accomplished through hard work and effort (Bifulco, 2015). Students’ perseverance is negatively impacted by beliefs that they are not intelligent enough to succeed in mathematics (Schunk & Richardson, 2011). It is also important to note that a range of resources are available to aid students in developing a growth mindset through Carol Dweck’s website (https://www.mindsetworks.com) as well as Stanford’s Mindset Kit (https://www.mindsetkit.org/), and Jo Boaler’s site through Stanford University which focuses more on the implications of a growth mindset in mathematics (https://www.youcubed.org). Therefore, a growth mindset intervention will be conducted within the focus high school.

The two main mediums through which the mindset interventions were carried out within the literature is through direct delivery by an instructor (Blackwell et al., 2007; Good et al., 2003) and via online delivery (Paunesku et al., 2015; Yeager et al., 2014). Yeager and Walton (2011) warn that changes in the delivery of an intervention, even when trying to maintain the main theoretical messages can drastically change the impacts. One possible concern within this study is the fidelity of implementation of teachers who conduct the intervention as it has been shown that teachers will not always institute reforms as intended within the classroom (Tyack & Cuban, 1995). This is an important consideration when determining if the intervention should be conducted by an
individual or administered to students through an online medium. Participant completion of the intervention through an online medium may increase fidelity of implementation, as teachers would only need to monitor the intervention instead of directly facilitate sessions. Other conditions such as classroom management may also impact implementation fidelity and the success of the intervention (Yeager & Walton, 2011). Technology requirements of conducting the intervention online would not be a concern within the context. All students within the school are given a Chromebook and the school uses the Learning Management System (LMS) Canvas, which can be used as the platform for the intervention. Taking this into consideration and given the existing infrastructure of the school and the timetable of the researcher, the completion of the intervention through the online platform Canvas will be conducted.

There is also now the question of what population of students will participate within the study. Blackwell et al. (2007) noted the importance of completing mindset interventions with students who were undergoing a transition such as ninth grade students moving into high school. Teachers within the focus school and the literature (Ader, 2013; Cross, 2009; Lynch & Star, 2014) pointed to lower achieving students needing the development of perseverance. Ninth grade students within the focus school whose mathematical skills are two or more grade levels below are enrolled in an Instructional Seminar class during their freshmen year to allow for additional support throughout the year. This population would meet both of these criteria of undergoing a transition to a new educational institution and historically underachieving in mathematics, and will therefore be the population considered here. Being that these students would be enrolled in the Instructional Seminar class, it would also offer a good time in which students can
complete the intervention. The teachers would not oppose the intervention, as they would not be concerned about losing instructional time.

A variety of stakeholders will be involved including ninth grade mathematics teachers who will monitor students as they complete the intervention, school administration whom must approve the intervention, and a local nonprofit organization who are partially funding the research. Strong leadership in delivering the vision to these stakeholders and the school will be very important. Depending on the results of an intervention, a school-wide diffusion could be considered. Success of such an implementation would depend on the support of stakeholders, particularly teachers, administration and parents. It will be important to consider these various groups as well as the individual to ensure the widespread acceptance and shared vision (Onorato, 2013). A transformational leadership perspective becomes a strong asset within an educational context in creating a vision that staff can support and take on as their own (Warrick, 2011). Ensuring this shared vision can also help in the short-term to ensure greater fidelity to the intervention program by teachers of the Instructional Seminar course who will monitor student progress of the intervention in class.

This chapter reviewed the pertinent research on possible interventions to alter student and teachers’ beliefs of learning and mathematics to impact students’ academic perseverance in mathematics classrooms. The selection of a growth-mindset intervention has been explained. The next chapter will explain the intervention in further detail and outline the methodology and design to evaluate the process and outcomes of the program.
Several plausible interventions exist which could possibly aid in the development and support of perseverance in high school mathematics classrooms. In the last chapter, a discussion of these programs and the particulars of the context led to the selection of a growth-mindset intervention for this study. The intervention was conducted with ninth grade students who have historically underachieved in mathematics. Participants completed the growth mindset intervention through an online medium during their Instructional Seminar course. This trial study conducted within these classes provides for increased observability of the innovation, which would hopefully aid in the diffusion process upon success of the initial intervention (Rogers, 2003). This chapter provides a detailed description of the intervention, and the research design and methodology, including data collection and analysis. The design of a study should be selected to ensure that the researcher will be able to persuasively answer the research questions. Therefore, the purpose and research questions of the current study will be articulated first.

**Purpose and Research Questions**

The purpose of this study was to determine the impact of a growth mindset intervention on students’ beliefs of learning and intelligence, students’ beliefs of mathematics, and students’ academic perseverance within high school mathematics classrooms. A mindset intervention within the focus high school would also extend the current literature as none of note have investigated the impact of mindset interventions on student perseverance within mathematics classrooms. To guide the study the following research and evaluation questions were designed. These questions are an outgrowth of the
needs assessment and therefore are different than the original research questions designed to guide the intervention.

1. Is at least 80% of the intervention implemented as planned?
2. Do at least 80% of eligible participants complete at least 80% of the activities designed within the mindset intervention?
3. What is the difference in underachieving students’ theories of intelligence between those who participated in the growth mindset intervention and the comparison group?
4. What is the difference in underachieving students’ beliefs of mathematics between those who participated in the growth mindset intervention and the comparison group?
5. What is the difference in underachieving students’ academic perseverance between those who participated in the growth mindset intervention and the comparison group?

These questions served to evaluate implementation fidelity and process, as well as outcomes of the intervention. It is important to determine if students are obtaining the experiences planned within the intervention and actively engaging in these activities, leading to changes in the participants’ mindsets. The last research question then speaks directly to the goal of increasing student perseverance in mathematics classrooms through changes in student beliefs. While previous studies have demonstrated there is an impact on academic achievement of students, this long-term outcome will not be considered in the current study to limit the breadth of the research and allow for a thorough examination of the medium and short-term outcomes.

The collection of both qualitative and quantitative data will allow a thorough examination of the impact of the intervention on students’ academic perseverance. Perseverance can be difficult to measure and while self-report measures can be the easiest
to complete, it may not quantify a students’ academic perseverance accurately, therefore informant reports of students’ perseverance resulting in qualitative data can allow for a more accurate account of students’ perseverance (Shechtman et al., 2013). This methodology was utilized within the current study with mathematics teachers completing informant reports on students’ academic perseverance. To best achieve the answer to the research questions employed, an embedded convergent mixed methods design has been selected and employed for the current study (Creswell & Plano Clark, 2011). A mixed methods approach was chosen because a single quantitative strand would not provide the information and context sought to adequately answer the research questions as developed.

Clarification of Terms

The operationalization of perseverance as academic perseverance has been discussed previously, but the explanation of a few more terms is needed. Students’ beliefs of mathematics within the current study will focus on students’ perceptions of the role of effort and mistakes in learning mathematics. It looks at students’ beliefs of what determines success in mathematics: for instance the dependence of their parents’ success in mathematics on their own and how much time is required for this success (Schoenfeld, 1989). It includes students’ beliefs of whether success in mathematics is choosing the correct equation or a correct strategy to go about solving a problem. Intelligence is a students’ ability to learn and apply new information. Their beliefs of intelligence are then the students’ perceptions of their potential to learn or not learn material (Dweck, 2015).

Research Design
A logic model was constructed to demonstrate the reasoning behind the plan of the intervention and to aid in the design of both the process and outcomes evaluation. The logic model is seen in Figure 4.1 and discussed below.

Figure 4.1. Logic model of mindset intervention.

**Inputs**

The supervisor of mathematics, principal and other administrators within the district have been kept appraised of the research and results of the needs assessment, and their continued support through the planning and implementation of the intervention was expected. This will be important as approvals and resources will be needed. Canvas
(LMS) was adopted by the school and was utilized to bring the intervention to students in an online environment. The freshmen mathematics teachers employ various techniques to provide extra support to the students and their enthusiastic help was expected during the intervention. Resources used within similar interventions are available in the construction of session activities (Blackwell et al., 2007; Good et al., 2003; Paunesku et al., 2015). These resources can be acquired freely although some financial support is necessary for supplies such as copies and materials for posters. A fellowship was awarded to the researcher to support this study by a non-profit foundation, which provides funding to the school district in which the focus school resides.

**Activities**

High school freshmen students who historically had lower mathematics achievement are automatically enrolled in an Instructional Seminar class in addition to their normal mathematics course to offer supplementary support. Students’ mathematics achievement and skill levels are evaluated the summer before entering their freshmen year in the high school and enrolled as necessary for September. They will remain enrolled at least one semester, perhaps the entire year depending on their progress within their mathematics course. These students served as the participants within the intervention. There are four Instructional Seminar classes. The school’s one-to-one Chromebook program and the Canvas LMS allowed for ease in constructing the intervention sessions online and determining students’ engagement in the intervention.

Activities conducted within intervention sessions with students were drawn from past research (Blackwell et al., 2007; Good et al., 2003; Paunesku et al., 2015). This includes the main messages of the intervention, articles participants read, and endeavors
participants engaged in to learn the neuroscience foundation, the growth mindset itself, and began to assimilate these beliefs with their own. A lesson on the structure and functioning of the brain including plasticity was completed first. This included students reading an article on neuroscience research that details the potential of effort in learning as well as watching a video on similar information. Materials have been procured from similar studies (Blackwell et al., 2007; Good et al., 2003; Paunesku et al., 2015) as these resources have been tested to ensure a suitable level of complexity for the students. A class discussion was conducted on an online discussion board through the Canvas LMS. The main message throughout this first lesson was that learning occurs through mistakes and difficulty (Blackwell et al., 2007). During the second session students were arranged into small groups and completed a growth versus fixed mindset poster. The third and final session focused on beliefs of learning mathematics in conjunction with the growth mindset, such as misconceptions about how long a mathematics problem should take and the importance of process over getting the correct answer (Schoenfeld, 1989). Participants within the comparison condition did not complete any of the intervention activities.

The researcher went into the Canvas LMS after each intervention session to monitor student progress, understanding, and engagement in spot checks. Participants submitted elements such as discussion posts and projects each session through the Canvas LMS. Monitoring the online elements allowed the researcher to ensure that students were engaged and understanding the intervention content. This also allowed the researcher to take measures if an element of the intervention was not working properly or a participant was not completing the activities as planned.
PERSEVERANCE IN MATH CLASSROOMS

Outputs

Discussions, integration of the arts and other activities planned within the lessons will aid in maintaining students’ attention and engagement in the intervention sessions (Hardiman, 2012). The inclusion of a multi-tiered incentive structure seen in the logic model was deemed necessary, as a low participation rate within the needs assessment has demonstrated that additional incentives are crucial (Bifulco, 2015). Students were given incentives of candy and a pizza party to offer additional motivation to complete all sessions and activities.

Outcomes

Study participants engaged in the intervention activities previously described. These activities were designed to lead to short term outcomes seen in the logic model including students’ greater understanding of the malleability of intelligence and a growth mindset (Dweck, 1999). While beliefs can be difficult to change (Leder et al., 2002), these changes in beliefs have been an identified outcome in similar studies completed in approximately the same amount of time (Blackwell et al., 2007; Aronson et al., 2002). Intervention activities can also lead students’ beliefs of mathematics to shift to those aligned with a reform-based classroom. As noted, previous studies have not included the possibility of altering students’ mathematics beliefs within mindset interventions.

Hardiman (2012) explains how current research of the brain shows that learning is stronger when an individual faces and overcomes difficulty. While mathematics instruction has begun to focus on the creation of productive struggle within the classroom (NCTM, 2014), this struggle can be difficult for teachers to utilize when students do not acknowledge the need or desire to persist through their difficulties. Bransford et al.
PERSEVERANCE IN MATH CLASSROOMS

(2000) note that some learners are concerned about making mistakes. Students and teachers were also seen to become very preoccupied in some cases with finding the answer instead of ensuring a deep conceptual understanding of the topic (Henningsen & Stein, 1997). Students within the focus high school feel that a mathematics problem should be completed within three minutes. Activities within the intervention such as the Crumpled Reminder, which aids students in understanding the growth that occurs in your brain through those mistakes, addressed these beliefs. Several of the activities conducted during the intervention will address the specific fixed mindset beliefs common in mathematics. These beliefs include those that suggest that problems should be completed quickly and the correct answer is more important than a correct process (Schoenfeld, 1989).

These changes in beliefs of learning and mathematics can lead to increased perseverance in mathematics classrooms. Blackwell et al. (2007) asked teachers to comment on changes in the participants’ motivation and attitude, and discovered positive effects on student persistence. Social cognitive theory also supports the anticipated increase in student perseverance. Bandura (1986) insists that students with stronger beliefs that they are able to succeed will persevere. A mindset intervention teaches students that success is possible with effort and hard work (Dweck, 1999). Persistence can be abandoned and learning can be resisted when students perceive the probability of success as small (Alexander et al., 2009). Schunk and Richardson (2011) declare that students need to believe that they are capable of success and therefore will have the confidence to take part and persist in mathematical problem solving. The activities within
PERSEVERANCE IN MATH CLASSROOMS

this intervention assured students that they are capable of learning in mathematics and
effort cannot be discounted when calculating the likelihood of success.

These shifts in beliefs and increased perseverance then lead to the long-term
impact of increased school achievement, which has been seen in other studies (Good et
al., 2003; Paunesku et al., 2015). However, the time restrictions of the current study did
not permit the evaluation of this long-term outcome. This could be an interesting
extension of the study and explored in future research.

Process Evaluation

Fidelity of implementation can be conceptualized as an efficacy or effectiveness
study, both of which are important to conduct when evaluating an intervention
(O’Donnell, 2008). Mindset interventions similar to the intervention conducted within
this study have already undergone various efficacy studies (Blackwell et al., 2007; Good
et al., 2003; Yeager et al., 2014). The current study will be considered an effectiveness
study to further add to the research of the generalizability of mindset interventions
(O’Donnell, 2008). The fact that four separate teachers acted as implementing staff, made
it necessary to measure adherence and quality of delivery of the intervention. The study
then relates program outcomes to differences in fidelity levels within each of the
implementing classrooms (O’Donnell, 2008). Intervention fidelity will be considered
“…the extent to which an intervention’s core components have been delivered as
prescribed and differentiated from the comparison condition” (Nelson, Cordray,
Hulleman, Darrow, & Sommer, 2008, p. 375). It is plausible that some core components
of the treatment can appear in the comparison condition, perhaps through existing
practices of the implementing teacher. Fidelity will, therefore, include assessing the differentiation between treatment and comparison conditions (Nelson et al., 2008).

The causal processes denoted within the theory of treatment, as seen in Figure 4.2, depict the core components of the growth mindset intervention, which will mediate the intermediate outcomes of students’ beliefs of the malleability of intelligence, and mathematics and learning. These core components differentiated the treatment condition from the comparison condition. As an effectiveness study, fidelity of implementation will focus on measures of variations of fidelity between the four treatment classrooms (O’Donnell, 2008). Rogers (2003) explains how some adaptation should be anticipated during diffusion of an innovation and, therefore, the current focus was on determining the optimal mix of fidelity and adaptation that can result in the most positive outcomes (Holliday, 2014).

Figure 4.2. Theory of treatment for proposed growth-mindset intervention.

Durlak and DuPre (2008) showed there is no standard level for high or low fidelity but is context specific and assert that 100% fidelity is impossible within any field experiment. However, a relatively high level of fidelity was plausible within the current study given the online medium used to deliver the intervention, which ensured a highly
structured intervention (Durlak & DuPre, 2008). Given the importance of ensuring the key components of the intervention are delivered high fidelity will be considered to be 80% or greater. This was considered the level of adequate fidelity, essential for outcomes to be obtained.

**Outcome Evaluation**

A mixed methods quasi-experimental approach was utilized to determine treatment effects through a regression discontinuity design (Shadish, Cook, & Campbell, 2002). Under the regression discontinuity design students’ scores of a predetermined assignment or forcing variable decides units’, in the current study individuals, assignment to either the treatment or comparison condition (Schochet et al., 2010). The assignment variable is a pre-chosen variable, a certain value of which determines participants’ assignment to conditions (Schochet et al., 2010). This predetermined value of the assignment variable is referred to as the cut-score or cutoff score, and if strictly adhered to eliminates selection bias (Schochet et al., 2010; Trochim, 1984). Within the current study, a score higher than the cutoff score assigned participants to the comparison condition, while participants with scores lower than the cutoff score will be assigned to the treatment condition. A treatment effect, if one exists, is seen within the discontinuity of the graph at the cutoff score (Shadish et al., 2002). Pre and post-tests were completed with both treatment and comparison conditions to measure changes in students’ theories of intelligence and academic perseverance.

While single nonequivalent groups will be used, the model takes this into account since assignment is based on the cutoff score and the pretest measure will be accounted for (Trochim, 1984). This is a strength of the RD design. Approximately 50 to 60
students were asked to participate within the treatment condition. A 1:1 ratio of participants in treatment and comparison groups increases power (Shadish et al., 2002) and also aid in modeling the regression (Smith, 2014). Regression discontinuity (RD) designs are considered very strong and the best alternative to random assignment designs (Henry, 2010). While elements of randomization are possible to embed within an RD design (Shadish et al., 2002), this was not plausible within the current study due to stakeholder concerns. A qualitative strand was embedded within this typically quantitative design.

**Strengths and limitations of the design.** Other possible designs considered for the current study included random assignment but it was determined to not be plausible for the current iteration of the study. Stakeholders including administration and the foundation financially supporting the research would like to see all students given the opportunity to participate in the intervention who could benefit from the treatment. This is a common concern with randomization in education research (Shadish et al., 2002). A value-added design adjusted for additional covariates (Henry, 2010) was considered for the current study, however selection bias and a smaller sample size would have limited the statistical power and as a result decreased the probability that statistical significance might be detected. One out of the four IS classes would have been selected to act as a comparison group, as stakeholders were not open to the idea of control groups, and would only consent to one class acting as the comparison. The choice of the regression discontinuity (RD) design allowed all four sections of IS to engage in the treatment condition, which is what stakeholders wanted. Selecting students for the comparison condition who were greater than the cut-score, also doubled the sample size and allowed
PERSEVERANCE IN MATH CLASSROOMS

a 1:1 ratio between the number of participants within the treatment and comparison conditions, increasing statistical power (Shadish et al., 2002).

While still considered quasi-experimental, the RD design comes close to testing the counterfactual condition given the assumption that students near the cut-point will have very similar characteristics (Flaster & DesJardins, 2014). A threat to internal validity is regression to the mean since participants will be lower achieving students (Shadish et al., 2002). The plausibility of this threat is minimized with the use of an RD design since the researcher attempted to find a discontinuity at the cutoff (Shadish et al., 2002). This focus of analysis around or close to the cut-score does, however, limit the generalizability of these findings (Shadish et al., 2002). Within a sharp RD design where assignment based on the cut-score is strictly adhered to, selection bias is eliminated (Schochet et al., 2010). A fuzzy RD design is defined as one in which the cut-score has not been observed as the only factor that decides which treatment condition a participant should be placed (Schochet et al., 2010). For instance, when a student should be placed in the comparison condition based upon their score of the assignment variable, but is instead manually placed in the treatment condition. Within the current study, there was a chance that assignment by the cut-score will not be firmly followed, resulting in a fuzzy RD design (Shadish et al., 2002), which did occur. There was potential within the context for attrition, where individuals decline treatment, and crossovers, where students who are close, but still greater than the cut-score are manually placed in treatment by school administration (Shadish et al., 2002). This increases the threat of selection bias (Trochim, 1984) and therefore the threat to internal validity (Shadish et al., 2002). A fuzzy RD design can still result in causal inferences, but it is essential that the integrity of the
assignment variable is determined (Trochim, 1984). If less than 5% of individuals are incorrectly assigned, analysis to determine treatment effects can still be conducted by considering it a sharp RD design (Trochim, 1984). A clear description of the assignment process and a graphical analysis of the density of the assignment variable close to the cut-point to determine the prominence of this threat of manipulation of assignment will be completed (Schochet et al., 2010).

Another assumption embedded into the research design is that the assignment variable does not determine the use of any other intervention (Schochet et al., 2010). The current assignment variable also determined if students are placed into the IS class. Students who are two or more grade levels below ninth grade mathematics skills will be automatically enrolled in the IS class for the start of their freshmen year of high school. Jacob, Zhu, Somers, and Bloom (2012) explain that in this case the RD design would not be valid for determining treatment effects of the mindset intervention, but would instead demonstrate the combined impact of the mindset intervention and enrollment in the IS class. Therefore, the analysis will be able to answer the question of differences between academic perseverance between the treatment and comparison groups. However, in an attempt to make causal inferences measures of academic perseverance of students currently in the ninth grade were taken and will hopefully demonstrate a significant difference between levels of perseverance of treatment participants and students enrolled in IS who did not complete the intervention this year. This difference would then account for some of the variance introduced by treatment participants’ enrollment in the IS class.

Initially the researcher planned to use the regression discontinuity design previously described to determine treatment effects. However, it was determined that
significant manipulation of assignment had occurred and therefore this would not be strongest design. Instead, a two group repeated measure design to measure the variance over time across treatment and comparison groups was utilized. A secondary analysis included independent sample \( t \)-tests. This test is appropriate as different participants were assigned to different conditions (Field, 2013). It will therefore be able to ascertain if there is a significant difference of the outcome variables between the comparison and treatment groups after the intervention is completed, as the research questions ask. If the participants come from the same population, we would expect the means of the treatment and the comparison groups to be roughly equal (Field, 2013). This is a parametric test and therefore many of the sources of bias are introduced through violations of assumptions (Field, 2013). Outliers can also significantly impact the parameter estimate and the error associated with that parameter (Field, 2013). Outliers will be removed and a thorough examination of assumptions will be completed to minimize bias. The standardized mean difference effect size statistic will be calculated to understand the practical significance of the work (Lipsey, 1998).

Method

Sample and Participant Selection

**Adult participants.** The site of the study is a large suburban high school in the Northeast. Four ninth grade mathematics teachers recruited student participants and monitored student participant progress throughout the intervention and evaluation. These teachers were the instructors for the mathematics courses and the Instructional Seminar class of the student participants. Three of these teachers also participated in the process and outcome evaluations by completing intervention session notes and surveys on student
participants’ academic perseverance. One of the teachers did not recruit any students to participate in the study. As colleagues of the principle investigator, a good rapport has already been formed and a discussion of the study and expected outcomes was utilized to recruit them. No incentive for participation was offered to teacher participants. Teachers who agreed to participate completed an informed consent seen in Appendix H.

As seen in the logic model in Figure 4.1, existing materials from mindset interventions were utilized to construct the intervention sessions and ensured the core components are maintained within the sessions. The administration of the intervention sessions online ensured that these messages are maintained throughout the sessions. It is possible that the teacher within the comparison condition could voice core components of the treatment condition, although this is not believed to have occurred within the current study. As seen in the logic model in Figure 4.1, teachers completed a training session on appropriate monitoring of the intervention before the start of the program.

**Student participants.** Freshmen students who have historically unachieved in mathematics were the participants within the study. Individuals, who are English Language Learners below level five, have a high level of perseverance as denoted by a pretest or a strong growth mindset related to mathematics were excluded from the study. Due to the limitations of resources only native English speakers or ELL students who are able to learn and interact with the content provided in English were included. Students were offered incentives for their participation. Student participants who completed the study will be given a pizza party during the lunch period with pizza, beverages, and a dessert item. Students also received a candy bar after they successfully finished each
session of the intervention. Participants within the control condition received a candy bar after completing the pre and post-tests.

Recruitment materials including scripts (seen in Appendix I) were provided to teachers to recruit student participants. Recruitment was completed in the beginning of the school year in all Algebra I classes as requested by school administration. A meeting with teachers ensured their understanding of materials and was conducted before recruitment of student participants. Special emphasis was placed on teachers following protocols and not adding any additional emphasis on incentives, or any other statements that could be seen as coercive. Recruitment scripts note that students are not required to complete the intervention and can withdraw at any time several times to ensure this is understood. Parental consent and student assent was obtained from all participants, seen in Appendix J.

As previously described the value of the forcing or assignment variable is considered the cut-point or cutoff score, which determines assignment to conditions (Schochet et al., 2010; Trochim, 1984). The district in which the focus school resides utilizes the software program iReady. Incoming ninth grade students with scores that place their mathematics capabilities two or more grade levels behind the summer entering high school are placed into an Instructional Seminar (IS) class, similar to a study hall. The students’ mathematical skills grade level as measured by the iReady program was the assignment variable of the current study. The students’ mathematical skills grade level is a continuous variable, a prerequisite of the assignment variable in an RD design (Schochet et al., 2010) and also serves to increase power in an RD design (Shadish et al.,
2002). Individuals’ score of this assignment variable below two grade levels assigned
them to the treatment condition and above to the comparison condition.

Instrumentation and Measures

Teacher Fidelity Measure & Learning Management System Data

The Teacher Fidelity Measure and data obtained from the learning management
system Canvas was utilized as indicators of fidelity. The Teacher Fidelity Measure can be
seen in Appendix K. Dusenbury, Brannigan, Falco, and Hansen (2003) contend that
measures the elements of fidelity including adherence, dose, quality of delivery,
participant responsiveness and program differentiation should be taken to attempt to
mitigate the risk of a Type III error. Indicators of the various components of fidelity were
considered for the current study.

Adherence. The first dimension of fidelity, adherence is the extent to which the
intervention was implemented as designed (Dusenbury et al., 2003). Given that the
intervention will be completed online through the school’s Canvas LMS, teacher
coverage of content was not an issue. The students completed the sessions and the
activities in each session in chronological order as seen within the theory of treatment in
Figure 4.2. Requirements within the modules of the Canvas LMS ensured that students
could not move on to the next element of the session before completing the previous one.
There was, however, the threat that the implementing teacher would not follow protocols
for recruitment and monitoring of students. A teacher report including a checklist
delineating the recruitment protocols and open-ended comments were completed by the
implementing teacher after the intervention was first introduced to students.
Implementing teachers completed a report including a checklist and open-ended
comments after each session about any discussion with students they had during the intervention and what they spoke about. Teachers also noted any issues, such as with technology or fire drills that occurred during a session.

Dose. Dose refers to the quantity of the treatment obtained by the participants (Schulte, Easton, & Parker, 2009). The logic model seen in Figure 4.1 shows that participants will complete three lessons, including two on brain malleability and one on implications of a growth mindset when learning mathematics. Implementing teachers were asked after each of the scheduled three sessions to complete an attendance roster of participants on the Teacher Fidelity Measure. The intervention was completed online through the Canvas LMS, which provided data on the completion of activities and the length of time students’ utilized the intervention materials. These activities, denoted as student-created artifacts within the logic model, include discussion posts, answers to open-ended questions, and student created presentations they submitted online.

Participant responsiveness. Attention and engagement are essential for learning to occur (Schunk, 2008) and, therefore, it is important to determine the responsiveness or the level that students engaged with the intervention content (Schulte et al., 2009). An indicator was the data from the Canvas LMS that indicated how long students spent on each session of the intervention. The study team member collected this after each of the three intervention sessions. Each of the three sessions was designed to take students approximately 40 minutes to complete, so if a participant only spent 15 minutes completing one of the sessions, it can be assumed that the engagement of that student was low.
Program differentiation. Within the logic model seen in Figure 2, lessons on the growth mindset and misconceptions about learning and mathematics are products that will only be utilized within the treatment condition. To ensure that these elements were only seen within the treatment condition, an indicator utilized was the checklists and open-ended comments that were completed by implementing teachers after the intervention was first introduced and after each session.

Student Focus Group

Eight treatment participants were randomly selected and asked to participate in a focus group after the third session was complete, lasting about 30 minutes. Two participants from each intervention class were randomly selected to participate in the focus group. A study team member intended to conduct the focus group during lunch after the last session of the intervention. However, only two participants came to the focus group scheduled at lunch and therefore a secondary focus group was conducted with five participants during the Instructional Seminar class. Questions included their thoughts about the usefulness of the intervention sessions, their engagement during the sessions and if they noticed any changes in their behavior upon completion of the sessions, as seen in Appendix L. This was used to determine participant responsiveness, a component of fidelity.

Perseverance, Intelligence, and Beliefs Inventory

The Perseverance, Intelligence, and Beliefs Inventory was administered to all student participants through Google forms including those within the treatment and comparison conditions at the beginning of session 1 and at the end of session 3 as seen in
Appendix N. This instrument will be used to capture the constructs of theories of intelligence, academic perseverance, and beliefs of mathematics.

**Theories of intelligence.** Dweck’s (1999) instrument was utilized to determine participants’ implicit theories of intelligence. The original instrument contains six items, three growth mindset statements and three fixed mindset statements (Dweck, 1999). Dweck (1999) asserts that the three fixed mindset items can be used alone (e.g., “You have a certain amount of intelligence, and you really can’t do much to change it”). To limit the length of the questionnaire participants completed only the three items. The variable is measured using a six point Likert scale ranging from (1) which denoted “Strongly Agree” to (6) denoting “Strongly Disagree”. A value of (1) denotes a pure fixed mindset theory while a value of (6) denotes a pure growth mindset theory. Blackwell et al. (2007) found an internal reliability of .78 and the test-retest reliability was .77 over a 2-week period.

**Academic perseverance.** Duckworth and Quinn’s (2009) Short Grit Scale including two sub-scores of Consistency of Interests and Perseverance of Effort was utilized in the needs assessment. However, given that further clarification of the operationalization of perseverance was needed upon completion of the needs assessment, this same instrument was no longer appropriate given the definition of the construct of academic perseverance.

Two measures were used to determine participants’ academic perseverance. The first was a self-reporting effort and perseverance measure designed by Marsh, Hau, Artelt, Baumert, and Peschar (2006), which has an alpha level of 0.83. The instrument consists of four items measured on a 4-point Likert scale (1) “Almost Never” to (4)...
“Almost Always” (Marsh et al., 2006). Considering that the current study is specifically considering the impact on perseverance in mathematics classrooms, “for math” was added to each of the items. For instance, one item is “when studying for math, I work as hard as possible” (Marsh et al., 2006). A higher value would denote a participants’ greater academic perseverance. Similar to Blackwell et al. (2007), mathematics teachers were asked to comment in writing about any changes they have observed in students’ perseverance after the intervention was completed through a Google Form. The Students’ Perseverance Observation Instrument (seen in Appendix M) included five questions to guide teachers on specific behaviors they were looking for and was completed through a Google Form. This was modified from Dweck’s Mindset Kit (Effective Effort Rubric, 2016) with the current operationalization of perseverance used in the current study taken into account. While the instrument has not been norm referenced for validity, to be consistent for the work being undertaken, it was deemed most important to draw on the current research. This qualitative data was used in conjunction with students’ self-reported perseverance to determine impacts of the intervention on participants’ academic perseverance.

**Beliefs of mathematics.** Tapia and Marsh’s (2004) ATMI instrument was utilized in the needs assessment to determine student attitudes towards mathematics. Student beliefs of mathematics here however focused on their perceptions of the role of effort and mistakes in learning mathematics. De Corte’s (2015) students’ mathematics-related beliefs questionnaire (MRBQ) includes four factors including beliefs about the role of the teacher, mathematics as a learnable subject, the necessity of mathematics and the significance of mathematics. The instrument had been used and slightly altered in several
different studies with the current revision being marginally shorter but with all factors resulting in approximately the same degree of internal consistency with alpha levels greater than or equal to 0.79 (De Corte, 2015). The 45 items use a 6-point Likert scale from (6) “totally agree” to (1) “totally disagree” (De Corte, 2015).

While the beliefs of mathematics, theories of intelligence and academic perseverance measures were included on the Perseverance, Intelligence, and Beliefs Inventory completed by student participants in treatment and comparison conditions, student comprehension of the intervention content was collected only after the last session. Student perceptions and engagement in the intervention activities was completed after the last session by treatment, but not comparison participants.

**Comprehension of intervention content.** Five multiple choice questions was given on the post-test to participants within both the treatment and comparison conditions to assess understanding of the content covered in the treatment sessions. Questions assessed student understanding of brain functioning and malleability. This served to ensure that participants within the treatment condition understood the main messages of the sessions, and also that this information and messages did not leak into the comparison condition. An example question is: “What do brain neurons do during learning? (A) are inactive (B) form new connections and strengthen old ones (C) operate by themselves (D) don’t create new neural circuits” (Blackwell et al., 2007, p. 255). Participants were assured that the purpose of the test was to determine strengths and weaknesses of the intervention sessions, and their score did not impact their grades in any class or incentives. Some of the questions from Blackwell et al.’s (2007) study for this measure
were utilized. This data was an indicator of intervention fidelity, specifically program differentiation.

**Student perceptions and engagement.** These questions appeared only on the post-test of treatment, not comparison participants. This indicator was used to determine participant responsiveness. It contained several Likert-type scale questions that ask students to rate their interest and engagement during the intervention sessions. Treatment participants were asked to rate the usefulness and their interest in the material covered during the intervention sessions. These questions appeared only on the post-test completed after the last session. A 5-point Likert scale was used where (1) denotes “not useful/no interest” to (5) “Extremely useful/Extremely interesting”.

**Procedure**

**Intervention Description**

Four freshmen mathematics teachers handled recruitment of participants and implementation of the intervention within their instructional seminar classes. These teachers were trained on recruitment and intervention procedures at the end of August 2016 during a 20 to 30 minute session. Student recruitment occurred in the beginning of September. Administration within the school requested that all students taking Algebra I be asked to complete the informed consent. This included students within the target population, but also those not within the population. Informed consent of participants within the treatment and comparison conditions was reserved while the remaining was discarded.

Participants within the treatment condition completed the mindset intervention over three weeks, finishing one 40-minute session each week. The three sessions were
PERSEVERANCE IN MATH CLASSROOMS

consducted during the end of October and beginning of November 2016. If a student was absent from a session, they completed the session the following class period. To ensure students had enough time to complete all three sessions, four weeks was allotted for the completion of the three sessions.

**Session 1: Brain malleability and the growth mindset.** The first session focused on neuroscience research of brain malleability and the growth mindset. Plasticity and brain malleability was explained first, in order for students to understand the research foundation of the growth mindset. Participants watched some short video clips, and read articles designed for a younger audience on content. Online discussion forums prompted participants to reflect on this material.

**Session 2: Growth vs. fixed mindsets.** The second session continued with the content seen in the first session, but included activities such as making a poster designed to encourage students to internalize the messages. Participants compared the messages of both the growth and fixed mindsets.

**Session 3: Growth mindset and mathematics.** The third session included misconceptions about learning mathematics and the implications of a growth mindset in mathematics. Activities focused on ensuring students understood that mistakes will lead to greater understanding, and process in mathematics is as important as obtaining the correct answer.

A focus group composed of eight randomly selected treatment participants, two from each treatment classroom, was then scheduled to be completed at the end of November or the beginning of December 2016. Participants within the comparison group were asked to complete pre and post-tests completed by participants of the treatment
group at approximately the same time. The comparison group did not complete any alternate intervention material.

**Data Collection**

Qualitative and quantitative data was collected concurrently from teacher participants through Google Forms and student participants through Canvas LMS. Details of the data collection and analysis are included below and given in the summary matrix (seen in Appendix O) which also shows the alignment between the research questions, measures, data collection and analysis.

**Teachers.** Participating teachers completed and submitted a report online through a Google Form once after the intervention was introduced to students in September and again after each session. This included a checklist for teachers to ensure that they followed protocols, an attendance roster of participants, and open-ended responses to collect information teachers felt was pertinent to the study and needed to be shared with the researcher. The data collected here was aimed at answering research questions one and two. After the final session was completed, teachers were asked to describe any changes in academic perseverance of individual students who were included in the treatment or comparison condition.

**Student participants.** Participants within both the treatment and control conditions completed a pre-test at the beginning of session one and a post-test at the end of session 3. Both the pre and post-tests were administered through Canvas LMS, downloaded to Excel and uploaded to SPSS 22 for storage and analysis. The pre-test was utilized to acquire baseline data on students’ theories of intelligence, beliefs of mathematics, and academic perseverance. The post-test included these measures,
multiple-choice questions on the intervention content, and their perceptions of the value of the intervention. Treatment participants, not those within the comparison group, completed the questions about their opinions of the value of the intervention. The questions on content were designed to ensure that participants within the treatment condition understand the content and also that the main messages of the intervention were only in the treatment, not the comparison condition.

Eight treatment participants, two from each treatment classroom, were chosen to complete a focus group after all three sessions were completed at the end of November or beginning of December. Students were asked about what they learned during the intervention and if this information has altered their behavior in mathematics class. They were also asked about their perceptions of the intervention and their engagement during the various activities. This data was transcribed in preparation for qualitative coding. The length of time spent on each session for each student was retrieved from the Canvas LMS at the end of each session by the researcher.

Data Analysis

In order to answer the first research question, pertaining to the fidelity with which the intervention was implemented, the Teacher Fidelity Measure was analyzed using logic model mapping. These reports included both closed and open-ended questions. Percentages of technology issues, student difficulties and other issues were calculated. Qualitative data obtained from teachers’ open-ended responses was analyzed using logic model mapping. The process of linking responses to the logic model can aid in understanding outcome results (Holliday, 2014). A one-way analysis of variance (ANOVA) was utilized to determine how participants within the treatment and
comparison condition differed on their learning and understanding of the material. A comparison of content learning between the four treatment groups using ANOVA was also completed.

A percent of each student’s completed activities was calculated using the data obtained from the Canvas LMS to answer the second research question. Attendance rates for each participant were also calculated as a percentage. Students’ interest and engagement in the intervention sessions, determines their attention during activities and therefore this information was collected and analyzed using measures of central tendency. Two indicators of this measure include quantitative data obtained from the questions answered by treatment participants on the post-test and students’ responses during the focus group. Means from the Likert-type questions were calculated and an ANOVA determined if there are any differences between treatment groups. Student focus groups were coded for positive and negative opinions of the intervention and themes (Saldaña, 2016).

To determine the impact of the intervention on students’ beliefs of mathematics, theories of intelligence and students’ academic perseverance, scatter-plots of the assignment variable against each of the three outcomes were graphed. Only Marsh et al.’s (2006) self-reporting measure of academic perseverance of students was used as an indicator of academic perseverance within this analysis. As described above, within an RD design a treatment effect should be seen at a discontinuity at the cut-point (Trochim, 1984). A frequency histogram of the assignment variable scores was constructed to determine if there was any manipulation of the assignment variable near the cut-point that could undermine the validity of the results (Smith, 2014). Outliers and inconsistencies
with the model at the tails of the sample necessitate the determination of a bandwidth before analysis can be done (Smith, 2014). The bandwidth is the range of scores of the forcing variable that will be included in the analysis (Smith, 2014). This possible narrowing of the sample size used in the analysis needs to be considered when determining options to increase statistical power.

Essential to the ability of the RD design to correctly estimate treatment effects is the correct model of the functional form of the relationship between the assignment and outcome variables (Shadish et al., 2010). A linear model for the relationship should not be assumed and it is suggested that at least six models are run to find the best fit (Jacob et al., 2012). Since the vertical distance at the discontinuity between the model for the treatment group and the model for the comparison group is the treatment effect, an incorrect model could lead to an incorrect measurement of this impact (Shadish et al., 2002). The regression should be adjusted for covariates (Henry, 2010), including the use of the pretest, and other measures such as race, gender, and attendance records (Paunesku et al., 2015) to strengthen the model and any causal inferences the researcher can conclude from it (Trochim, 1984). It is also important to control for the teacher, as each of the four classes will have a different mathematics teacher, who also monitored implementation of the intervention in IS classes (Blackwell et al., 2007). The height of the discontinuity at the cut-point is the treatment effect (Trochim, 1984).

To determine the strength of this treatment effect multiple sensitivity tests are suggested (Smith, 1984). First, the bandwidth will be increased to determine if the generalizability of the results can be increased. Within a RD design, a discontinuity should only be seen at the cut-point and therefore analysis at points other than the cut-
point will also be completed. If a significant effect is seen at locations other than the
predetermined cut-point, the validity of the results will be called into question (Smith,
2014). Assignment conditions were not conducive of analysis using the RD design within
the study and therefore a secondary analysis including t-tests was completed instead.

Participants’ academic perseverance was collected through the use of informant
reports (Shechtman et al., 2013). Teachers were asked to comment on changes in
students’ behavior and academic perseverance in mathematics classes. This qualitative
data was copied into a separate Word document and separated by question with a wide
right margin to write notes and codes as suggested by Saldaña (2008). The responses
were read through once to look for themes and then read again, and assigned initial
codes. Saldaña (2008) suggests reading through qualitative data several times to check
coding, and recoding as necessary. This qualitative data and the quantitative data from
the Marsh et al. (2006) self-assessment instrument was triangulated to understand
changes, if any, in students’ academic perseverance.

**Conclusion**

This chapter described the development of a growth mindset intervention
designed to increase students’ academic perseverance in high school mathematics
classrooms. Through a growth mindset intervention, students will begin to understand
that intelligence is malleability and hard work is necessary in learning. Participants will
also begin to appreciate the importance of process in learning mathematics. As these
beliefs shift, students’ academic perseverance in mathematics classrooms will increase.
The intervention was completed with 9th grade students who have historically
underachieved in mathematics during three 40-minute sessions. A timeline of activities
PERSEVERANCE IN MATH CLASSROOMS

can be seen in Appendix P. The design, data collection and analysis to evaluate both process and outcomes of the intervention were also explained. The following chapter will elucidate and discuss the findings.
CHAPTER 5- RESULTS AND DISCUSSION

The purpose of this applied research study was to determine if students’ perseverance within high school mathematics classrooms, beliefs of intelligence, and beliefs of mathematics could be impacted by a growth mindset intervention. In the last chapter, I presented the research study design and explained the components of the growth mindset intervention. The goal of this chapter is to present the findings, discussion, limitations, and implications. First, a reminder of the research questions will be given.

Research Questions

The following research questions addressed both process and outcomes. The first two questions considered implementation fidelity and the third, fourth, and fifth studied the impact of the intervention and outcome variables.

RQ1: Is at least 80% of the intervention implemented as planned?

RQ2: Do at least 80% of eligible participants complete at least 80% of the activities designed within the mindset intervention?

RQ3: What is the difference in underachieving students’ theories of intelligence between those who participated in the growth mindset intervention and the comparison group?

RQ4: What is the difference in underachieving students’ beliefs of mathematics between those who participated in the growth mindset intervention and the comparison group?
RQ5: What is the difference in underachieving students’ academic perseverance between those who participated in the growth mindset intervention and the comparison group?

These questions focused the analysis of this study and will therefore be used to organize the findings.

**Findings**

**Implementation Fidelity**

The first research question asked if at least 80% of the intervention was implemented as planned, which is important given that four different teachers acted as recruitment and implementing staff. Teacher reports and personal communications with the researcher were analyzed using logic model mapping with results seen in Figure 5.1 (Holliday, 2014). Holliday (2014) suggested mapping themes seen in qualitative data to an activity and associated short-term outcome on the logic model. However, the data collected here relates to the ability of teachers to implement the intervention with fidelity, under participation in the logic model, and therefore this was considered instead of one of the short-term outcomes.

![Figure 5.1. Logic model map showing challenges and needs during recruitment and implementation.](image-url)
PERSEVERANCE IN MATH CLASSROOMS

Four mathematics teachers were trained on recruitment and implementation. While all four of the teachers participated during recruitment, one of the teachers did not recruit any students and therefore only three teachers participated during implementation. All four of the implementing mathematics teachers (100%) noted a challenge being students’ limited understanding of the study and incentive structure during recruitment.

All teachers also mentioned student motivation at least once either during recruitment or implementation of the intervention as a challenge. They felt motivation was a significant challenge when recruiting students to participate, and was also a reason for some attrition of treatment participants. The number of participants recruited for either treatment or comparison conditions by each teacher is given in Table 5.1. Participants who attrited are shown in parentheses.

Table 5.1

<table>
<thead>
<tr>
<th></th>
<th>Treatment</th>
<th>Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(N = 16)</td>
<td>(N = 19)</td>
</tr>
<tr>
<td>Teacher A</td>
<td>7 (3)</td>
<td>3 (1)</td>
</tr>
<tr>
<td>Teacher B</td>
<td>6 (1)</td>
<td>1 (1)</td>
</tr>
<tr>
<td>Teacher C</td>
<td>3 (0)</td>
<td>15 (0)</td>
</tr>
<tr>
<td>Teacher D</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Outliers on both ends of the continuum were taken out of sample for quantitative analysis because they unrealistically skewed the data. The resulting analysis consisted of 10 treatment participants and 11 comparison participants. All treatment and comparison participants answered five questions to determine their comprehension of the intervention content. An independent sample t-test indicated no significant difference between treatment (\( M = 78.00, SD = 17.51 \)) and comparison participants’ (\( M = 70.91, SD = 22.56 \));
PERSEVERANCE IN MATH CLASSROOMS

$t = -0.80, p = 0.44$) comprehension of the intervention content. The three different treatment rooms were compared using a one-way Analysis of Variance conducted to determine if the implementing teacher influenced participants’ comprehension of intervention content. No significant differences were found, $F(2,18) = 2.02, p = .16$. A Pearson correlation was calculated between treatment participants’ ($n = 10$) comprehension of intervention content and the time they spent completing the intervention. A moderate positive correlation was found between the variables, $r = .65, p = .04$. The amount of time treatment students took to complete the workshops was also considered in the analysis of the second research question.

**Participant Exposure and Responsiveness**

The second research question asked if at least 80% of eligible participants completed at least 80% of the activities designed within the mindset intervention. Eligible treatment participants included ninth grade Algebra I students who are two or more grade levels below in mathematics calculated from their end of 8th grade iReady score. These students should have been placed into an Instructional Seminar class. There were 218 ninth grade students enrolled in Algebra I and 67 students enrolled in Instructional Seminar. Seven of these 67 students (10%) enrolled in Instructional Seminar were at grade level for mathematics, 18 (27%) were one level below grade level, and 35 (52%) students were two or more levels below. Some students who came from outside districts did not have iReady scores and were assigned a mathematics level based on transcripts from their previous school. Sixteen students in Instructional Seminar consented to participate in the treatment and 19 students enrolled in Algebra I but not Instructional Seminar consented to participate within the comparison condition. Demographics and
mathematics achievement levels for participants who completed both pre and post-tests can be seen in Table 5.2.

Table 5.2

Demographics & Mathematics Level of Treatment (n = 12) & Comparison Participants (n = 17)

<table>
<thead>
<tr>
<th></th>
<th>Treatment</th>
<th>Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Female</td>
<td>6</td>
<td>13</td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Latino/Hispanic</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Caucasian</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>African</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>South Asian</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Mixed</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td>No Response</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Mathematics Achievement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>On Level</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>1 Level Below</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>2 or More Levels Below</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

Note. Mathematics achievement is based on students’ iReady scores at the end of 8th grade.

Treatment participants completed a questionnaire of three Likert-type questions to determine their perceptions and engagement in the intervention activities, where (1) denoted not useful or never engaged and (5) denoted extremely useful or engaged all of the time. The purpose of this measure was to determine participant responsiveness to the intervention and to better understand the reasons for findings relating to dose. Responses from the three questions were averaged resulting in the student engagement and interest variable and descriptive statistics were calculated for the variable and each individual question as seen in Table 5.3.
Table 5.3

*Participant Mean (SD) Engagement and Interest in Intervention Workshops (n = 10)*

<table>
<thead>
<tr>
<th>Student Engagement and Interest</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>3.80</td>
<td>0.39</td>
</tr>
<tr>
<td>Usefulness</td>
<td>4.20</td>
<td>0.42</td>
</tr>
<tr>
<td>Interest</td>
<td>4.10</td>
<td>0.57</td>
</tr>
<tr>
<td>Engagement</td>
<td>3.10</td>
<td>0.74</td>
</tr>
</tbody>
</table>

As explained previously, while four teachers participated during recruitment only three of these teachers recruited student participants and therefore there were only three treatment rooms. A one-way Analysis of Variance was conducted to determine the effect of the treatment room on participants’ engagement and interest in the intervention. A statistically significant difference between treatment rooms was not found as seen in Table 5.4.

Table 5.4

*One-Way Analysis of Variance of Student Engagement and Interest by Treatment Room*

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between groups</td>
<td>2</td>
<td>0.35</td>
<td>0.18</td>
<td>1.19</td>
<td>0.36</td>
</tr>
<tr>
<td>Within groups</td>
<td>7</td>
<td>1.03</td>
<td>0.15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>1.38</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A focus group was conducted to further understand the reasons for participants’ levels of engagement and interest in the intervention sessions and student perceptions. Qualitative data was collected and analyzed using In Vivo coding to honor student participants’ voice and also because it is appropriate for beginning qualitative researchers (Saldaña, 2016). Treatment participants said that the intervention workshops were somewhat to very useful giving reasons of increased understanding of “HOW BRAIN
WORKS” and also “WHAT TYPE OF MINDSET I AM.” Participants agreed that there was a lot to enough variety in activities in the three workshop sessions, although they did not agree on which activities were useful and engaging. Five students said that they enjoyed the crumpled reminder activity greatly while another student said he just “WASTED TIME” and it did not aid his understanding of the ideas. When probed the student said that he “messed around more than actually learned.” One student out of seven who participated either in the focus group or mini-interviews said that her behaviors in mathematics class had altered, “like saying like I’m not bad in math, like I will get better at it as time goes on.” Several of the other students said there were no changes in their behaviors but also noted that they have always put in a lot of effort and worked hard in mathematics class. When asked for any additional thoughts or suggestions, students mentioned “MORE COLORING THINGS,” “MORE CANDY,” and also conducting the intervention with younger students.

Treatment participants completed the three intervention sessions online through the school’s learning management system, Canvas. Functionality in Canvas allowed each item in each session to be locked until the previous item was completed. For example, in Figure 5.2 all the activities within session one can be seen in the module within Canvas. Students must view “The Session 1 Introduction” before continuing to the “Session 1 Introduction Video,” which in turn must be submitted before continuing on to the “Findings From Brain Research” activity.
Due to the activity requirements, the 10 treatment participants who completed the intervention completed 100% of the activities. Outliers were not included in this calculation. Each of the three sessions was designed to take approximately 40 minutes, with a total time of 120 minutes. Descriptive statistics were completed of treatment participants’ number of page views and the total time it took them to complete the intervention, seen in Table 5.5.

Table 5.5

<table>
<thead>
<tr>
<th></th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Page Views</td>
<td>52.00</td>
<td>132.00</td>
<td>78.20</td>
<td>26.27</td>
</tr>
<tr>
<td>Total Time to Complete</td>
<td>75.05</td>
<td>169.97</td>
<td>110.47</td>
<td>26.32</td>
</tr>
</tbody>
</table>

No significant correlation was found between treatment participants’ time to complete the intervention and the engagement and interest variable ($r = -.01, p = .98$). One of the two treatment participants who completed the intervention and were
outliers not considered in the statistical analyses above was able to complete the final activity of the intervention without completing the one previous to this. How he was able to bypass the conditional structure of the LMS is unclear. It is also interesting to note that while the minimum time spent of the intervention by the 10 treatment participants included in analyses was 75.05 minutes seen in Table 5.5, the two outliers both logged less time than this: 73.7 minutes and 47.42 minutes to complete the entire intervention designed to take 120 minutes.

**Impact on Students’ Theories of Intelligence, Beliefs of Mathematics & Perseverance**

While the first two research questions focused on process, the remaining three questions then focused on outcome variables as seen below.

RQ3: What is the difference in underachieving students’ theories of intelligence between those who participated in the growth mindset intervention and the comparison group?

RQ4: What is the difference in underachieving students’ beliefs of mathematics between those who participated in the growth mindset intervention and the comparison group?

RQ5: What is the difference in underachieving students’ academic perseverance between those who participated in the growth mindset intervention and the comparison group?

**Regression discontinuity design.** A regression analysis was originally intended to determine these differences. However, the regression discontinuity design requires that assignment to either the treatment or comparison condition occur based solely, or at least
primarily, on the cut-score of the assignment variable (Jacob et al., 2012). Therefore, it is first recommended that an analysis be completed to determine if the cut-point and therefore assignment to conditions were manipulated (Jacob et al., 2012). Manipulation of assignment would call into question the internal validity of the design (Jacob et al., 2012). This analysis was conducted although the previous discussion of participant characteristics did lead the researcher to believe that there was significant manipulation of assignment. A scatterplot was constructed seen in Figure 5.3.

![Figure 5.3](image)

*Figure 5.3. Scatterplot of assignment variable and participants’ academic perseverance at post.*

The assignment variable, participants’ iReady scores, was plotted against the outcome variable of academic perseverance. The vertical line represents the cut-score of
Students below this cut-score should have been placed in instructional seminar and hence been placed in the treatment condition, while students above the cut-score should have been placed in the comparison condition. The mix of treatment and comparison participants above and below this cut-score indicates that there was a fair amount of manipulation of assignment to conditions. Therefore the regression discontinuity analysis will be discontinued in favor of $t$-tests to determine impact of the mindset intervention. Box plots of the assignment variable and the pre-assessment of all outcome variables were constructed to determine outliers. Outliers were taken out of sample for remaining analysis because they unrealistically skewed the data. The resulting analysis consisted of 10 treatment participants and 11 comparison participants.

**Testing assumptions.** Before beginning initial statistical analyses to answer the last three research questions it is important to search the data for patterns and also test the assumptions of normality and homogeneity of variance (Field, 2013). First, reliability of all subscales on the pre and post-test was analyzed using Cronbach’s alphas. Correlations between each item in the scale and the total score were found. Items with correlation values of less than .30 were dropped since this indicated some items did not correlate well with the overall score (Field, 2013). Table 5.6 gives reliability for each of the scales, the number of items, if any, deleted based on this analysis, and the final number of items comprising the scale. The scales showed high reliability after items with low correlations were deleted.
Table 5.6

Reliability of Variables

<table>
<thead>
<tr>
<th></th>
<th>Number Items in Scale</th>
<th>Cronbach’s Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>Academic Perseverance</td>
<td>4 (0)</td>
<td>4 (0)</td>
</tr>
<tr>
<td>Implicit Theories of Intelligence</td>
<td>3 (0)</td>
<td>3 (0)</td>
</tr>
<tr>
<td>Factor 1: Beliefs about the</td>
<td>8 (3)</td>
<td>11 (0)</td>
</tr>
<tr>
<td>significance of and competence in</td>
<td></td>
<td></td>
</tr>
<tr>
<td>mathematics (task-value and self-ef-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ficiency beliefs)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Factor 2: Beliefs about the role</td>
<td>5 (6)</td>
<td>8 (3)</td>
</tr>
<tr>
<td>and functioning of the teacher</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Factor 3: Beliefs about mathematics</td>
<td>7 (1)</td>
<td>8 (0)</td>
</tr>
<tr>
<td>as a learnable subject</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The original scale of the fourth factor of beliefs about mathematics which focused
on beliefs of mathematics as a functional necessity of school life on the pre-test resulted
in an alpha of .57, demonstrating the subscale had relatively low reliability. Six of the
nine items had correlations of less than .30 and were dropped. The resulting subscale of
three items still had a Cronbach’s alpha of .48. Cronbach’s alpha was .25 for the fourth
factor of beliefs of mathematics on the post-test. The researcher decided not to include
this factor of beliefs of mathematics in any subsequent analyses due to the low reliability
of this scale on both the pre and post-test.

Normality is an assumption of many of the statistical tests utilized in this study
and therefore this was first checked for variables beginning with a visual inspection of the
histograms and Q-Q plots. Since all of my predictions are about there being differences
between the means of the treatment and comparison groups, normality was determined
within each of these groups separately (Field, 2013). An example can be seen in Figure 5.4 for the beliefs of mathematics Factor 3 variable with separate plots for treatment and comparison.

**Figure 5.4.** Histogram with imposed normal curve and Q-Q plot of factor 3: Beliefs about mathematics as learnable subject for treatment and comparison

Next, skewness, kurtosis, and a comparison of the sample scores to a normally distributed set of scores using the Shapiro-Wilk test was calculated and can be seen in Table 5.7. A Shapiro-Wilk significance of greater than .05 signifies that the distribution
of the sample is not significantly different to a normal distribution (Field, 2013). The results seen in Table 5.7 suggests both groups’ scores are normally distributed for each of the outcome variables except for the comparison group’s scores on the implicit theories of intelligence scale. Robust methods to deal with violations of assumptions, specifically bootstrapping, will be used (Field, 2013).

Table 5.7

Tests for Normality and Homogeneity of Variance of Post-Scores of Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Skew</th>
<th>Kurtosis</th>
<th>Shapiro-Wilk Sig.</th>
<th>Levene Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic Perseverance</td>
<td></td>
<td></td>
<td></td>
<td>.56</td>
</tr>
<tr>
<td>Comparison</td>
<td>-.97 (SE = .66)</td>
<td>2.28 (SE = 1.28)</td>
<td>.28</td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>-.32 (SE = .69)</td>
<td>1.17 (SE = 1.33)</td>
<td>.73</td>
<td></td>
</tr>
<tr>
<td>Implicit Theories of Intelligence</td>
<td></td>
<td></td>
<td></td>
<td>.88</td>
</tr>
<tr>
<td>Comparison</td>
<td>-1.48 (SE = 0.66)</td>
<td>2.67 (SE = 1.28)</td>
<td>.05*</td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>.40 (SE = .69)</td>
<td>-1.16 (SE = 1.33)</td>
<td>.58</td>
<td></td>
</tr>
<tr>
<td>Factor 1: Beliefs about the significance of and competence in mathematics</td>
<td></td>
<td></td>
<td></td>
<td>.33</td>
</tr>
<tr>
<td>Comparison</td>
<td>-.40 (SE = .66)</td>
<td>1.43 (SE = 1.28)</td>
<td>.70</td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>.77 (SE = .69)</td>
<td>-52 (SE = 1.33)</td>
<td>.23</td>
<td></td>
</tr>
<tr>
<td>Factor 2: Beliefs about the role and functioning of the teacher</td>
<td></td>
<td></td>
<td></td>
<td>.22</td>
</tr>
<tr>
<td>Comparison</td>
<td>-.11 (SE = .66)</td>
<td>-1.01 (SE = 1.28)</td>
<td>.94</td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>-.65 (SE = .69)</td>
<td>-.50 (SE = 1.33)</td>
<td>.44</td>
<td></td>
</tr>
<tr>
<td>Factor 3: Beliefs about mathematics as a learnable subject</td>
<td></td>
<td></td>
<td></td>
<td>.12</td>
</tr>
<tr>
<td>Comparison</td>
<td>-.71 (SE = .66)</td>
<td>.95 (SE = 1.28)</td>
<td>.59</td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>.17 (SE = .69)</td>
<td>.12 (SE = 1.33)</td>
<td>.81</td>
<td></td>
</tr>
</tbody>
</table>

*Note. Comparison (n = 11) and treatment (n = 10). SE = standard error. *two-tailed

The assumption of homogeneity of variances was evaluated using Levene’s test with results seen in Table 5.7 (Field, 2013). If Levene’s test is significant it suggests the assumption of homogeneity of variances has been violated. The variances were equal for treatment and comparison participants for all outcome variables since Levene’s test results were not statistically significant and therefore homogeneity of variance can be
assumed. Violations of assumptions can introduce potential sources of bias and therefore it is important to pinpoint bias before proceeding. Now that this has been done, statistical tests to determine differences in outcome variables can be run with confidence.

**Testing differences between conditions.** Independent sample $t$-tests were conducted to compare the variance between groups of all outcome variables with results shown in Table 5.8. A robust confidence interval was calculated using a bootstrap for the reasons mentioned previously. The effect size for the difference between groups at post-test was calculated to determine the practical importance of any effects found using Cohen’s $d$.

Table 5.8

<table>
<thead>
<tr>
<th>Variable</th>
<th>Treatment $M (SD)$</th>
<th>Comparison $M (SD)$</th>
<th>95% CI</th>
<th>$p$</th>
<th>ES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic Perseverance</td>
<td>3.08 (0.54)</td>
<td>2.64 (0.71)</td>
<td>[-1.05, 0.06]</td>
<td>0.13</td>
<td>0.62</td>
</tr>
<tr>
<td>Implicit Theories of Intelligence</td>
<td>4.37 (1.02)</td>
<td>4.24 (1.20)</td>
<td>[-1.19, 0.75]</td>
<td>0.80</td>
<td>0.11</td>
</tr>
<tr>
<td>Factor 1: Beliefs about the significance of and competence in mathematics</td>
<td>4.55 (0.70)</td>
<td>3.88 (1.10)</td>
<td>[-1.54, 0.09]</td>
<td>0.12</td>
<td>0.61</td>
</tr>
<tr>
<td>Factor 2: Beliefs about the role and functioning of the teacher</td>
<td>4.30 (0.63)</td>
<td>4.05 (0.87)</td>
<td>[-0.93, 0.37]</td>
<td>0.46</td>
<td>0.29</td>
</tr>
<tr>
<td>Factor 3: Beliefs about mathematics as a learnable subject</td>
<td>4.84 (0.56)</td>
<td>4.06 (1.07)</td>
<td>[-1.58, -0.09]</td>
<td>0.05*</td>
<td>0.73</td>
</tr>
</tbody>
</table>

*Note.* Treatment participants $n = 10$ and comparison participants $n = 11$. CI = confidence interval; ES = effect size calculated using Cohen’s $d$; * two-tailed
A significant difference between treatment ($M = 4.84$, $SD = 0.56$) and comparison participants’ ($M = 4.06$, $SD = 1.07$; $t = -2.06$, $p = 0.05$) beliefs about mathematics as a learnable subject after the intervention (Factor 3) was found. An effect size of 0.73 for this difference between groups at post-test was also found. No other statistically significant differences were determined, although the differences between groups of academic perseverance and beliefs about the significance of and competence in mathematics (Factor 1) had medium-sized effects, $d > 0.60$.

**Qualitative results on changes in academic perseverance.** Marsh et al.’s (2006) self-reporting effort and perseverance measure completed by participants provided quantitative data to determine changes in academic perseverance. Treatment participants’ teachers answered several questions regarding changes in treatment participants’ perseverance in mathematics class as an additional qualitative measure. Magnitude coding was used to analyze this qualitative data since the purpose was evaluation (Saldaña, 2016). Responses were coded as POS for positive changes, NEG for negative changes, NEU for no change and MIX for both positive and negative changes in academic perseverance. Table 5.9 combines results from this qualitative and quantitative data.

The third column in Table 5.9 shows the changes in academic perseverance based on the Marsh et al.’s (2006) instrument, but using the same positive to negative scale as the qualitative measure. The mixed methods approach utilized in this study provided rich results to answer the five research questions of this investigation. Next, a discussion surrounding each of the research questions will utilize these findings and the literature to answer the research questions. The limitations and implications will then be considered.
### Table 5.9

*Changes in Academic Perseverance for Each Treatment Participant*

<table>
<thead>
<tr>
<th>Participant</th>
<th>Academic Perseverance Pre-Score</th>
<th>Academic Perseverance Post-Score</th>
<th>Academic Perseverance Change Pre to Post</th>
<th>Teacher Perceptions of Participant Changes in Perseverance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant A</td>
<td>2.5</td>
<td>3</td>
<td>Positive</td>
<td>Positive</td>
</tr>
<tr>
<td>Participant B</td>
<td>3</td>
<td>3</td>
<td>Neutral</td>
<td>Neutral</td>
</tr>
<tr>
<td>Participant C</td>
<td>4</td>
<td>3.5</td>
<td>Negative</td>
<td>Positive</td>
</tr>
<tr>
<td>Participant D</td>
<td>4</td>
<td>3.25</td>
<td>Negative</td>
<td>Neutral</td>
</tr>
<tr>
<td>Participant E</td>
<td>4</td>
<td>4</td>
<td>Neutral</td>
<td>Neutral</td>
</tr>
<tr>
<td>Participant F</td>
<td>2.5</td>
<td>2.75</td>
<td>Positive</td>
<td>Positive</td>
</tr>
<tr>
<td>Participant G</td>
<td>3</td>
<td>3.5</td>
<td>Positive</td>
<td>Neutral</td>
</tr>
<tr>
<td>Participant H</td>
<td>3</td>
<td>2</td>
<td>Negative</td>
<td>Negative</td>
</tr>
<tr>
<td>Participant J</td>
<td>3</td>
<td>2.75</td>
<td>Negative</td>
<td>Mixed</td>
</tr>
<tr>
<td>Participant K</td>
<td>2.25</td>
<td>3</td>
<td>Positive</td>
<td>Positive</td>
</tr>
</tbody>
</table>
Discussion

The importance of the process of implementation and the fidelity of that implementation promoted the creation of the first two research questions that focused on adherence, dose, participant responsiveness, and differentiation between the conditions (Dusenbury et al., 2003).

Fidelity of Implementation

Reviewing the main findings related to fidelity indicated teachers followed recruitment and implementation procedures. All four of these teachers mentioned two challenges were students’ lack of understanding of the study during recruitment and lack of student motivation during recruitment and implementation. Teachers were trained on recruitment and their role as implementing staff. Specific details of the growth mindset intervention were kept largely hidden from teachers to decrease the possibility that their interactions with students would impact results. They were given recruitment scripts in order to explain some of the details to students, but there were still student questions that they were unprepared to answer. The teachers’ lack of understanding did not permit them to explain it to students. Previous studies utilized researchers and graduate students to conduct a great deal of the intervention (Blackwell et al., 2007), which was not possible in the current study. While this lack of understanding was not a significant barrier during implementation, it was during recruitment.

Recruitment. The rate at which students returned informed parental consent and student assent was slow. I had all the teachers communicate that the students had questions about the incentives for completing the study and how they would be placed into either the treatment or comparison condition. This challenge during recruitment
prompted completion of some of the contingency plans. A flow chart of the incentive structure and a short video explaining the flow chart was created for teachers to share with students. With a slow rate of return and teachers specifying that students still had questions I decided to go into the classrooms to answer student questions at the end of September 2016. This also did not significantly impact the rate of return of informed consent with all four recruiting teachers pointing to student motivation as another challenge. This is particularly interesting given that students’ understanding of the growth mindset was cited for increasing student motivation in Blackwell et al.’s (2007) study. The multi-tiered incentive structure within the current study was designed partly due to similar recruitment problems experienced during the needs assessment. Unfortunately, it did not incentivize students to participate as anticipated. It would seem to be a Catch-22 situation where completion of the intervention would aid in increasing student motivation, but student motivation is not high enough to volunteer to participate in the growth-mindset workshops.

**Adherence and program differentiation.** An ANOVA to determine differences in participants’ understanding of the content across the three implementing classrooms was not significant, $F(2,18) = 2.02, p = 0.16$. This indicates that fidelity within the three implementation rooms was essentially the same. Since the workshops were conducted online this finding is logical, with teachers only acting as monitors within the classroom. This was also supported by one of the teacher’s comments. While responding about changes in participants’ perseverance he added, “I truthfully didn’t pay too much attention to it. I just let them go through it” referring to student completion of the online intervention sessions.
PERSEVERANCE IN MATH CLASSROOMS

No statistically significant difference between treatment ($M = 78.00, SD = 17.51$) and comparison participants’ ($M = 70.91, SD = 22.56; t = -0.80, p = 0.44$) comprehension of the intervention content was found. Treatment participants’ mean for comprehension of the content was higher although not statistically significantly higher than the comparison participants’ mean score. A difference was expected to indicate differentiation between conditions (Dusenbury et al., 2003). Treatment participants and not comparison participants received instruction on the malleability of the brain and the growth mindset and therefore were expected to do significantly better on the content comprehension questions. Results may have been skewed because there were only five questions on the survey scored as either correct or incorrect, which was then converted to a percentage. The online nature of the intervention, implementing teacher comments about how they monitored student progress during the intervention, and the lack of differences between the implementing classes does not indicate that teachers introduced critical features of the mindset intervention into the comparison condition. Treatment participants completed the intervention workshops within their instructional seminar class, but the Algebra I courses are mixed with comparison and treatment participants. It is possible that treatment participants discussed the content of the intervention over the course of the two months it took for all students to complete the workshops. It also seems possible that the questions did not measure what was intended and were more intuitive so participants were able to guess the answers correctly. Students were reminded during the survey that it did not matter if they got the correct answer, but it is possible that worried about accuracy participants used the Internet to find the answers to the questions. While
this finding was not expected and calls into question the differentiation between conditions, various other findings support that differentiation was maintained.

**Dose and participant responsiveness.** Teachers’ comments on student motivation discussed above seem to apply in considering the second research question if 80% of eligible participants completed 80% of the activities within the mindset intervention. Manipulation of assignment to conditions did impact the success of this goal, as all eligible participants were not recruited for the appropriate condition. The findings showed that treatment participants who completed the intervention finished 100% of the intervention activities, with a mean time of 110.47 minutes (SD = 26.32). The workshops were designed to be completed within 120 minutes, but this time was a maximum to ensure students did not take a large amount of time over this total. Although treatment participants completed all workshop activities due to the functioning of the LMS, the dose still varied with the time it took participants to go through activities. The significant positive correlation ($r = 0.65$, $p = 0.04$) between comprehension of the intervention content and time spent completing the intervention also provides evidence of the importance of dose. It implies that the greater amount of time students spent completing the intervention, the more they understood the concepts. While the ability to require participants to complete all activities through the LMS was helpful, there is no option to require the student to spend a certain amount of time on the activity before proceeding. The LMS does give the option of requiring a certain score before proceeding to another element, but this would mean that activities would need to be manually graded and students would not be able to move on until this was done. Permitting a larger number of students to complete the intervention and decreasing the cost were two of the
purposes of completing the mindset intervention through an online medium. Requiring activities to be manually graded would necessitate a designated staff member and nullify some of the benefits of the online medium. While the researcher did comment on participants’ submissions after the fact, there is no guarantee that students looked at this feedback and utilized it to correct misconceptions or deepen their understanding. A designated staff member could engage with students face-to-face, ensure their understanding of the content, and perhaps aid in increasing the interest and engagement of students. The plausibility of such a change will be discussed further in the implications section.

Treatment participants completed three items that were averaged to determine their interest and engagement in the intervention workshops. The high mean of this variable ($M = 3.80$, $SD = 0.39$) denotes that treatment participants found the intervention workshops largely engaging, interesting, and useful. Participants’ ratings of the usefulness of the intervention ($M = 4.20$, $SD = 0.42$) and their interest in the material covered in the sessions ($M = 4.10$, $SD = 0.57$) were both higher than their ratings of their average engagement in the sessions ($M = 3.10$, $SD = 0.74$). This implies that while participants generally found the information useful and interesting, this did not keep them highly engaged throughout the sessions. This could be a reason for several barriers during implementation including attrition of intervention participants. An ANOVA demonstrated that there were no differences between the three treatment rooms in regards to their engagement and interest. If students were not engaged throughout all of the sessions, this could be a reason for the lack of difference between treatment and comparison participants’ understanding of the content. All treatment participants in the
focus groups said they found the workshops helpful or useful, but the majority also stated that their behavior in class was unchanged following completion of the intervention. Focus group participants also agreed that there were a good variety of activities although participants disagreed on activities they found helpful and interesting and ones they did not. This finding will be discussed further in the following sections in connection to the results regarding the impact of the intervention on beliefs of mathematics and intelligence.

**Differences in Implicit Theories of Intelligence**

A two-tailed independent sample t-test resulted in no significant difference between treatment ($M = 4.37, SD = 1.02$) and comparison participants’ ($M = 4.24, SD = 1.20; t = -0.25, p = 0.80$) implicit theories of intelligence, the focus of the third research question. A six on Dweck’s measure of implicit theories of intelligence indicates a pure growth mindset and a score of one a pure fixed mindset. A significant positive correlation ($r = 0.65, p = 0.04$) was found between treatment participants’ comprehension of intervention content and the time they spent on completing the intervention. As previously explained, this suggests that in general the more time a participant spent completing the intervention workshops, the greater understanding they had on the content. This finding was anticipated and was the reasoning behind the focus of the first two questions on implementation fidelity and student responsiveness.

It was the intention of the researcher to determine the length of time participants spent on each workshop to increase the specificity of the findings, but participants seldom finished an entire session’s activities in one day. Participants completed the intervention workshops during their instructional seminar class. The course does not have additional
content to complete, however was often a time to complete half-back points on Algebra I
assignments, homework, make-up assessments, or get extra time on assessments as
applicable. Due to this, students may not have completed an entire session in one sitting
and linking specific activities or sessions to outcomes was not possible. The total time
spent on the intervention was not correlated to implicit theories of intelligence, beliefs of
mathematics, or academic perseverance. These findings related to implicit theories of
intelligence are interesting in conjunction with results related to changes in participants’
theories of intelligence and will therefore be discussed further in the following section.

Differences in Beliefs of Mathematics

De Corte’s (2015) students’ mathematics-related beliefs questionnaire (MRBQ)
was utilized in this study and includes four factors. The three factors, which will be
discussed, include (a) beliefs about the significance of and competence in mathematics,
(b) beliefs about the role and functioning of the teacher, and (c) beliefs about
mathematics as a learnable subject. The Factor 4 subscale was not analyzed because of
issues with reliability discussed previously. The fourth research question focused on
differences between treatment and comparison participants’ beliefs in mathematics. The
intervention was thought to alter students’ beliefs of mathematics to be more in line with
a reform-based classroom as seen in the Theory of Treatment (Figure 4.2), a short-term
outcome in the logic model of the intervention (Figure 4.1).

An independent sample $t$-test revealed a significant difference between treatment
($M = 4.84, SD = 0.56$) and comparison participants’ ($M = 4.06, SD = 1.07; t = -2.06, p =
0.05$) beliefs about mathematics as a learnable subject (Factor 3) after the intervention.
An effect size of 0.73 for the difference between groups at post-test was also found. The
95% bootstrap confidence interval for this finding ranges from -1.58 to -0.09. This strengthens the significance of this finding. A significant difference was not found between treatment ($M = 4.55$, $SD = 0.70$) and comparison participants’ ($M = 3.88$, $SD = 1.10$; $t = -1.639$, $p = 0.12$) beliefs of mathematics Factor 1 subscale. The Factor 1 subscale focused on beliefs about the significance of and competence in mathematics. The mean is larger for treatment participants and can be considered a significant if not statistically significant finding with a medium-sized effect of 0.61. Cohen (1992) suggests $d = 0.2$ be considered a small effect, $d = 0.5$ a medium effect, and $d = 0.8$ a large effect in general. Effect sizes in education can very often be considered small or medium using these standards, but there is a practical significance in education when considering the expectation of growth without the intervention (Hill, Bloom, Black, & Lipsey, 2008).

No significant differences were found between treatment and comparison participants’ scores on the beliefs of mathematics Factor 2 subscale, which centered on beliefs about the role and functioning of the teacher. Activities within the intervention focused on brain malleability, the growth mindset, and the implications of the growth mindset in mathematics. The third session, or workshop as participants referred to them, attempted to ensure that students understood that mistakes will lead to greater understanding, and process in mathematics is as important as obtaining the correct answer. The role and functioning of the teacher (Factor 2) was not directly considered within the workshop activities, but was implied as the focus on process over finding the correct answer in mathematics necessitates a change in the role of the teacher. It is possible that these beliefs were not explicit for the students during the workshops and is the reason for a lack of difference.
Beliefs of mathematics and beliefs of intelligence were both short-term outcomes derived from student participation in the intervention workshops as seen within the logic model of the intervention (Figure 4.1). These two outcomes were considered separately since the first two workshops focused on students’ learning about brain malleability and the differences between fixed and growth mindsets, while the third workshop focused on the growth mindset specifically in mathematics. It is noteworthy that a significant difference was found for the Factor 3 subscale of beliefs of mathematics and not implicit theories of intelligence. As a reminder, Factor 3 focused on student beliefs of mathematics as a learnable subject with example items being “Making mistakes is an important part of learning mathematics” and “Anyone can learn mathematics” (De Corte, 2015). This factor’s subscale is closely aligned with the implicit theories of intelligence subscale, although focused on mathematics instead of general mindsets. Yet, the differences between treatment and comparison participants for the Factor 3 subscale was found to be statistically significant and not for implicit theories of intelligence. Dweck (2015b) has explained that all individuals’ hold fixed and growth mindset beliefs instead of being solely one or the other, as many believed her original research demonstrated. Individuals can also hold different levels of growth mindset beliefs about different areas or subjects (Dweck, 2015b). For instance, an individual could hold fixed mindset beliefs about mathematics, but growth mindset beliefs about football. They understand practice and effective strategy use can improve their performance in football, but do not believe the same for mathematics.

The findings demonstrate that the intervention workshops were able to alter participants’ beliefs of mathematics to be more in line with a growth mindset in
mathematics, but not their general implicit theories of intelligence. The significant positive correlation ($r = 0.65, p = 0.04$) found between treatment participants’ comprehension of intervention content and the time they spent on completing the intervention means that treatment participants who spent more time on the intervention had a greater understanding of the content. Statistically significant strong positive correlations were seen between student engagement and interest and implicit theories of intelligence ($r = .79, p = 0.01$) and student engagement and the factor 3 subscale of beliefs of mathematics ($r = .68, p = .03$). Greater engagement and interest in workshops sessions generally correlated to students’ beliefs to be more in line with a growth mindset. Findings discussed previously also implied that while participants generally found the information useful and interesting they were not highly engaged throughout the sessions. No significant correlation between was found between treatment participants’ time to complete the intervention and the engagement and interest variable ($r = -.01, p = .98$).

The first two sessions of the mindset intervention drew on activities from past research (Aronson et al., 2002; Blackwell et al., 2007; Good et al., 2003). The third session drew from Jo Boaler’s site through Stanford University and focused more on the implications of a growth mindset in mathematics (https://www.youcubed.org). The importance of student attention and engagement to learning is widely accepted (Bransford et al., 2000; Hardiman, 2012). Given this fact and the findings of this study it seems plausible that participants’ found the activities within the third session which focused on the growth mindset in mathematics specifically more engaging, increasing their attention, and therefore their learning. This increased learning and understanding of
the content resulting in the significant differences between the factor 3 subscale of mathematics beliefs and not implicit theories of intelligence. This idea is also supported by the qualitative data. When asked for what activities they found the most interesting and useful several of the students mentioned the activities within the last session. One participant mentioned “Well, for me, my favorite one was when you got to draw what, like…” with another participant knowing which one the first student spoke of finished the thought “When you had to like write it and then you crumpled it up and threw it at the board.” A third student also agreed “That was a fun one.” The findings indicate that the greater engagement and interest of students within the third session was able to begin to alter their beliefs of mathematics to be more in line with a growth mindset but not their general implicit theories of intelligence. The focus of this study has been on improving student perseverance in mathematics specifically through altering beliefs, but to improve the practical implications of a growth mindset intervention, the ability to alter students’ general beliefs of intelligence is important.

As mentioned previously activities for all three sessions were drawn from previous research, but the level of engagement and interest for individual activities varied for each individual student. Activities mentioned by some students as very engaging, were referred to as a waste of time by another student. The generalizability of these activities to various student sub-populations may be limited for a diverse school community like the focus school. Greater variety and choice in intervention activities may improve engagement and therefore learning of growth mindset messages, particularly in the first two sessions that focused on general theories of intelligence.

**Differences in Academic Perseverance**
The fifth and final research question focused on differences between treatment and comparison participants’ academic perseverance. This was the initial problem that has been the focus of this dissertation. Theoretically, changes to students’ beliefs of intelligence and beliefs of mathematics to be more in line with a growth mindset should have led to increases in students’ academic perseverance as seen in the logic model of treatment (Figure 4.1). Academic perseverance was conceptualized as a medium-term outcome within this logic model. A significant difference between treatment ($M = 3.08$, $SD = 0.54$) and comparison participants’ ($M = 2.64$, $SD = 0.71$; $t = -1.579$, $p = .13$) academic perseverance at post was not found. Teachers cited four treatment participants (40%) as exhibiting increased perseverance and effort in mathematics classrooms as shown in Table 5.9. Three of these students also showed increased perseverance from pre to post-test using the self-reporting measure designed by Marsh et al. (2006). The fourth student showed a negative change from pre to post per this measure, however the pre-test score was a 4, the highest on the scale. Paunesku et al. (2015) warn that mindset interventions could have a smaller impact on students who lack challenging learning opportunities. For instance, students who are doing very well in their math class already. One additional student demonstrated positive change using the self-reporting measure and was labeled as neutral by the teacher. Some of the example comments from teachers of the treatment students labeled as positive include:

[She] spent more time on math problems this marking period. Granted, a lot of the problems in our recent chapters just happen to take longer by nature, but [she] has persevered through them and not given up.

Another teacher commented that one of her student’s
...attitude to even just doing the problems and trying has improved throughout the school year. I think she discovered that she can be good at math and now she’s actually, I think, happy with it. Her grades are good and I think getting better. So I think she’s definitely improved since the beginning of the school year.

Several of the students who were noted as demonstrating neither positive nor negative change in their academic perseverance were noted as neutral with teachers saying statements similar to “She’s always been like that.” These thoughts were also mentioned by some students in the focus group when asked if any of their behaviors in math class had changed since learning about the material. One student commented “Um, no cause I’m most, I get good grades in math, that’s my favorite subject to do.” This again calls into question the discussion from above if the intervention reached the intended audience of underachieving ninth grade students.

Academic perseverance was considered a medium-term outcome, but it seems plausible that while the intervention was able to begin shifting student beliefs of intelligence and mathematics within the short time frame, converting these beliefs into actions may need a greater amount of time. Academic perseverance could be a long-term outcome that the limitations on the length of the current study would not have been able to accurately assess. It also seems possible that while beliefs can change, actions resulting from these beliefs could need consistent growth-mindset messages.

**The Importance of Consistency**

Yeager and Walton (2011) warn that social-psychological interventions can be powerful, but are dependent on the context and environment in which they are delivered. Bandura (1986) stresses the importance of the role of environmental factors in student
behavior within the social cognitive perspective. Dweck (2015) claims that a consistent message in line with the growth mindset is needed throughout an environment for students to fully convert their beliefs to be in line with a growth mindset. Before student actions can be altered this change in beliefs needs to occur. The needs assessment pointed to the beliefs of teachers and students impacting student perseverance (Bifulco, 2015). The limited resources of the current study permitted a focus on students only, but the literature and theory are pointing to the need for students to experience these growth-mindset messages throughout the school environment. A student who learns about the growth mindset and only experiences classrooms where high achievement instead of effort and effective strategy use is praised will not maintain those beliefs or convert them to actions and change behaviors. A consistent growth-mindset message may need to be infused within the school environment for significant differences to be detected.

Treatment participants learned about the growth mindset within the workshop sessions but may not experience these ideals throughout the rest of the school community. Student J when asked if she was maintaining the growth mindset beliefs she claimed to have developed mentioned, “I don’t feel like I have the encouragement to do it, it’s all just one-sided here do it and then you get graded for it.” The focus on completing a task and obtaining the grade for the task was not supporting the growth-mindset ideals that she had learned in the workshops. This conflict between personal beliefs about the growth mindset and environmental factors interact to determine behavior and therefore if the strength of the environmental factors is stronger could force the fixed mindset behavior (Bandura, 1986).

**Limitations**
PERSEVERANCE IN MATH CLASSROOMS

The study was conducted in a single school with a small convenience sample limiting the generalizability of these findings (Shadish et al., 2002). The originally planned regression discontinuity design would have eliminated the selection bias introduced with the nonrandomized sample, however manipulation of assignment of students was determined to have seriously weakened the assumptions, which support the robustness of the design (Jacob et al., 2012). There were significant barriers to recruitment with implementing teachers pointing to student motivation. A detailed and multi-tiered incentive structure was constructed after similar issues with recruitment during the needs assessment. Unfortunately, the structure did not incentivize students to participant as anticipated. Other limitations include the use of self-assessment measures which can introduce bias as students may not be experts at self-assessment or they may choose the answers they think are socially correct but do not truly believe. Considering these limitations these findings still have practical implications. These implications are slightly different for the various key stakeholders and will therefore be discussed separately.

**Implications for Researchers**

Future studies should determine how researchers can engage a diverse student body in participating in research and what would incentivize students to participate. As discussed previously, one of the reasons for student completion of the intervention through an online medium was to reach the largest number of students with the lowest marginal cost. Paunesku et al. (2015) found that mindset interventions conducted online with minimal administration could result in student beliefs being more in line with a growth mindset and increased achievement. Although the current study did not compare
an online versus in person intervention medium, the findings indicate that at least within the current context greater administration and support from an adult could increase the engagement of students, their understanding, and therefore the impact of the intervention. Conducting the intervention through a blended learning environment could offer the ability to employ a range of instructional strategies (Oliver & Stallings, 2014). Feedback and interaction between students and teachers can be increased through blended learning, which has been linked to student satisfaction (Oliver & Stallings, 2014). The medium rating of treatment participants’ engagement in the current study should be considered within future research. Increased feedback within a blended learning model could potentially increase student engagement and attention, thereby increasing the impact on students’ implicit theories of intelligence, beliefs of mathematics, and academic perseverance.

A flex blended learning model could be utilized where the activities are still online, and students work through these at their own pace, but a teacher is present in the classroom to offer support throughout the time students are working on it (Staker & Horn, 2012). Some schools have utilized a model like this where a large number of students will work individually under the guidance of several paraprofessionals (Staker & Horn, 2012). If the paraprofessionals are trained on the implementation of the intervention and how to support students as they work through the online activities, it could lower the cost, but also provide the increased feedback and support to students needed. The blended medium would also permit construction of intervention sessions with greater choice and varied activities. Future research could determine the optimal construction of sessions to increase outcomes.
Good et al.’s (2003) study utilized a type of blended learning environment where college students mentored seventh grade students through face-to-face as well as online meetings. While this environment was successful, its application in schools is limited due to the high level of collaboration between the university and school district essential to success. This is not to imply that connections between researchers and schools are not important. The conversion of research into practical applications that can be implemented into schools and classrooms can take a great amount of time (NCTM Research Committee et al., 2006). Partnerships and collaboration with universities and researchers allow teacher leaders and researchers to ensure that evidence-based practices are translated for all relevant stakeholders (NCTM Research Committee et al., 2006). However, given the reliance of both higher education research institutions and public schools on public policy and funding, any solution should allow for the greatest plausibility of maintaining implementation. Schools should be able to maintain implementation without the continued support of a higher education institution. Due to all of these reasons, a flex blended learning environment for students to complete the growth mindset intervention is a suggested focus for additional research.

Implications for Practitioners & Schools

The social cognitive perspective and Bandura’s (1986) triadic reciprocal determinism acknowledge the importance of environmental factors in student behavior. The needs assessment indicated the beliefs of teachers and students impacting student perseverance (Bifulco, 2015). Dweck (2015) has also claimed that consistent growth-mindset messages need to be delivered to students throughout the school environment. It is therefore suggested that teachers receive professional development on implicit theories
of intelligence to ensure a constant message is being transmitted to students. As the beliefs of both students and teachers are entwined (Leder et al., 2002), professional development offers a place in which teachers’ can begin to assess and change their beliefs. Professional development opportunities have been seen to alter the beliefs of teachers leading to changes in the choices of their instructional practices (Koellner, Jacobs, & Borko, 2011). As teachers begin to alter their beliefs, changes in instructional practices will initiate transformations to student beliefs of learning and mathematics (Leder et al., 2002). There is a range of resources to teach practitioners about the growth mindset. Time seems to be the one important constraint to consider, as various educational reforms demand time for professional development. However, it is important the teachers are provided adequate time to understand and take on these growth mindset beliefs as their own to limit reinvention which frequently occurs during implementation (Rogers, 2003).

Implications for Policy Makers

Organizations such as school districts function in a world of influences, calculation and bargaining (Crozier & Friedberg, 1980). Development of a strategic plan for local policy changes to include a growth mindset intervention to aid in the development of non-cognitive skills in students is important and the results of this study demonstrate it is feasible. Equality and equity are commonly utilized evaluative criteria in choosing a policy alternative (Bardach, 2012). Since the Coleman Report (Coleman et al., 1966) equity and access has, and continues to be, a federal and state goal of K-12 education (Zhao, 2016). The ability to conduct the growth mindset intervention online or through a blended environment could ensure fairness for all students. Equity and equal
are not synonyms for each other as opportunities to learn vary for different students (Banks, 2015). The online platform of the intervention would allow alterations to be made to ensure the best educational experience for all students. For instance, to increase the opportunity to learn of the increasing number of English Language Learners the conversion of the workshops into other languages is suggested.

Participant engagement during intervention sessions was a concern. The construction of a blended learning environment as discussed previously could aid in improving this weakness. A greater range of activities and allowing students a choice between activities could also improve engagement and learning during the intervention. The learning management system Canvas that hosted the growth mindset workshops has introduced MasteryPaths, which allows students to choose from a selection of activities, and creates a more individualized pathway for each child. MasteryPaths could serve as another tool to provide students with a larger variety of activities and increase engagement. The convenience and low cost of a mindset intervention, as well as the greater equity it would be permit, adds to the perceived advantageousness, which would increase the rate of diffusion (Rogers, 2003).

The possibility of a growth mindset intervention is of particular interest to the researcher. The school district I am currently situated in has a blended learning initiative, which would make the plausibility of obtaining approvals for a blended growth mindset intervention high. I have already begun conducting professional development sessions for teachers focusing on the neuroscience research, growth versus fixed mindset, and practical ways a growth mindset can be supported in their classrooms. As previously explained, the importance of ensuring consistent growth mindset messages can not be
underscored and teachers and staff must be given practical ways in which to support
growth mindset beliefs within their classrooms. These sessions have included teachers
from elementary to secondary levels. While a first step can be ensuring consistency
within a school community, it is important to begin considering how to implement
growth mindset messages throughout a district.

Monetary support for a growth mindset intervention could come from Every
Student Succeeds Act (ESSA) scheduled to take effect in the 2017-18 school year,
although the direction of education remains unclear under the new administration in the
White House. ESSA places various provisions and funding opportunities for K-12
institutions to advance deeper learning to ensure that students can solve complex
problems, collaborate effectively, be critical thinkers, and become self-directed learners
(Alliance for Excellent Education, 2016). This focus is built on the principle that deeper
learning will develop competencies students need to succeed in college or a career upon
graduating high school (Alliance for Excellent Education, 2016). ESSA also placed
additional focus on K-12 institutions meeting the social and emotional learning needs of
students, which “include a range of skills, habits, and attitudes that facilitate functions
well in school, work, and life. They include self-awareness, self-management, social
awareness, and relationship skills as well as perseverance, motivation, and growth
mindsets” (U.S. Department of Education, 2016, p. 6). It seems plausible that funding for
the growth mindset intervention could come from federal funding and grants through
ESSA.

Conclusion
This study clearly showed that a growth mindset intervention can be utilized to begin to alter student beliefs of intelligence and mathematics, ultimately leading to increased academic perseverance. This study is important and contributes to the existing literature by considering the implications of a growth mindset intervention on students’ academic perseverance and mathematics beliefs, previously unconsidered. Particularly as it becomes more recognized that individuals can hold varying growth and fixed mindset beliefs dependent on a situation, it is important to consider these beliefs in specific contexts, such as mathematics. This research does call into question whether an online growth mindset intervention can be generalizable to a diverse population. While the online medium has shown promise in other studies to scale the growth mindset intervention, the current study’s findings question whether the medium is generalizable to larger and distinct schools and individuals. Further research could look at the possibility of conducting a blended learning growth mindset intervention to permit the strengths of both online and in person mediums to be harnessed. Findings also suggest that consistent growth mindset messages need to be transmitted to students throughout the school environment and therefore professional development of implicit theories of intelligence is suggested for school staff as well. The practical implications for researchers, teacher practitioners, and policy makers have a great amount of overlap and therefore connections between these stakeholders need to be forged.

An understanding of the variety of stakeholders and their objectives and priorities is critical for successful approval and implementation of any policy. Through the lens of stakeholder theory the organization should act to balance the concerns and goals of the various stakeholders (Ehrensal & First, 2008). The school board and the superintendent
need to engage all stakeholders. It will be important to consider these various individuals and groups to ensure widespread acceptance and a shared vision of any policy proposal (Onorato, 2013). The growth mindset intervention is a shift from traditional content-based instruction and its importance and purpose needs to be clearly communicated to all stakeholders.

Solutions for many of the challenges in education cannot be corrected with a “...easily identifiable silver-bullet solution” (Manna, 2012, p. 641). Zmuda et al. (2015) discuss how mindset interventions are only one singular cog in the network that needs to be in place in order for the impact of reform on student achievement to be seen. These mindset interventions are not a replacement of educational reforms, but will serve to make the changes occurring within education more effective (Yeager & Walton, 2011). This is one of many pathways that must be constructed for students to aid their success during their educational career and prepare them to become responsible global citizens. It is imperative that all stakeholders are engaged and correctly comprehend the outcomes of the proposed growth mindset intervention (Bryson & Patton, 2010; Hess, 2008). Equally important is stakeholders’ understanding that improvements can take time to be fully implemented and to see the positive outcomes that are anticipated (Hess, 2008). Education can no longer maintain its sole focus on content specific objectives when it is clear the significant role that beliefs, motivation, and perseverance play in student success.
PERSEVERANCE IN MATH CLASSROOMS

References


PERSEVERANCE IN MATH CLASSROOMS


PERSEVERANCE IN MATH CLASSROOMS


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doi:http://dx.doi.org.proxy1.library.jhu.edu/10.1016/j.ijer.2015.03.006


doi:10.1007/s10464-008-9165-0


PERSEVERANCE IN MATH CLASSROOMS


PERSEVERANCE IN MATH CLASSROOMS


PERSEVERANCE IN MATH CLASSROOMS


Perseverance in Math Classrooms


PERSEVERANCE IN MATH CLASSROOMS

Appendix A

Introduction to Student Participants

Research is being conducted by Ms. Bifulco, through Johns Hopkins University on the development of perseverance in the math classroom. You are being asked to participate in a survey over the course of two homerooms. You are in no way required to participate and you would be able to withdraw at any time. You and your parents are required to sign the letter of consent if you agree to take part in this study. Your identity will be kept confidential. I would urge you to consider participating if you feel comfortable as there is potential for greater understanding, grit and increased achievement in mathematics courses through this study. Again, there are no penalties if you choose not to participate. Please bring the signed letter of consent back to homeroom by Wednesday.
Appendix B

Student Participant Code: __________

Johns Hopkins University
Homewood Institutional Review Board (HIRB)

<table>
<thead>
<tr>
<th>Student Assent and Parental Informed Consent</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Title:</strong> Examining the development of perseverance in mathematics classrooms</td>
</tr>
<tr>
<td><strong>Principle Investigator:</strong> Dr. Christine Eith, Johns Hopkins University</td>
</tr>
<tr>
<td><strong>Date:</strong> April 13, 2015</td>
</tr>
</tbody>
</table>

**PURPOSE OF RESEARCH STUDY:**

The purpose of this research study is to determine the ways in which perseverance is fostered and encouraged in mathematics classrooms and to support teachers toward this goal. We anticipate that approximately 600 students will participate.

**PROCEDURES:**

There will be a few components for this study:

1. Your son or daughter will be asked to complete a brief survey that comprises their views and attitudes toward mathematics and to determine their current level of perseverance.
2. Your son or daughter’s prior achievement scores and GPA will be collected (without their name attached to these scores).
3. Your son or daughter may be asked to participate in a focus group that will take 30 minutes outside of class time.

Time required: Your son or daughter will be asked to participate in this study for approximately two weeks. The survey will be completed during homeroom. If selected, your son or daughter will be asked to participate in a focus group that will take 30 minutes outside of class time (either during lunch or after school).

**RISKS/DISCOMFORTS:**

There are no anticipated risks to students.

**BENEFITS:**

Potential benefits are an increased understanding of how teachers can foster perseverance in their classrooms. It is believed that students will better understand and feel more comfortable learning mathematics within these classrooms. This will also ensure students have the 21st century skills necessary for success outside of school. The potential is for greater understanding, grit and increased achievement in mathematics courses.
VOLUNTARY PARTICIPATION AND RIGHT TO WITHDRAW:

Your child’s participation in this study is entirely voluntary. You choose whether to allow your child to participate, and your child will indicate below whether he or she agrees to take part in the study. If you decide not to allow your child to participate, or you child chooses not to participate, there are no penalties, and neither you nor your child will lose any benefits to which you would otherwise be entitled.

You or your child can stop participation in the study at any time, without any penalty or loss of benefits. If you want to withdraw your child from the study, or your child wants to stop participating, please contact Ms. Christina Bifulco via phone or email:

CONFIDENTIALITY:

Any study records that identify you or your child will be kept confidential to the extent possible by law. The records from your child’s participation many be reviewed by people responsible for making sure that research is done properly, including members of the Johns Hopkins University Homewood Institutional Review Board and officials from government agencies such as the Office for Human Research Protections. (All of these people are required to keep your identity and the identity of your child confidential.) Otherwise, records that identify you and your child will be available only to people working on the study, unless you give permission for other people to see the records.

All measures will be examined by the Principal Investigator and research affiliates only (including those entities described above). No identifiable information will be included in any reports of the research published or provided to school administration. A participant number will be assigned to all surveys and the student’s achievement scores.

Surveys will be collected in either electronic or paper format. Survey data completed electronically will be collected via a password protected Google account. If the student is unable to complete the surveys electronically, paper copies will be provided. All data collected for this study will be de-identified by substituting a participant number for the person’s name prior to analysis.

Audio data of focus groups may be transcribed by an outside agent (transcriptionist), who will de-identify all transcripts by deleting all names from the transcript and only a participant number or pseudonym will be included on these transcripts.
All research data including paper surveys and audiotapes will be kept in a locked office. Electronic data will be stored on the study team member’s computer, which is password protected. Any original tapes or electronic files will be erased and paper documents shredded, ten years after collection.

**COMPENSATION:**

Your child will not receive any payment or other compensation for participating in this study.

**IF YOU HAVE QUESTIONS OR CONCERNS:**

You and your child can ask questions about this research study at any time during the study by contacting Ms. Christina Bifulco via phone or email:

If you [or your child] have questions about your child’s rights as a research participant or feel that your child has not been treated fairly, please call the Homewood Institutional Review Board at Johns Hopkins University at (410) 516-6580.

**SIGNATURES:**

**WHAT YOUR SIGNATURE MEANS:**

Your signature below means that you understand the information in this consent form. Your signature also means that you agree to allow your child to participate in the study. Your child’s signature indicates that he or she agrees to participate in the study.

By signing this consent form, you and your child have not waived any legal rights your child otherwise would have as a participant in a research study.

________________________________________________________________________
Child’s Name

_______________________________________________________________________
Child’s Signature

________________________ ________________________________________________
Signature of Parent or Legal Guardian

________________________________________________________________________
Signature of Person Obtaining Consent
(Investigator or HIRB-Approved Designee)

Date
Appendix C

Student Beliefs of Perseverance and Mathematics Survey

Dear Student,

The following survey is about the development of perseverance in high school mathematics classrooms. It is being conducted, in part, as a section of my dissertation through Johns Hopkins School of Education. This will hopefully be able to aid in the teaching and learning of mathematics and the development of perseverance in mathematics classes.

Questions in the survey will focus on your perception of mathematics, and your perseverance. It is divided into two sections, to be conducted on two separate days in homeroom. Each day should take approximately 10-15 minutes to complete the survey.

Every 10th and 11th grade student is being asked to complete the survey and every response is vital to the success of the survey. The survey report must represent the full range of experiences.

You may be assured of complete confidentiality. No one outside of the university will have access to the questionnaire you return, including anyone else in the high school. Please remember you can decide not to participate in the study at any time and just exit out of the window.

Thank you for your assistance!

Christina Bifulco
Principal Investigator
PERSEVERANCE IN MATH CLASSROOMS

Student Participant Code:__________________

PART I:

This first section of the survey has statements about your attitude toward mathematics. There are no correct or incorrect responses. Read each item carefully. Please think about how you feel about each item. Circle the number that corresponds to the strength of your agreement to each statement to best describe your feelings. Please answer every question.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Mathematics is a very worthwhile and necessary subject</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2. I want to develop my mathematical skills</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3. Mathematics helps develop the mind and teaches a person to think</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>4. Mathematics is important in everyday life</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5. Mathematics is one of the most important subjects for people to study</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>6. High school math courses would be very helpful no matter what I decide to study</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>7. I can think of many ways that I use math outside of school</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>8. Mathematics is one of my most dreaded subjects</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>9. My mind goes blank and I am unable to think clearly when working with mathematics</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>10. Studying mathematics makes me feel nervous</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>11. Mathematics makes me feel uncomfortable</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>12. When I hear the word mathematics, I have a feeling of dislike</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>13. Mathematics does not scare me at all</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>14. I have a lot of self-confidence when it comes to mathematics</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>15. I am able to solve mathematics problems without too much difficulty</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>16. I expect to do fairly well in any math class I take</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>17. I am always confused in my mathematics class</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>18. I learn mathematics easily</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>19. I have usually enjoyed studying mathematics in school</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
## PERSEVERANCE IN MATH CLASSROOMS

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>20. Mathematics is dull and boring</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>21. I like to solve new problems in mathematics</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>22. I would prefer to do an assignment in math than to write an essay</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>23. I would like to avoid using mathematics in college</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>24. I really like mathematics</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>25. I am happier in a math class than in any other class</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>26. Mathematics is a very interesting subject</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>27. I plan to take as much mathematics as I can during my education</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>28. The challenge of math appeals to me</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>29. I believe studying math helps me with problem solving in other areas</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>30. I am comfortable expressing my own ideas on how to look for solutions to a difficult program</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>31. I am comfortable answering questions in math class</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>32. I believe I am good at solving math problems.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

### PART II:

This section of the survey has statements about your perseverance. Be honest- there are no right or wrong answers. Please answer every question.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Not at all like me</th>
<th>Not much like me</th>
<th>Somewhat like me</th>
<th>Mostly like me</th>
<th>Very much like me</th>
</tr>
</thead>
<tbody>
<tr>
<td>33. New ideas and projects sometimes distract me from</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>34. Setbacks don’t discourage me</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>35. I have been obsessed with a certain idea or project for a short time but later lost interest</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>36. I am a hard worker</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>37. I often set a goal but later choose to pursue a different one</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>38. I have difficulty maintaining my focus on projects that take more than a few months to complete</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>39. I finish whatever I begin</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

165
PERSEVERANCE IN MATH CLASSROOMS

<table>
<thead>
<tr>
<th>Statement</th>
<th>Not at all true</th>
<th>Not very true</th>
<th>Sort of true</th>
<th>Very true</th>
</tr>
</thead>
<tbody>
<tr>
<td>40. I am diligent</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>41. Some people are good at math and some just aren't</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>42. In mathematics something is either right or wrong.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>43. Good math teachers show students lots of different ways to look at the same question.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>44. Good math teachers show you the exact way to answer the math questions you'll be tested on</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>45. Math problems can be done correctly only in one way</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>46. In mathematics you can be creative and discover things by yourself</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>47. Real math problems can be solved by common sense instead of math rules you learn in school</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>48. To solve math problems you have to be taught the right procedure, or you can't do anything.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>49. The best way to do well in math is to memorize all the formulas.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

50. If you understand the material, how long should it take to solve a typical homework problem? Please write your answer on the line in minutes.

51. What is a reasonable amount of time to work on a problem before you know it’s impossible? Please write your answer on the line and include units (minutes, hours, days etc.).

52. What math class(es) are you enrolled in now? Please include the level of the class (A, Honors etc.)

53. What grade are you in? Please circle the appropriate one.
   A. 9
   B. 10
   C. 11
   D. 12
54. What is your gender? Please circle the appropriate one.
   1. Male
   2. Female
Appendix D

Introductory Email for Teacher Participants:

I hope that everyone is having a great and restful break! I know I was feeling like it was time for a break! I just wanted to send a quick email to explain something that I am going to be leaving in your mailboxes on Monday morning.

I think most of you know that I am in a program to earn my doctorate degree. My dissertation being an applied dissertation, I am required to complete a needs assessment and in the coming years an intervention focusing on my chosen Problem of Practice. My problem will be focusing on development of students' perseverance in the math classroom. I would greatly appreciate if you all would be willing to complete a survey on your perceptions of student perseverance and teaching practices. The survey is completely voluntary and confidential. No login information will be collected to determine the teacher participating.

On Monday morning I will be putting a Informed Consent Form into each of your mailboxes. It gives further information about the purpose and also your rights as a participant. Please feel free to ask me any additional questions that you may have. If you agree to complete the survey please sign the informed consent and either give it to me or place it in my mailbox. Once I have the informed consent I will send you an email with the link to the survey. If you would prefer the survey on paper please let me know and I can also have this printed for you instead.

Please know that I will completely understand if you decide you do not feel comfortable participating! Have a great rest of your break!
Title: Examining the development of perseverance in mathematics classrooms

Principle Investigator: Dr. Christine Eith, Johns Hopkins School of Education

Date: March 31, 2015

PURPOSE OF RESEARCH STUDY:

The purpose of this research study is to determine the ways in which perseverance is fostered and encouraged in mathematics classrooms. Perseverance is an important 21st century skill and a standard within the Common Core Curriculum.

We anticipate that approximately 10 teachers will participate.

PROCEDURES:

You will be asked to complete a survey online in which you will be asked some open ended questions and some multiple choice questions. The questions will ask about your perception of students’ perseverance levels, instructional activities and materials, and some demographic information. The survey is expected to take approximately 30-40 minutes.

You may be asked to participate in an interview to aid in further explanation of some of the results of the survey. If asked to participate, the interview should be expected to last about 30 minutes.

RISKS/DISCOMFORTS:

There are no known sources of risk anticipated from participation in this study.

BENEFITS:

There are no direct benefits to you from participating in this study. The findings from this study may aid in the development of students’ perseverance in mathematics.

VOLUNTARY PARTICIPATION AND RIGHT TO WITHDRAW:
Your participation in this study is entirely voluntary: You choose whether to participate. If you decide not to participate, there are no penalties, and you will not lose any benefits to which you would otherwise be entitled.

If you choose to participate in the study, you can stop participation in the study at any time, without any penalty or loss of benefits. If you want to withdraw from the study, please contact Ms. Christina Bifulco via phone or email:

**CONFIDENTIALITY:**

Any study records that identify you will be kept confidential to the extent possible by law. The records from your participation may be reviewed by people responsible for making sure that research is done properly, including members of the Johns Hopkins University Homewood Institutional Review Board and officials from government agencies such as the Office for Human Research Protections. (All of these people are required to keep your identity confidential.) Otherwise, records that identify you and your child will be available only to people working on the study, unless you give permission for other people to see the records.

All measures will be examined by the Principal Investigator and research affiliates only (including those entities described above). No identifiable information will be included in any reports of the research published or provided to school administration. A participant number will be assigned to all surveys and data collected.

Surveys will be collected in either electronic or paper format. If you are unable to complete the survey electronically, a paper copy will be provided. All data collected for this study will be de-identified by substituting a participant number for the person’s name prior to analysis.

Audio data of interviews may be transcribed by an outside agent (transcriptionist), who will de-identify all transcripts by deleting all names from the transcript and only a participant number or pseudonym will be included on these transcripts.

All research data including paper surveys and audiotapes will be kept in a locked office. Electronic data will be stored on the study team member’s computer, which is password protected. Any original tapes or electronic files will be erased and paper documents shredded, ten years after collection.
Title: Examining the development of perseverance in mathematics classrooms
PI: Dr. Christine Eith
Date: March 31, 2015

COMPENSATION:
You will not receive any payment or other compensation for participating in this study.

IF YOU HAVE QUESTIONS OR CONCERNS:
You can ask questions about this research study now or at any time during the study by contacting Ms. Christina Bifulco via phone or email:

If you have questions about your rights as a research participant or feel that you have not been treated fairly, please call the Homewood Institutional Review Board at Johns Hopkins University at (410) 516-6580.

SIGNATURES:

WHAT YOUR SIGNATURE MEANS:
Your signature below means that you understand the information in this consent form.
Your signature also means that you agree to participate in the study.

By signing this consent form, you have not waived any legal rights you otherwise would have as a participant in a research study.

Participant’s Signature                       Date

Signature of Person Obtaining Consent
(Investigator or HIRB-Approved Designee)       Date
Dear Teacher,

The need to ensure students have the tenacity and perseverance to become active members in society is felt keenly in education. The following survey is about the development of perseverance in high school mathematics classrooms. It is being conducted, in part, as a section of my dissertation through Johns Hopkins School of Education.

As a math teacher, you understand the strengths and weaknesses of your student's grit and motivation. Questions in the survey will focus on your perception of students' perseverance, as well as your instructional practices, factors relating to the decisions behind these practices and your beliefs about mathematics. It will begin with some open-ended questions and also has some multiple-choice questions. It should take about 30-40 minutes to answer all of the questions.

Every mathematics teacher is being asked to complete the survey and every response is vital to the success of the survey. The survey report must represent the full range of experiences.

You may be assured of complete confidentiality. No one outside of the university will have access to the questionnaire you return, including anyone else in the high school. Please remember you can decide not to participate in the study at any time and just exit out of the window.

Please complete the survey by Monday, April 13th, and feel free to call or email me if you have any questions. Thank you for your assistance!

Christina Bifulco
Principal Investigator
cbifulc1@jhu.edu
Perseverance in Math Classrooms Survey

PART I:
Please write your answers to the following questions in the space provided. Please feel free to add pages as needed.

1. Describe mathematics using four words and why you think these words came to mind.

2. What types of instructional practices did your mathematics teachers use when you were a student in high school?

3. Do you think in general students demonstrate perseverance in the mathematics classrooms that you teach?

4. Which groups of students do you think might benefit more from the development of their perseverance?

5. Which groups of students do you think might benefit less from the development of their perseverance?

PART II:
Please indicate by circling the number the extent to which you use each of the following in your classroom instruction.

<table>
<thead>
<tr>
<th>Don’t use</th>
<th>Rarely (Average less than 1 day per week)</th>
<th>Occasionally (Average 1 day per week)</th>
<th>Regularly (Average 2 to 4 days per week)</th>
<th>Mostly (Average 4 to 5 days per week)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6. Individual projects</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>7. Textbook based problem sets</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>8. Group projects</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>9. Discussion groups</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>10. Multiple-choice questions</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>11. Open-ended response questions</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>12. Inquiry/Investigation</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>
### PERSEVERANCE IN MATH CLASSROOMS

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>13. Problem-solving activities</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>14. Worksheets</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>15. Creative/critical thinking questions</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>16. Use of various representations (graphs, data tables etc)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>17. Math problems that can be solved in many different ways</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>18. Use of math journals</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>19. Use of rubrics or scoring guidelines</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>20. Math problems that you do not have a solution to</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

#### PART III:

Please indicate by circling the number the extent to which you use each of the following in your classroom instruction.

<table>
<thead>
<tr>
<th></th>
<th>Don’t use</th>
<th>Rarely (Average less than 1 day per week)</th>
<th>Occasionally (Average 1 day per week)</th>
<th>Regularly (Average 2 to 4 days per week)</th>
<th>Mostly (Average 4 to 5 days per week)</th>
</tr>
</thead>
<tbody>
<tr>
<td>21. Interdisciplinary instruction</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>22. Lecturing</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>23. Modeling</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>24. Cooperative learning/group work</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
PART IV:

Please indicate by circling the number the extent to which you use each of the following materials in your classroom.

<table>
<thead>
<tr>
<th>Material</th>
<th>Don’t use</th>
<th>Rarely (Average less than 1 day per week)</th>
<th>Occasionally (Average 1 day per week)</th>
<th>Regularly (Average 2 to 4 days per week)</th>
<th>Mostly (Average 4 to 5 days per week)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25. Textbooks</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>26. Supplementary materials</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>27. Newspaper/magazines</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>28. Audiovisual materials</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>29. Lab equipment</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>30. Calculators</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>31. Computers/educational software/internet</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>32. Visual aids (i.e. posters, graphs, models)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

PART V:

Please select your answer with an X on the line next to your selection.

33. Do you prepare students for PARCC?

YES________
NO________
DOES NOT APPLY ________ (you do not teach any PARCC tested courses)

* For No or Does Not Apply please skip question 34

34. Please select the amount of instructional time you spend preparing students for the PARCC tests. Days are referring to school days (weekends are not included).

_______ No more than 1 day
_______ 2-4 days
_______ 1 week-9 days
_______ 2-3 weeks
_______ 1 month
_______ 2-3 months
_______ 4-6 months
PERSEVERANCE IN MATH CLASSROOMS

_________ Over 6 months

Please indicate by circling the number the extent to which you agree or disagree with the statement:

The instructional practices I use have been influenced by the following:

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Undecided</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>35. Personal Desire</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>36. Beliefs these are the best instructional practices</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>37. Format of the PARCC examination</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>38. Interest in helping my school improve PARCC exam scores</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>39. Interest in helping my students attain test scores that will allow them to graduate high school</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>40. Interest in avoiding sanctions at my school</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>41. Interactions with school principal</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>42. Interactions with colleagues</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>43. Staff development in which I have participated</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>44. Interactions with parents</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

Please feel free to leave comments regarding your selection of instructional practices at your discretion:
PART IV:

45. Please state your gender:

________ Male

________ Female

46. How long have you been teaching in total?

________ First year

________ 2-6 years

________ 7-9 years

________ 10-14 years

________ 15-19 years

________ 20-24 years

________ 25-29 years

________ 30 years or more

47. What is the highest level of education you have attained?

________ Bachelor’s Degree

________ Master’s

________ Master’s +15

________ Master’s +30

________ Master’s +30

________ Master’s +45

________ Master’s +60

________ Doctorate
Appendix G

Interview Protocol for Key Respondent:

1. As you know, in this project we are interested in the development of students’ perseverance in mathematics classrooms. Do you think perseverance is being fostered and or developed in mathematics classrooms in this school?
   a. *If yes, ask:* In what ways is perseverance fostered or developed? Can you think of any examples?
   b. *If no, ask:* What do you think hinders the development of perseverance in math classrooms?

2. Do you think perseverance is necessary for student success in mathematics classrooms?

3. Do you think in general students in this school demonstrate perseverance in the mathematics classrooms that you teach?
   a. *If responds with ‘depends’:* What does it depend on? Student attributes, math achievement, student background?

4. Which groups of students do you think might benefit more from the development of their perseverance?

5. Which groups of students do you think might benefit less from the development of their perseverance?

6. Do you think students in the school demonstrate a greater amount of perseverance in other subject areas within the school?
   a. *If yes:* In what ways?
Title: Examining the development of perseverance in mathematics classrooms through understanding learning: Teacher participants

Principal Investigator: Dr. Eric Mayes, Johns Hopkins School of Education

Date: September 1, 2016

PURPOSE OF RESEARCH STUDY:
The purpose of this research study is to determine how instruction on the brain and learning can impact the level of student perseverance in the math classroom.

We anticipate that approximately 100 people will participate in this study.

PROCEDURES:
There will be a few components for this study:

1. You will be asked to attend one twenty to thirty-minute introductory training session to explain the purpose and procedures of the study.

2. You will explain the study and distribute parental informed consent and student assent forms to students in your Instructional Seminar classes. Over a period of two to three weeks you will collect the forms in class, ensuring all signatures have been obtained.

3. You will monitor students as they complete the intervention online over three sessions of forty minutes each, one per week and complete a questionnaire at the end of each session about activities completed that day.

4. You will complete a brief survey about any perceived changes in student behavior in your mathematics class after all three sessions are complete that will take about three to five minutes for each student.

5. You may be asked to participate in an interview to aid in further explanation of some of the results of the survey. If asked to participate, the interview should be expected to last about 10 minutes.

RISKS/DISCOMFORTS:
Participation in this study may involve risks that cannot be foreseen at this time. The risks associated with participation in this study are no greater than those
encountered in daily life.

**BENEFITS:**

There are no direct benefits to you from participating in this study.

This study may benefit society if the results lead to a better understanding of how knowledge of learning can impact perseverance and achievement in math classrooms.

**VOLUNTARY PARTICIPATION AND RIGHT TO WITHDRAW:**

Your participation in this study is entirely voluntary: You choose whether to participate. If you decide not to participate, there are no penalties, and you will not lose any benefits to which you would otherwise be entitled.

If you choose to participate in the study, you can stop your participation at any time, without any penalty or loss of benefits. If you want to withdraw from the study, please contact Ms. Christina Bifulco via phone or email.

**CONFIDENTIALITY:**

Any study records that identify you will be kept confidential to the extent possible by law. The records from your participation may be reviewed by people responsible for making sure that research is done properly, including members of the Johns Hopkins University Homewood Institutional Review Board and officials from government agencies such as the National Institutes of Health and the Office for Human Research Protections. (All of these people are required to keep your identity confidential.) Otherwise, records that identify you will be available only to people working on the study, unless you give permission for other people to see the records.

All measures will be examined by the Principal Investigator and research affiliates only (including those entities described above). No identifiable information will be included in any reports of the research published or provided to school administration. A participant number will be assigned to all surveys and data collected.

Surveys will be collected in either electronic or paper format. If you are unable to complete the survey electronically, a paper copy will be provided. All data collected for this study will be de-identified by substituting a participant number for the person’s name prior to analysis.

Audio data of interviews may be transcribed by an outside agent (transcriptionist), who will de-identify all transcripts by deleting all names from the transcript and only a participant number or pseudonym will be included on these transcripts.

All research data including paper surveys and audiotapes will be kept in a locked office. Electronic data will be stored on the study team member’s computer, which is password protected. Any original tapes or electronic files will be erased and paper documents shredded, ten years after collection.
COMPENSATION:
You will not receive any payment or other compensation for participating in this study.

IF YOU HAVE QUESTIONS OR CONCERNS:
You can ask questions about this research study now or at any time during the study, by talking to the researcher(s) working with you or by calling Christina Bifulco, the study team member.

If you have questions about your rights as a research participant or feel that you have not been treated fairly, please call the Homewood Institutional Review Board at Johns Hopkins University at (410) 516-6580.

SIGNATURES

WHAT YOUR SIGNATURE MEANS:
Your signature below means that you understand the information in this consent form. Your signature also means that you agree to participate in the study. By signing this consent form, you have not waived any legal rights you otherwise would have as a participant in a research study.

Participant's Signature  Date

Signature of Person Obtaining Consent  Date
(Investigator or HIRB Approved Designee)


**Appendix I**

**Student Participant Recruitment Protocol**

<table>
<thead>
<tr>
<th><strong>Study Title:</strong></th>
<th>Examining the development of perseverance in mathematics classrooms through understanding learning: Student participants</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Principal Investigator:</strong></td>
<td>Dr. Eric Mayes, Johns Hopkins School of Education</td>
</tr>
<tr>
<td><strong>Study Team Member:</strong></td>
<td>Christina Bifulco</td>
</tr>
<tr>
<td><strong>Date:</strong></td>
<td>September 1, 2016</td>
</tr>
</tbody>
</table>

Dear teacher,

Thank you very much for agreeing to aid in this research. All 9th grade students enrolled in Algebra I are eligible to participate within this study. Please follow the script provided to introduce students to this research and offer some information. This introduction should occur as early in the school year as possible to ensure students have an adequate amount of time to return consent forms if they and their parents decide the child will participate.

Please read the following information to the students as background and give out Letters of Consent seen in the envelope upon completion. Please post a copy of this information in the classroom for students to use at their discretion and direct them to the location.

*Dr. Christine Eith and Ms. Bifulco, through Johns Hopkins University, are conducting research on the development of perseverance in the math classroom. You are being asked to participate in this research study. It is being done to learn about different strategies to help you learn. If you and your parents agree to you participating in the study, you may be asked to complete three 40-minute sessions over the course of three weeks in Instructional Seminar. A variety of activities would be completed during the sessions including watching videos, reading and discussing articles and completing surveys. A few students may be asked to participate in a 30-minute focus group during lunch after completing the three sessions in class and will be given lunch if they participate. Some participants will be assigned to a comparison group, where you would only complete a pre-test and a post-test.*

*You are in no way required to participate and you would be able to withdraw at any time. You and your parents are required to sign the letter of consent if you agree to take part in this study. Your identity will be kept confidential. Please consider participating if you feel comfortable as there is a possibility of greater understanding, grit and increased achievement in mathematics courses through this study. Participants will receive a candy bar upon the full completion of each of the three sessions and an invitation to a pizza party after all three sessions are completed. Participants within the comparison condition will get a candy bar when they complete the pre-test and when they complete the pre-test. Again, there are no penalties if you choose not to participate and you can decide not to participate at any time. Please bring the signed letter of consent back as soon as*
possible if you and your parents agree that you will participate. The sessions will begin in October.

If you have any additional questions or concerns please feel free to contact Ms. Bifulco, a study team member.
PERSEVERANCE IN MATH CLASSROOMS

Appendix J

Johns Hopkins University
Homewood Institutional Review Board (HIRB)

Parental Permission & Child Assent Form

**Title:** Examining the development of perseverance in mathematics classrooms through understanding learning: Student participants

**Principal Investigator:** Dr. Eric Mayes, Johns Hopkins School of Education

**Date:** September 1, 2016

**PURPOSE OF RESEARCH STUDY:**

The purpose of this research study is to determine how instruction on the brain and learning can impact the level of student perseverance in the math classroom.

We anticipate that approximately 100 children will participate in this study.

**PROCEDURES:**

There will be a few components for this study:

1. Your son or daughter will be asked to complete three 40 minutes sessions during their Instructional Seminar class to teach them about various learning strategies. One session will be completed each week. Sessions will include a variety of activities including some brief surveys on their views and attitudes toward mathematics and to determine their current level of perseverance.

   2. Your son or daughter’s grades and GPA may be collected (without their name attached to these scores).

   3. Your son or daughter may be asked to participate in a focus group that will take 30 minutes outside of class time during lunch.

Time required: Your son or daughter will be asked to participate in this study for approximately five weeks. If selected, your son or daughter will be asked to participate in a focus group that will take 30 minutes outside of class time (either during lunch or after school).

**RISKS/DISCOMFORTS:**

The risks associated with participation in this study are no greater than those encountered in daily life.

**BENEFITS:**

Through the sessions your child may acquire various strategies and knowledge to aid them in being successful in school.
This study may benefit society if the results lead to a better understanding of how knowledge of learning can impact perseverance and achievement in math classrooms.

VOLUNTARY PARTICIPATION AND RIGHT TO WITHDRAW:

Your child’s participation in this study is entirely voluntary: You choose whether to allow your child to participate and we will also ask your child whether he or she agrees to take part in the study. If you decide not to allow your child to participate, or your child chooses not to participate, there are no penalties, and neither you nor your child will lose any benefits to which you would otherwise be entitled.

If you and your child choose to participate in the study, you or your child can stop participation at any time, without any penalty or loss of benefits. If you want to withdraw your child from the study, or your child wants to stop participating, please contact Ms. Christina Bifulco.

CONFIDENTIALITY:

Any study records that identify you or your child will be kept confidential to the extent possible by law. The records from your child’s participation may be reviewed by people responsible for making sure that research is done properly, including members of the Johns Hopkins University Homewood Institutional Review Board and officials from government agencies such as the National Institutes of Health and the Office for Human Research Protections. (All of these people are required to keep your identity and the identity of your child confidential.) Otherwise, records that identify you or your child will be available only to people working on the study, unless you give permission for other people to see the records.

All measures will be examined by the Principal Investigator and research affiliates only (including those entities described above). No identifiable information will be included in any reports of the research published or provided to school administration. A participant number will be assigned to all surveys and data collected.

Surveys will be collected in either electronic or paper format. If your child is unable to complete the survey electronically, a paper copy will be provided. All data collected for this study will be de-identified by substituting a participant number for the person’s name prior to analysis.

Audio data of interviews may be transcribed by an outside agent (transcriptionist), who will de-identify all transcripts by deleting all names from the transcript and only a participant number or pseudonym will be included on these transcripts.

All research data including paper surveys and audiotapes will be kept in a locked office. Electronic data will be stored on the study team member’s computer, which is password protected. Any original tapes or electronic files will be erased and paper documents shredded, ten years after collection.
COMPENSATION:

If your child is selected and satisfactorily completes the study, he or she will be invited to a pizza party for participating. He or she will also be given an incentive of a candy bar after each session successfully completed. If your child is selected for the focus group and attends, he or she will be provided lunch. If you or your child end your child’s participation before the study is completed, your child will be compensated for his or her participation up to that time, in the form of a candy bar for each session completed.

IF YOU HAVE QUESTIONS OR CONCERNS:

You and your child can ask questions about this research study now or at any time during the study, by talking to the researcher(s) working with you and your child or by calling Ms. Christina Bifulco.

If you or your child have questions about your child’s rights as a research participant or feel that your child has not been treated fairly, please call the Homewood Institutional Review Board at Johns Hopkins University at (410) 516-6580.

SIGNATURES

WHAT YOUR SIGNATURE MEANS:

Your signature below means that you understand the information in this consent form. Your signature also means that you agree to allow your child to participate in the study. Your child’s signature indicates that he or she agrees to participate in the study.

By signing this consent form, you and your child have not waived any legal rights your child otherwise would have as a participant in a research study.

________________________________________________________________________
Child’s Name

________________________________________________________________________
Child’s Signature (if applicable)      Date

________________________________________________________________________
Signature of Parent                Date

________________________________________________________________________
Signature of Second Parent (if required)             Date
<table>
<thead>
<tr>
<th>Signature of Legal Guardian (if applicable)</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Signature of Person Obtaining Consent</td>
<td>Date</td>
</tr>
<tr>
<td>(Investigator or HIRB-Approved Designee)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Witness to Consent Procedures (if required by HIRB)</td>
<td></td>
</tr>
</tbody>
</table>
Appendix K

Growth Mindset Intervention

Teacher Fidelity Measure

Teacher Name: ______________________________

Date Completed: ____________________________

1. What session was completed today?
   a. Intervention introduction and explanation of informed consent
   b. Session 1
   c. Session 2
   d. Session 3

2. Please circle the name of any student not present in class:
   a. Student A
   b. Student B
   c. Etc...

3. Were there any difficulties with technology that impacted the session?
   a. Yes
      i. If yes, please explain:
   b. No

4. Were there any other unexpected events (for instance, a fire drill) that impacted the session?
   a. Yes
      i. If yes, please explain:
   b. No

5. Were there any difficulties with particular students (for instance, refusal to complete the session)?
   a. Yes
      i. If yes, please explain:
   b. No

6. How long did students appear to spend on the session approximately?

7. Did you speak to any students about the content of the session?
   a. No
   b. Yes
      i. If yes, please give the student name and what you spoke about.
Please answer the following questions during the introduction and explanation of informed consent.

1. Did you read the script describing the intervention and informed consent?
   a. Yes
   b. No
      i. If no, please explain:

2. Was it made clear to students that informed consent must be completed by their parents and assent must be supplied by them?
   a. Yes
   b. No
      i. If no, please explain:

3. Were the students reminded that participation is voluntary and there are no consequences for not participating?
   a. Yes
   b. No
      i. If no, please explain:
Appendix L

Student Focus Group Protocol

*Students will be asked to sit in a circle and reminded that the focus group will be audio-recorded although no names will be included in the transcription. They will be asked to be completely honest as this is designed to help make the intervention better. The researcher will sit on the outside of the circle and ask the questions. They will be asked in the following order, with the following question be asked when the group participants have exhausted the conversation on the previous question.*

1. Did you feel that the information you learned about in the intervention sessions was useful? Why or why not?

2. What were the activities like?
   
   a. What, if anything, helped you to stay focused?

3. Have any of your behaviors in class changed since learning about this material? If so, please describe them.
   
   a. What do you think caused this change?
Appendix M

Students’ Perseverance Observation Instrument

Teacher’s Name: ___________________________

Student’s Name: ___________________________

Date Completed: ___________________________

1. Have you noticed a change in the amount and/or quality of homework completed? Please explain.
2. Have you noticed a change in the amount of time the student will spend attempting a mathematics problem? Please explain.
3. Have you noticed a change in the student’s level of focus during completion of mathematics work? Please explain.
4. Have you noticed a change in the amount of prompting and support the student needs to maintain focus on mathematics work? Please explain.
5. Have you noticed a change in how the student approaches new content or tasks? Please explain.


## Appendix N

### Student Pre and Post-Tests

<table>
<thead>
<tr>
<th>Question</th>
<th>Variable</th>
<th>Instrument</th>
</tr>
</thead>
<tbody>
<tr>
<td>What grade are you in?</td>
<td>Grade</td>
<td>Pretest only</td>
</tr>
<tr>
<td>What is your gender?</td>
<td>Gender</td>
<td></td>
</tr>
<tr>
<td>What is your ethnicity?</td>
<td>Ethnicity</td>
<td></td>
</tr>
<tr>
<td>You have a certain amount of intelligence and you really can't do much to change it.</td>
<td>Dweck</td>
<td>Intelligence</td>
</tr>
<tr>
<td>Your intelligence is something about you that you can't change very much.</td>
<td>Effort and</td>
<td>perseverance scale</td>
</tr>
<tr>
<td>You can learn new things, but you can't really change your basic intelligence.</td>
<td>Effort and</td>
<td>perseverance scale</td>
</tr>
<tr>
<td>When studying for math, I work as hard as possible</td>
<td>Effort and</td>
<td>perseverance scale</td>
</tr>
<tr>
<td>When studying for math, I keep working even if the material is difficult</td>
<td>Effort and</td>
<td>perseverance scale</td>
</tr>
<tr>
<td>When studying for math, I try to do my best to acquire the knowledge and skills taught.</td>
<td>Effort and</td>
<td>perseverance scale</td>
</tr>
<tr>
<td>When studying for math, I put forth my best effort.</td>
<td>Effort and</td>
<td>perseverance scale</td>
</tr>
<tr>
<td>I am very much interested in mathematics</td>
<td>Effort and</td>
<td>perseverance scale</td>
</tr>
<tr>
<td>I like to learn mathematics</td>
<td>Effort and</td>
<td>perseverance scale</td>
</tr>
<tr>
<td>I believe that I will receive an excellent grade for mathematics this year</td>
<td>Effort and</td>
<td>perseverance scale</td>
</tr>
<tr>
<td>I can understand the course material in mathematics</td>
<td>Effort and</td>
<td>perseverance scale</td>
</tr>
<tr>
<td>To me mathematics is an important subject</td>
<td>Effort and</td>
<td>perseverance scale</td>
</tr>
<tr>
<td>Taking into account the level of difficulty of our mathematics course, my knowledge and skills, I am confident that I will get a good grade for mathematics</td>
<td>Pre and</td>
<td>post test</td>
</tr>
<tr>
<td>When I have a mathematical task I exert myself in order to find the solution</td>
<td>Pre and</td>
<td>post test</td>
</tr>
<tr>
<td>I want to do well in mathematics and show my teacher that I am as good as my fellow students</td>
<td>Pre and</td>
<td>post test</td>
</tr>
<tr>
<td>Our mathematics teacher is friendly to us</td>
<td>Pre and</td>
<td>post test</td>
</tr>
<tr>
<td>Our mathematics teacher listens carefully when we ask or say something</td>
<td>Pre and</td>
<td>post test</td>
</tr>
<tr>
<td>I expect to get good grades on assignments and tests of mathematics</td>
<td>Pre and</td>
<td>post test</td>
</tr>
<tr>
<td>Our mathematics teacher gives us time to really explore new problems and to try out possible solution strategies</td>
<td>Pre and</td>
<td>post test</td>
</tr>
<tr>
<td>Our mathematics teacher explains why mathematics is</td>
<td>Pre and</td>
<td>post test</td>
</tr>
</tbody>
</table>

**Factor 1:** Beliefs about the significance of and competence in mathematics

**Factor 2:** Beliefs about the role and
<table>
<thead>
<tr>
<th>Important</th>
<th>Functioning of the teacher</th>
</tr>
</thead>
<tbody>
<tr>
<td>Those who are good in mathematics can solve many problems in a few minutes</td>
<td>Factor 3: Beliefs about mathematics as a learnable subject</td>
</tr>
<tr>
<td>Solving a mathematics problem requires much thinking</td>
<td></td>
</tr>
<tr>
<td>Our mathematics teacher cares that we feel at ease when we learn new things</td>
<td></td>
</tr>
<tr>
<td>Our mathematics teacher first shows step by step how we have to solve a specific mathematical problem, before he gives us similar exercises</td>
<td></td>
</tr>
<tr>
<td>My main concern when learning mathematics is to get a good grade</td>
<td></td>
</tr>
<tr>
<td>Mathematics is continuously evolving. Many things remain to be discovered</td>
<td></td>
</tr>
<tr>
<td>Our mathematics teacher cares how we feel in the mathematics lessons</td>
<td></td>
</tr>
<tr>
<td>I think that I will be able to use what I have learned in mathematics also in other courses</td>
<td></td>
</tr>
<tr>
<td>Our mathematics teachers understand the problems and difficulties we experience</td>
<td></td>
</tr>
<tr>
<td>Making mistakes is an important part of learning mathematics</td>
<td></td>
</tr>
<tr>
<td>Our mathematics teacher thinks that errors are okay and can be helpful for learning</td>
<td></td>
</tr>
<tr>
<td>Our mathematics teacher appreciates it when we have tried hard, even if our results are not so good</td>
<td></td>
</tr>
<tr>
<td>Our mathematics teacher tries to make the lessons interesting</td>
<td></td>
</tr>
<tr>
<td>Mathematics is used by a lot of people in their daily life</td>
<td></td>
</tr>
<tr>
<td>I can understand even the most difficult material presented in the mathematics course</td>
<td></td>
</tr>
<tr>
<td>If I work hard, then I will understand the course material of the mathematics class</td>
<td></td>
</tr>
<tr>
<td>Anyone can learn mathematics</td>
<td>Factor 4: Beliefs about mathematics as a functional necessity of school life</td>
</tr>
<tr>
<td>Only students with exceptional intelligence can learn mathematics well</td>
<td></td>
</tr>
<tr>
<td>Our mathematics teacher thinks that she/he knows everything best in mathematics and that we cannot contribute to learning mathematics</td>
<td></td>
</tr>
<tr>
<td>There is only one way to find the correct solution of a mathematics problem</td>
<td></td>
</tr>
</tbody>
</table>
Our mathematics teacher does not really care how we feel in class. She/he is totally absorbed with the content of the mathematics course.

It is a waste of time when the teacher makes us think on our own about how to solve a new mathematical problem.

We are not allowed to ask fellow students for help during classwork.

Mathematics learning is mainly memorizing.

By doing the best I can in mathematics I want to show the teacher that I am better than most of the other students.

I am only satisfied when I get a good grade in mathematics.

Please rate the usefulness of the material that you learned.

Please rate your interest in the material covered in the sessions.

Please rate your average engagement in the sessions.

During learning brain neurons
a. are dormant.
b. form new connections and strengthen old ones.
c. operate in isolation.
d. do not create new neural circuits.

What does the phrase "use it or lose it" mean when referring to neural connections in the brain?

a. Neural connections deteriorate over time.
b. Neural connections are strengthened with practice.
c. Limited use of neural connections is the cause of poor academic performance.
d. Neural connections in the brain are lost with age.

What happens in your brain when you learn something new?

a. You run out of neurons
b. You grow strong new connections between nerve cells
c. Your brain chemicals get worn out

What does neuroplasticity refer to?

a. How the brain changes throughout life
b. How the brain is like plastic
c. How your heart changes as you grow older
What do brain neurons do during learning?
- a. are inactive
- b. form new connections and strengthen old ones
- c. operate by themselves
- d. don’t create new neural circuits
### Research Question

#### RQ1

<table>
<thead>
<tr>
<th>Measures</th>
<th>Data Collection</th>
<th>Data Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sessions completed per schedule</td>
<td>Teacher reports collected once after introduction of intervention and after each session</td>
<td>Logic model mapping</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Measures</th>
<th>Data Collection</th>
<th>Data Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teachers followed protocols</td>
<td>Student completed questions on content on post-test</td>
<td>ANOVA</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Measures</th>
<th>Data Collection</th>
<th>Data Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Essential elements of intervention seen only in treatment not comparison condition</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### RQ2

<table>
<thead>
<tr>
<th>Measures</th>
<th>Data Collection</th>
<th>Data Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of sessions completed</td>
<td>Teacher report to include attendance rosters- collected after each session</td>
<td>Attendance rate as a percentage</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Measures</th>
<th>Data Collection</th>
<th>Data Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of activities completed in each session</td>
<td>LMS data retrieved after each session on length of time spent on session</td>
<td>Percentage activities completed for each participant</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Measures</th>
<th>Data Collection</th>
<th>Data Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student perceptions and engagement in intervention activities</td>
<td>Student completed questionnaire</td>
<td></td>
</tr>
</tbody>
</table>

#### RQ3

<table>
<thead>
<tr>
<th>Measures</th>
<th>Data Collection</th>
<th>Data Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dweck’s (1999) self-reporting measure of students’ beliefs/theories of intelligence</td>
<td>Included within pre and post-test questionnaires completed by all participants</td>
<td>Regression analysis or t-tests</td>
</tr>
</tbody>
</table>

#### RQ4

<table>
<thead>
<tr>
<th>Measures</th>
<th>Data Collection</th>
<th>Data Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>De Corte (2015) self-reporting measure of students’ Mathematics-related Beliefs Questionnaire</td>
<td>Included within pre and post-test questionnaires completed by all participants</td>
<td>Regression analysis or t-tests</td>
</tr>
</tbody>
</table>

#### RQ5

<table>
<thead>
<tr>
<th>Measures</th>
<th>Data Collection</th>
<th>Data Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marsh et al.’s (2006) self-reporting measure of academic perseverance of students</td>
<td>Included within pre and post-test questionnaires completed by all participants</td>
<td>Regression analysis or t-tests</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Measures</th>
<th>Data Collection</th>
<th>Data Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher reports of changes in students’ academic perseverance (Blackwell et al., 2007)</td>
<td>Teacher open-ended feedback on students collected after all three sessions completed</td>
<td>Qualitative coding to determine positive, negative or no growth</td>
</tr>
</tbody>
</table>
### Appendix P

Timeline of Intervention Activities

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
</tr>
</thead>
</table>
| End of August – Beginning of September | - Obtain informed consent from teachers  
- Complete training with teachers on procedures and their responsibilities during intervention (20-30 minute session) |
| September 2016              | - Obtain informed consent from students/parents  
- Use cut-score to assign participants to treatment and comparison conditions |
| Middle October 2016         | - Administer pre-test to treatment and comparison participants  
- Administer initial instrument to student’s teachers to obtain pre-intervention measures of student perseverance and achievement |
| Middle of October – Beginning of November 2016 | - Participants will complete three intervention sessions of 40 minutes each (half of the block), one session per week. Four weeks will be allotted to ensure completion of all three sessions.  
- Teachers facilitating sessions will complete Teacher Fidelity Measure after each session and return to researcher  
- Researcher will review student responses and intervention activities through the Canvas LMS throughout time period |
| Middle to end of November 2016 | - Treatment and comparison participants will complete post-test  
- Focus group of eight participants will be completed |
| End of November – Beginning of December 2016 | - Teachers complete report on their perceptions of changes in participants’ perseverance |
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Christina_Bifulco@yahoo.com

Education
Ed.D. 21st Century Teaching and Learning, 2017 • Johns Hopkins University
M.A. Teaching, Secondary Education: Math, 2008 • The College of New Jersey
B.S. Civil Engineering, 2004 • Rutgers University

Experience
Morristown High School, Morristown, NJ • September 2011 - Present
• Mathematics Teacher & Design Team Member

Johns Hopkins School of Education, Baltimore, MD • September 2016 - Present
• Graduate Teaching Assistant

The College Board, Princeton, NJ • June 2016 & June 2017
• AP Calculus Reader

South Brunswick High School, South Brunswick, NJ • April 2011 – June 2011
• Maternity Leave Replacement Math Teacher

Springwood High School, Kings Lynn, England • September 2008 – April 2011
• Mathematics Teacher

Certifications & Awards
• CEAS, Secondary Education: Mathematics, State of New Jersey, August 2008
• Qualified Teacher Status, 2010, England
• Google Certified Teacher, Level 1, December 2016