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A Quantitative Study: The Relationship Between School-Wide Instructional Practices, Teacher Beliefs, and Growth Mindset and Value-Added Student Growth in Elementary Mathematics for Grades 3–5

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A QUANTITATIVE STUDY: THE RELATIONSHIP BETWEEN SCHOOL-WIDE INSTRUCTIONAL PRACTICES, TEACHER BELIEFS, AND GROWTH MINDSET AND VALUE-ADDED STUDENT GROWTH IN ELEMENTARY MATHEMATICS FOR GRADES 3–5

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Title: A Quantitative Study: The Relationship Between School-Wide Instructional Practices, Teacher Beliefs, and Growth Mindset and Value-Added Student Growth in Elementary Mathematics for Grades 3–5

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This study investigated the correlation between instructional practices, teacher beliefs, and teacher mindset on elementary student growth in mathematics. Growth was considered as the Average Growth Index (AGI), a value-added metric derived from the Pennsylvania System of School Assessment. The study exclusively focused on Pennsylvania elementary schools responsible for teaching mathematics in Grades 3, 4, and 5 only. Publicly available AGI scores for the 2014-2015 school year were identified as the measure of student growth in mathematics. School district superintendents, elementary school principals, and classroom teachers were identified and linked to preexisting AGI scores. Three existing, validated surveys designed to quantify school-wide levels of instructional practices, teacher beliefs, and growth mindset were administered to elementary teachers who provided permission and agreed to participate in the study. Results were correlated to AGI using statistical regression models to ascertain the extent each independent and interdependent block of variables was predictive of AGI.

Although the sample size fell short of the recommended size for the statistics utilized, the data set showed little indication of failing to meet assumptions of linearity, homoscedasticity, and multicollinearity. Because of the normality of the sample, it can be inferred that a more robust sample size may have reached significance for some or all of the regression analyses. Pearson correlations revealed several important positive relationships existed among the 6

independent variables identified for this study. For all 4 research questions, the null hypothesis failed to be rejected, demonstrating that not enough evidence was available to suggest the null hypotheses were false at the 95% confidence level.

Based on analysis of variance adjusted *R*-squared effect size for each regression, it can be gleaned the 6 independent variables studied were positively correlated to student growth in mathematics. To varying degrees, instructional practices (Social Constructivist Orientation and Transmission Orientation), teacher beliefs (Teacher Allowance for Student Struggle with Problems, Teacher Modeling for Incremental Mastery, and Teachers' Awareness of their Students' Mathematical Dispositions), and teacher mindset (Growth or Fixed Mindset) were either interdependently, or independently, positively correlative and predictive of AGI.

ACKNOWLEDGMENTS

First and foremost, this dissertation is dedicated to my family—my wife Melissa and my two sons Domenic and Geno. To Dom and Geno—it is my hope that completing this terminal degree will serve as an example throughout your academic and professional careers. If you put your mind to it, and make your best effort, you both can do whatever you dream of. Don't ever forget that commitment, effort, and perseverance are required to complete worthwhile tasks. Mom and Dad will always be there to love, support, and encourage you every step of the way. To Melissa—you graciously endured this lengthy and time-consuming doctoral program and dissertation writing process. No matter the trials and tribulations it created, I always knew that I had your unconditional, loving support— and, that you were proud of my efforts and eventual accomplishment. I love you—we finally made it! We can now focus on moving and starting anew in our new home.

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I also extend a debt of gratitude to my committee members, Dr. Paquette and Dr. Reilly. Dr. Paquette—as your doctoral student you empowered me as an academic writer, and as your graduate assistant you provided a wealth of real-world academic experience to extend my professional knowledge in education. And Dr. Reilly—thank you for providing your valuable time and professional expertise in the area of school mathematics. Your input and feedback were invaluable to clarifying several key aspects of this dissertation, particularly with the refinement for Chapter 5. To my entire committee, it was always my pleasure throughout this process. Thank you!

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CHAPTER 1

THE PROBLEM

The Every Student Succeeds Act of 2016, the newest reauthorization of the Elementary and Secondary Education Act of 1965, succeeded the 13-year-old No Child Left Behind Act of 2002 (U.S. Department of Education, n.d.). The Every Student Succeeds Act eliminated the federal system "that judged U.S. schools based on math and reading test scores and required them to raise scores every year or face escalating penalties" (Layton, 2015, p. 1). Although No Child Left Behind was increasingly criticized for its federally mandated accountability approach to improving education, the resulting successes and failures led to important dialogue for improving educational outcomes for all students (U.S. Department of Education, n.d.). Senator Lamar Alexander (Rep.) of Tennessee, an architect of the new law, in discussing criticisms of the No Child Left Behind Act, said they helped bipartisan lawmakers "to remember that the path to higher standards and better teaching and real accountability is community by community, classroom by classroom, state by state, and not through the federal government dictating the solution" (Davis, 2015, p. 22). Alexander and his colleagues recognized federally mandated protocols failed to meet the No Child Left Behind Act goal of 100% students being *proficient*, a word that Andrew Ho at the Harvard Graduate School of Education has called a "weasel word" (Kamenetz, 2014, p. 1). Ho established that considering proficiency as a measure of learning effectively "inspires consensus where there really is none" (Kamenetz, 2014, p. 1) adding that that No Child Left Behind Act policymakers "turned an aspirational goal that inspires support, into a target for accountability, meant for consequences" (Kamenetz, 2014, p. 1). Despite its practical and philosophical shortcomings and failure to produce 100% student proficiency, however it might be considered, the No Child Left Behind Act widely increased examining student achievement in reading and mathematics via standards-based testing results at the state and national level. Empowered through efforts to recognize individual student growth, versus simply achievement relative to grade-level standards, value-added growth measures were developed as an alternative means to determine school and teacher effectiveness. The Association for Supervision and Curriculum Development reported that value-added modeling "levels the playing field by using statistical procedures that allow direct comparisons between schools and teachers—even when those schools are working with quite different populations of students" (Doran & Fleischman, 2005, p. 85). The Pennsylvania Value-Added Assessment System (PVAAS) provided an alternative approach to measure the efficacy of schools and teachers in value-added terms, based on yearly student progress, rather than the percentage of students able to meet an absolute standard (Ballou, Sanders, & Wright, 2004).

> Enthusiasm for this approach stems, in large part, from removing the effects of factors not under the control of the school, such as prior performance and socioeconomic status, and thereby provides a more accurate indicator of school or teacher effectiveness, than is possible when these factors are not controlled for. (McCaffrey, Lockwood, Koretz, Louis, & Hamilton, 2004, p. 2)

Realizing that many students may already start school behind their peers, value-added models provide schools with information regarding relative student performance to inform, and drive, efforts to more rapidly close existing achievement gaps.

Although standardized test data cannot provide all of the information necessary to determine the effectiveness of a teacher or school, they can be invaluable with linking student outcomes to specific teachers or schools (Wright, Sanders, & Rivers, 2006). Thus, in the midst of yet another reform effort to increase U.S. students' mathematics performance, teacher educators need to find new and better ways, such as utilizing value-added data, to improve student learning outcomes for learning mathematics.

Statement of the Problem

For nearly 30 years, U.S. students have underperformed in mathematics relative to their international peers. U.S. 15-year-olds ranked 25th in math and 21st in science achievement on the most recent international assessment conducted in 2006. "At the same time, the United States ranked relatively high in inequity, with the third largest gap in math and science scores between students from various socioeconomic groups" (Jerald, 2008, p. 5). Despite decades of reform efforts aimed to address these longstanding issues, relatively little has changed either in assessment results or in mathematics' classrooms nationwide. Although the National Council of Teachers of Mathematics (NCTM) first introduced its Curriculum and Evaluation Standards for School Mathematics in 1989, curriculum development and teaching practices have changed little over the past 25 years. "Surveying most unsuccessful expensive attempts at school reform in our past, historians Tyack and Cuban (1995) observed the same mistakes, in particular top–down remedies and a marked lack of teacher involvement with reform" (Rose, 2014, p. 1). The message remained clear; U.S. reform efforts for the teaching and learning of mathematics have largely failed, the question that remains is, why? The domestic and international research base provided wide-ranging foundational evidence to consider the best methods for helping students to learn, understand, and apply mathematics.

International assessments have provided the United States a broader context within which to understand student learning and teaching practices, adding to the knowledge base on how to improve curriculum and instruction. Van de Walle (2004) noted long-term efforts to shift the direction of mathematics education in U.S. schools towards an increasingly student-centered constructive approach to teaching mathematics. Yet, despite over 25 years of such effort, Van de Walle admitted the original 1989 NCTM vision has not been realized. Research showed that several considerations beyond curriculum and instruction might have contributed to stalling the movement's progress (Cuban, 1988). Based on the results of the First International Mathematics Study, Husen (1967) first declared U.S. mathematics curriculum to be "a mile wide and an inch deep." Davidson and Mitchell (2008) pointed out "that since 1967, as now, one plausible explanation of the relatively poor performance of American students in international tests of comparison was the large number of curricular topics covered, many of the topics that had been previously introduced" (p. 148). Yet, the U.S. 24th out of 29 ranking of developed countries on the 2003 Program for International Student Assessment, focused on mathematics literacy and problem solving, suggested a deeper pedagogical problem irrespective of the depth or breadth of U.S. mathematics curriculum (Slavin, 2008). Although curriculum certainly mattered, instructional practices appeared to be more problematic for U.S. classrooms (Ball, Hill, & Bass, 2005). A look into U.S. classrooms provided evidence of both the pedagogy and mathematics being taught.

In a study of teaching practices in Germany, Japan, and the United States, Stigler and Hiebert (1999) found that teachers in the United States continued a tradition to present mathematics as a large collection of terms and procedures. This extensive observational research found typical U.S. mathematics lessons consisted of a teacher-led presentation, followed by a quick-paced question-and-answer session, with the teacher demonstrating solution methods and having students work very similar problems, and then closing the class by assigning more similar type problems for homework (Roth McDuffie & Mather, 2006). Such traditional didactic teaching methodology stands in contrast to the constructivist, student-centered, conceptually based approach to learning mathematics research shows can increase students' ability to learn, understand, and apply, complex mathematics concepts (National Mathematics Advisory Panel, 2008). Teacher educators must determine why this gap between research and practice continued to exist, what the root causes may be, and whatever interventions are appropriate and available to remedy these variables. Evidence suggested previous reform attempts for the teaching of mathematics failed to produce the systematic changes necessary to do so.

Ball et al. (2005) established

> That research and experience consistently revealed that although the typical methods of improving U.S. instructional quality have been to develop curriculum, and—especially in the last 2 decades—to articulate standards for what students learn, little improvement is possible without direct attention to the practice of teaching. (p. 14)

As states and schools implement the Common Core State Standards for Mathematics (CCSS-Mathematics), the adoption necessitates that "teachers adapt to a new set of learning expectations that are clearer, deeper, and often more rigorous than previously required. Teachers are now required to develop students' conceptual understanding, procedural skills and fluency, and application, with equal intensity" (Conley, 2014, p. 5).

Theoretical Perspective

As is true when considering demonstrated student learning in all content areas, influences from both within and outside of the control of teacher educators impact levels of success with doing so. Specific to mathematics and the current shifts in content and pedagogy, a direct focus on teachers, situated within the greater context of those factors beyond their control, is considered from a theoretical perspective that is introduced here and extended upon through a review of the literature in Chapter 2.

Ernest (1989) asserted that teachers' pedagogy in the classroom depends upon their philosophical perspective of teaching and learning, which is driven by their beliefs about the practices for effective classroom teaching and learning. Beswick (2006) found that teacher beliefs are related to teachers' ability to create classroom environments that can be described as constructivist, and that such beliefs, rather than particular teaching methods or materials, shape teachers' instructional practices. Yates (2006) determined significant relationships exist between teachers' beliefs, practices, and reform practices, with related studies showing substantial coherence among teachers' beliefs, and associations between their beliefs and instructional practices (Stipek, Givvin, Salmon, & MacGyvers, 2001). It is clear that overcoming previously learned or formed beliefs are difficult and challenging for teacher educators.

Although research found that beliefs influence practice, a research gap exists linking productive or unproductive beliefs, practices, and teacher- or school-specific effects on academic growth (NCTM, 2014). Further complicating the notion of beliefs in education is that individual teacher beliefs naturally are situated within existing school or community cultures or norms, vary from student to student and teacher to teacher, can be influenced by school structures and leadership decisions, and may also vary with mandated curriculum, instruction, and assessment decisions. Gaining an insight into the root causes of such beliefs may provide an understanding of how teachers and school leadership may be able to overcome such hindrances, in order to enable teachers to improve in these areas.

For decades, beliefs have been a significant part of the discourse in the mathematics education community, as teachers' instructional decisions are considered to be a product of their beliefs (Hudson, Cross Francis, Rapacki, & Lee, 2015). The challenge for more effective "preservice and in-service teacher development is not merely to influence what teachers believe—it is to also influence how or why they believe it" (Brousseau, Book, & Byers, 1988, p. 39). Leatham (2006) added that when it comes to making pedagogical decisions, "there are certain desirable beliefs teacher educators want teachers to hold; they also want those beliefs strongly to influence practice" (p. 100). Research into students' achievement in mathematics, at all ages, is positively influenced by teachers who exhibit a growth-oriented mindset (Boaler, 2013).

Significance of the Study

Evidence suggested that teachers matter and that instructional change must start from the bottom, as opposed to the often-failed top–down approaches of the past (Rose, 2014). Ball et al. (2005) established

> That research and experience consistently reveal, that although the typical methods of improving U.S. instructional quality have been to develop curriculum, and—especially in the last decade—to articulate standards for what students learn, little improvement is possible without direct attention to the practice of teaching. (p. 14)

Ball et al. (2005) also added "that studies over the past 15 years consistently revealed that the mathematical knowledge of many elementary level mathematics teachers is dismayingly thin (p. 15). Hill, Ball, and Schilling (2004) also originated "that content knowledge refers to more than the mathematics knowledge held by any well-educated adult, indicating that effective teachers develop specialized pedagogical knowledge for teaching" (p. 12). Specifically, their findings suggested the utility of continuing to identify the content, so to speak, of specialized knowledge of content and thus expanding notions of the knowledge needed to teach it. Although mathematics content and specialized content and pedagogical knowledge for the teaching of mathematics has shown to impact teacher behaviors, previous notions and beliefs about mathematics brought to classrooms by teachers are most critical to how teachers will decide to teach math (Kajender, 2005). This study sought to determine the patterns of beliefs, and mindsets most correlated to research-based instructional practices teachers enact in their classrooms.

Some critics (Bishop, Clopton, & Milgram, 2012; Kirschner, Sweller, & Clark, 2006; Wu, 1997) argued the very philosophical grounding of the reform movement to improve mathematics instruction has actually contributed to the issue of U.S. students falling behind in mathematics. Terms such as *fuzzy* math often refer to the aforementioned constructivist approach to teaching mathematics emphasized by the Principles and Standards for School Mathematics (NCTM, 2000), with its reduced emphasis on explicitly taught procedures and skills. Critics, such as Hechinger (2006), ignored the notion that real mathematics required problem solving and student decision making, and pointed out the NCTM Curriculum Focal Points release, suggesting that the document represented a reversal of previous suggestions for curriculum and instruction set forth by the organization. Supporters countered that the focal points were actually a necessary step to initiate a national discussion to ultimately bring consistency and coherence to the U.S. mathematics curricula (Davidson & Mitchell, 2008). The National Mathematic Advisory Panel was appointed in 2006 by President Bush to advise the president and the United States Secretary of Education on the best use of scientifically based research to advance the teaching and learning of mathematics (NCTM, 2008), whose final report impacted the subsequent development of the CCSS-Mathematics.

Today’s shift to CCSS-Mathematics, specifically Pennsylvania Core State Standards in Pennsylvania, “represents an opportunity to reenergize and focus our commitment to significant improvement in mathematics education” (Leinwand, Huinker, & Brahier, 2014). Schmidt, Houang, and Cogan (2011) contended the nearly universal adoption of CCSS-Mathematics also provided a renewed opportunity to consider more demanding teacher preparation for elementary math teachers, because, according their internationally benchmarked research, U.S. preservice teachers have not received adequate coursework for both content and pedagogy.

A coherent national curriculum represents a potential opportunity international colleagues have benefited from tremendously (Schmidt & Burroughs, 2013). A nationally adopted curriculum can provide teachers an unprecedented opportunity to

> Work together with a shared language and goals; new teachers can receive clear guidance on what to teach; professional development may be anchored in the curriculum that teachers teach; textbooks may be more focused and go into greater depth with a smaller set of topics; and transient students may more easily adapt to new schools. (Schmidt, Houang, & Cogan, 2002, p. 16)

All of these factors can contribute to greater consistency and quality across schools. Meeting the differentiated needs of all students requires teachers to implement a balanced, comprehensive, and rigorous mathematics curriculum. However, a sound curriculum is just one key component for student success in mathematics, as curriculum implementation is significant.

Hill, Rowan, and Ball (2005) determined effective classroom instruction is even more important than curriculum. To improve mathematics achievement for all students, however, “teachers must be willing to ask questions about old habits and new trends and to adopt different ways to reaching old and new goals” (Hancock, 2005, p. 1). This research facilitated an examination of teacher beliefs, practices, and mindsets for effective teaching and learning of elementary mathematics.

Study Purpose

The purpose of this nonexperimental correlational relationship study was to determine the correlational relationship between teacher beliefs, practices, and growth mindset and the variable of value-added student growth. Value-added models "isolate the effects of outside factors—such as prior performance or student characteristics—from student achievement in order to determine how much value teachers, schools, and programs added to students' academic growth" (Hull, 2007, para. 33). Understanding teacher beliefs that may correlate to instructional practices and measurable student growth, as measured by PVAAS Average Growth Index (AGI), will establish a statewide baseline correlation between the most effective teachers and schools and the most widely shared beliefs for the teaching and learning of mathematics. The study results will begin to inform both short- and long-term preservice preparation and in-service professional development efforts in Pennsylvania, and beyond, at the elementary K–5 level. In sum, the purpose of this study is to recognize strengths and weaknesses; and, formatively, to utilize the results to identify and investigate potential paths for improvement.

The goal of this correlational study was to determine if there is a relationship between teacher beliefs, practices, and growth mindset to the variable of value-added student growth. Teacher beliefs, instructional practices, and growth mindset were derived and quantified from the survey instruments. *Value-added student growth* is operationally defined as the school-level AGI score, derived from PVAAS results. With this goal in mind, the following research questions were proposed.

Research Questions

1. How does the relationship amongst school-level averages of instructional practices, teacher beliefs, and teacher mindset relate to the school value-added Average Growth Index (AGI)?
2. How do school-level average instructional practices relate to school value-added Average Growth Index (AGI) when controlling for teacher beliefs and the teacher growth mindset?
3. How do school-level teacher beliefs relate to school value-added Average Growth Index (AGI) when controlling for instructional practices and the teacher growth mindset?
4. How does school-level average teacher growth mindset relate to value-added Average Growth Index (AGI) when controlling for instructional practices and teacher beliefs?

Brief Study Introduction

To address the research questions, the dependent variable of student academic growth will be determined by the Average Growth Index (AGI). Survey instruments, deemed to be valid and reliable, were administered to determine the independent variables of teacher instructional practices for teaching mathematics, teacher beliefs about the teaching of mathematics, and teacher growth mindset. Pennsylvania elementary schools were identified as potential participant schools in order to correlate with existing AGI values. Schools meeting the parameters necessary to correlate to AGI values were reduced through sampling procedures, while maintaining the minimum sample size necessary to effectively operate statistical procedures to explore the relationships reflected in the research questions. School districts and target schools were contacted for site approval and participant agreement. Teacher participant responses were considered in aggregate to determine school levels for the variables represented in the research questions. Univariate and multivariate statistical analyses were applied in order to determine the relationships reflected in the research questions.

Literature Review Framework

The subsequent literature review is grounded in the framework outlined in Figure 1, examining the interrelated considerations of the development, and significance, of academic content and practice standards for mathematics, the influence of beliefs and mindset on instructional practices, best practices for the teaching and learning of mathematics, and demonstrated student learning, in terms of academic growth and achievement.

Limitations

Although the researcher does hold preconceived notions regarding the design of the research study, each research question was objectively examined and efforts were made to reduce or eliminate subjectivity when analyzing the results. It is also worth noting self-reported affective instruments are inherently subject to response bias.

First and foremost, this study's hindering limitation was the limited sample size of school participants. Despite significant efforts to secure site approvals and participation from school district superintendents, building principals, and classroom teachers, the suggested minimum sample size for running hierarchical multiple regressions was unmet. For a regression model with six predictor variables, the recommended sample size is a minimum of $n = 79$, as calculated using http://www.danielsoper.com/statcalc/default.aspx. Although initial indications were promising, the collected sample size eventually fell short. Ninety-nine building principals provided permission to contact teachers for requesting participation in the survey. Of these approved schools, at least two teachers responded from 35 unique elementary school buildings.

The average teacher response per building was roughly 3, which should also be considered a limitation. In an ideal scenario, the number of schools would meet or exceed the minimum sample size of $n = 79$, plus all of the teachers responsible for teaching mathematics would have provided survey responses to deliver the most representative data set.

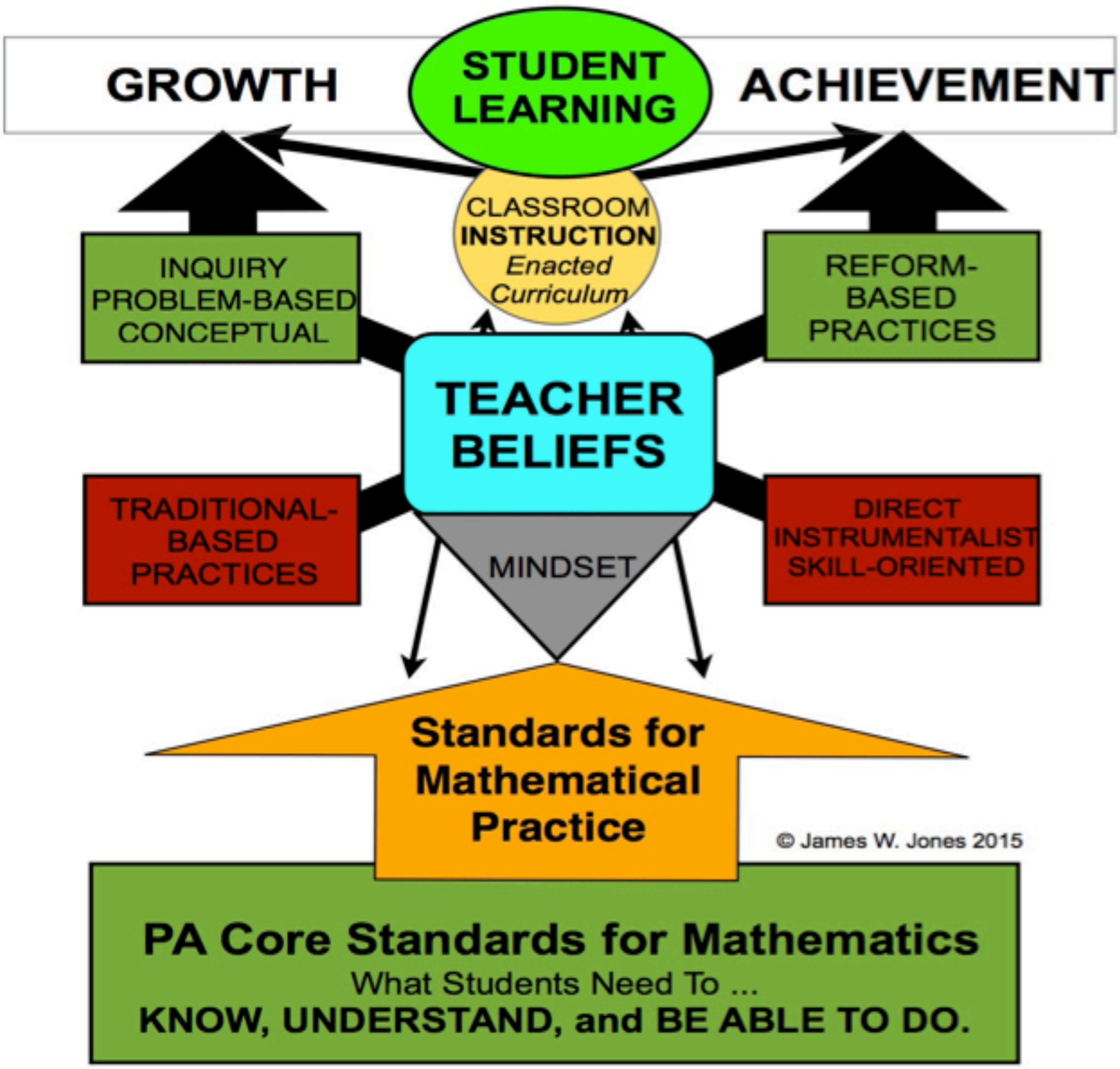

Figure 1. Conceptual framework of the review of literature for Chapter 2.

Because the researcher remains in the field as an elementary school educator, these suppositions for nonparticipation are the best that can be presented. For one, elementary classroom teachers are more overwhelmed than ever before with professional responsibilities. Today's teachers are inundated with a wider range of responsibilities for facilitating and meeting the needs and expectations of their students, principals, and district administrators. School accountability protocols and systems, in particular, have robbed productive planning time for teachers and administrators. This common theme was reflected in many e-mail denial replies from teachers and administrators alike. All things considered, the major theme for nonparticipation was a lack of time to commit to complete the survey.

Secondly, an important limitation of this study was the reliance on self-reported surveys rather than alternatives such as controlled scientific studies, observational studies, or teacher interviews. However, as mentioned in Chapter 3, studies involving surveys actually offer inherent advantages for data collection for potentially large sample pools. In addition, authors of well-designed and vetted surveys have gone to great lengths to validate the instruments.

Lastly, the timing of the study certainly may have contributed to a marginal level of principal and teacher response. Despite best efforts to expeditiously move the study forward at a more optimal time, circumstances necessitated otherwise. Once district site and building approvals were secured, the teachers first received notification of the study soon before the testing window in Pennsylvania. Anecdotally, teachers are often stressed and overwhelmed as they make last-ditch efforts to prepare students for the state assessment. Due to preparation for teaching duties, available time was quite limited, thus making a request for survey participation an easy request to ignore.

Summary

Green's (2014) *New York Times* article "Why Do Americans Stink at Math?" symbolized the notion that the reform movement for the teaching of mathematics actually never took place. Green added that "the trouble always starts when teachers are told to put innovative ideas into practice—without much guidance on how to do it. In the hands of unprepared teachers, the reforms turn to nonsense, perplexing students more than helping them" (p. 22). The intent of this correlational study was to examine teacher beliefs and practices relative to current practices situated in the midst of the current reform movement in mathematics, and to provide the dialogue and insights necessary to assist teachers, schools, and administrators with avoiding the troubling scenario shared by Green.

The increased academic rigor and depth of the mathematics found in both the revised CCSS-Mathematics content standards and Standards for Mathematical Practices is quite significant and will not be successfully realized without engaging elementary teachers in timely, rigorous, and extensive professional development. "Academically rigorous, developmentally appropriate learning environments are those in which teachers provide students with multiple learning opportunities to gain the knowledge and skills needed for success in elementary school" (Brown, Feger, & Mowry, 2015, p. 64). NCTM (2000, 2006, 2014) asserted that collaboration between researchers and teachers is critical if mathematics education research is to be responsive to questions regarding pedagogy and student learning. This study sought to identify relationships between teachers' beliefs, mindsets, and practices to reforms in mathematics at the elementary level, in order to inform efforts to improve professional development for the teaching of elementary mathematics.

Green (2014) discussed an interesting parallel, more of disconnect, between U.S. and Japanese classrooms. Green's case study involved an interview with famed Japanese elementary teacher and teacher educator, Akihiko Takahashi. As an undergraduate in 1978, Takahashi was first exposed to U.S. reform initiatives for the teaching of mathematics, learning from an influential mentor, Takeshi Matsuyama. Matsuyama taught his preservice teachers to encourage passionate discussions among children to develop a deeper conceptual understanding of common procedures and properties for themselves (Green, 2014). Matsuyama and Takahashi were at the center of revolutionizing the way students learned mathematics by radically changing the way teachers taught it (Green, 2014). The common sentiment is that the highest performing students internationally have been provided curricular and instructional approaches developed within the boundaries of the highest performing countries. The fact is that success in countries, such as Japan, was a result of implementing the research-based practices organizations such as the NCTM have promoted since the 1980s.

So, how can U.S. educators make this newest reform era a true success? The irony that Japanese teaching and learning were revolutionized through the very reforms that U.S. educators were unable to accomplish is striking. Although the U.S. education system was unable to embrace and actualize such a revolution, it is certainly encouraging to know positive results are possible should a similar shift for teaching mathematics be able to be replicated.

Definitions

Average Growth Index (AGI). "A measure of student progress across the tested grade levels in a school. This index is a value based on the growth [across] grade levels and its relationship to the standard error so that comparison among schools is meaningful. PVAAS utilizes this index (based on the standard error) to allow for a view across schools. If the standard error is not accounted for, users might get a skewed picture of the relative effectiveness of different schools" (Pennsylvania Department of Education, 2011, p. 6).

Correlation. A quantitative measure of the degree of correspondence; the degree to which two variables are correlated is expressed as a correlation coefficient, which is a value between −1.00 and +1.00 (Gay, Mills, & Airasian, 2008).

Correlational research. Research that involves collecting data to determine to what degree a relation exists between two or more quantifiable variables (Gay et al., 2008).

Common Core State Standards for Mathematics (CCSS-Mathematics). Set of academic standards in mathematics developed under the direction of the Council of Chief State School Officers (CCSSO) and the National Governors Association (NGA). The math standards include both content standards and mathematical practices outlining what each student should know and be able to do at the end of each grade. (Common Core State Standards Initiative, 2010).

Educational Value-Added Assessment System (EVAAS). "The statistical methodology used for value-added reporting in Pennsylvania. The EVAAS methodology is based on a mixed model multivariate longitudinal analyses of assessment data. In Pennsylvania, it is an analysis of the Pennsylvania System of School Assessment (PSSA). Pennsylvania's implementation of EVAAS is called the Pennsylvania Value-Added Assessment System (PVAAS)" (Pennsylvania Department of Education, 2011, p. 10).

Fixed mindset. "In a fixed mindset, people believe their basic qualities, like their intelligence or talent, are simply fixed traits" (Dweck, 2006, p.6).

Growth measure. An estimate of a school's influence on a group of students' academic progress. The growth measure value is the difference between the students' actual scores (average PSSA score) and their predicted scores (average predicted PSSA score). If students score as expected (i.e., students' observed scores are equal to their predicted scores), the estimated growth measure would be 0. The value of 0 indicates the group met the standard for PA academic growth or made their expected growth (Pennsylvania Department of Education, 2011).

Growth mindset. In a growth mindset, people believe their basic qualities, like their intelligence or talents, are things that one can cultivate through effort (Dweck, 2006). In a growth mindset, people believe that their most basic abilities can be developed through dedication and hard work—brains and talent are just the starting point.

Growth model. "Measures student achievement growth from one year to the next by tracking the same students. This model addresses the question, How much, on average, did students' performance change from one grade to the next? To permit meaningful interpretation of student growth, the model implicitly assumes the measurement scales across grades are vertically linked (i.e., that student scores on different tests across grades are directly comparable and represent a developmental continuum of knowledge and skill; Betebenner, 2009, pp. 4-5).

Inferential statistics. "Data analysis techniques for determining how likely it is that results based on a sample or samples are similar to results that would have been obtained for an entire population" (Fraenkel et al., 1993, p. 518).

National Assessment of Educational Progress. "Often called the *Nation's Report Card*, it is the largest continuing and nationally representative assessment of what the nation's students know and can do in core subjects," including mathematics (National Center for Education Statistics, n.d., para. 1)

Pennsylvania Core Standards. Pennsylvania's adopted version of the CCSS-Mathematics. Pennsylvania Core Mathematical Content Standards define what students should understand and be able to do. Pennsylvania Core Mathematical Practice Standards describes the level of expertise required to reach a level of mathematical proficiency (Pennsylvania Department of Education, 2015).

Pennsylvania System of School Assessment (PSSA). An annual standards-based, criterion-referenced assessment that provides students, parents, educators and citizens with an understanding of student and school performance related to the attainment of proficiency of the academic standards (Pennsylvania Department of Education, 2015).

Pennsylvania Value-Added Assessment System (PVAAS). "The statistical methodology used for value-added reporting in Pennsylvania. The PVAAS methodology is based on a mixed model multivariate longitudinal analyses of assessment data. In Pennsylvania, it is an analysis of the PSSA. Pennsylvania's implementation of EVAAS is called the Pennsylvania Value-Added Assessment System" (PVAAS; Pennsylvania Department of Education, 2011, p. 13).

Quantitative research. "A means for testing objective theories by examining the relationship among variables. These variables, in turn, can be measured, typically on instruments, so that numbered data can be analyzed using statistical procedures. The final written report has a set structure consisting of introduction, literature and theory, methods, results, and discussion" (Creswell, 2013, p. 5).

Trends in International Mathematics and Science Study (TIMSS). "Provides reliable and timely data on the mathematics and science achievement of U.S. [fourth- and eighth-grade] students compared to that of students in other countries. TIMSS data have been collected" (National Center for Education Statistics, n.d., para. 1) in 1995, 1999, 2003, and 2007.

Value-added growth. Students' "predicted performance on a current year test given their previous year's test score. This [value] is obtained by regressing the current year test score on the prior year test score. In other words, estimating growth addresses the question, "Compared to students with the same prior test score, is the current year test score higher or lower than would be expected?" (Lomax & Kuenzi, 2012, p. 7).

CHAPTER 2

REVIEW OF RELATED LITERATURE

Purpose of Study

The purpose of this nonexperimental correlational relationship study was to determine the correlation between teacher beliefs, practices, and growth mindset and the variable of value-added student growth. As is true with any consideration of academic growth and achievement, the influence of teachers' practice must always be considered. Marzano, Pickering, and Pollack (2001) substantiated its importance, establishing that, "although tens of thousands of research studies on effective teaching strategies have transformed the art of teaching to the science of teaching, teachers' practice remains unchanged" (p. 1). It is from this perspective that this chapter served to investigate the literature base regarding practices identified to most positively affect mathematics learning for children.

Focus of Study

The focus of this study considered mathematics education through multiple lenses, by first examining student achievement from an international perspective, narrowing down to an ultimate focus on the academic achievement and growth of third-, fourth, and fifth-grade elementary students in Pennsylvania. A brief analysis of domestic, international, and Pennsylvania-specific data trends served to introduce and frame the significance of the study, which is the demonstrated need to improve the teaching and learning of mathematics in Pennsylvania and the United States. A review of the implementation of standards-based mathematics education, previous attempts to reform mathematics education, along with the development and adoption of the Common Core Standards for Mathematics provided the foundation for investigating the current reform implementation in the United States.

The National Mathematics Advisory Panel (2008) determined that “use should be made of what is clearly known from rigorous research about how children learn, and that effort, not just inherent talent, absolutely counts in mathematical achievement” (p. 14), emphasizing the importance of considering such research and the need to recognize student growth when evaluating effective teaching and measuring student learning. For this reason, value-added statistical models of relative student achievement functioned as the primary method to determine student learning for this study.

Mathematics Performance Indicators

U.S. Domestic and International Trends

Domestic math performance indicators revealed a positive trend for elementary mathematics students, despite a slight decrease of 2 percentage points in 2015, with the percentage of fourth-grade students reaching the Trends in International Mathematics and Science Study (TIMSS) international benchmark ranking 9th out of 57 countries included in the assessment (U.S. Department of Education, 2016). Though U.S. students have recently shown increased mathematics achievement relative to international peers (U.S. Department of Education, 2015), the fact remains that only 7% of U.S. fourth-graders scored at the advanced level on the most recent TIMSS, compared to 38% of fourth-graders in Singapore, a world leader in mathematics achievement (U.S. Department of Education, 2016). From 1990 through 2013, the average performance of fourth-grade U.S. students has steadily increased with 27% more students scoring proficient or advanced from the 1990 baseline scores, while also increasing the percentage of students scoring *Basic* or above (U.S. Department of Education, 2015). Recent TIMSS results found that when compared with 1995, the U.S. average mathematics score at Grade 4 was 23 score points higher in 2011 (541 v. 518), and when compared with 2007, the

U.S. average mathematics score at Grade 4 was 12 score points higher in 2011 (541 v. 529; U.S. Department of Education, 2016). These performance indicators certainly showed a positive trend for U.S. elementary mathematics students.

Internationally benchmarked trends are not as promising, finding that

> The percentage of fourth- and eighth-grade students performing at or above the Advanced proficiency level international mathematics benchmark in 2011 was higher than in the United States in 11 education systems; was not different in 13 education systems; and was lower than in the United States in 31 education systems. (U.S. Department of Education, 2016)

As is found in national achievement indicators, Pennsylvania-specific trends include both promising and concerning data.

Pennsylvania-Specific Trends

From 2000 to 2013 Pennsylvania, on average, has ranked as the 7th highest performing state as determined by the National Assessment of Educational Progress mathematics scale score of fourth-grade public school students and percentage attaining mathematics achievement levels (U.S. Department of Education, 2016). To put Pennsylvania's ranking in greater perspective, *Education Week*'s Quality Counts indices reported that when looking at composite K–12 achievement data, Pennsylvania ranked 10th nationwide, but in terms of educational equity opportunity Pennsylvania ranked 30th in closing the poverty gap with yearly academic growth for less advantaged students (Edwards, 2016).

Considering Student Growth

As a result of his comparative review of U.S. math performance to international peers, Vigdor (2013) established that "society's goal should be to improve the status of low-performing students in absolute terms, not just relative to that of their higher performing peers" (p. 48) and that "America's lagging mathematics performance reflects a basic failure to understand the benefits of adapting the curriculum to meet the varying instructional needs of students" (p. 48). Tomlinson (2001) emphasized the robust interaction between teacher and student, and the deep respect for the identity of the individual student a teacher must have in order to design truly engaging instructional tasks, further supporting Vigdor's goals.

Considering that children develop at different rates, and they reveal different interests, strengths, and dispositions at various stages of their development (Boaler, 2005), Tomlinson's (1999) conception of differentiated instruction is key for teachers creating opportunities for students to grow mathematically. According to Tomlinson and Javius (2012), the process to differentiate instruction is consistent regardless of the range of student readiness to learn and that effective instruction is a result of teachers focusing and adapting to student readiness, interest, and learning profiles. Today's curricular and instructional decisions invariably are predicated on academic standards that define the content, knowledge, and understandings required by students, providing teachers the baseline from which to differentiate curriculum and instruction for students. Although the underlying objectives for adopting standards-based mathematics education in the United States were well intended, the consequent implementation did not aspire to the originally anticipated goals.

Academic Standards for K–12 Mathematics

Richard Marzano, a preeminent K–12 educational researcher, believed the primary lesson to be learned from U.S. students' lackluster performance on TIMSS testing, in order to improve student performance in mathematics, was to not fear the resultant downsizing of curriculum that standards-based education would produce (Schmoker & Marzano, 1999). However, the history of the standards-based movement in education is filled with evidence this 17-year-old prediction never did materialize, and, in fact, furthered the *mile-wide, inch-deep* curricular tendency U.S. mathematics educators have battled for the past 30-plus years. As early as 2001, Marzano (as cited in Scherer, 2001) reported that the 2000 National Council of Teachers of Mathematics (NCTM) Principles and Standards for the Teaching of Mathematics had yet to be efficiently and systematically implemented, calling most state level implementation attempts to be “clumsy” (p. 14) at best. Scherer (2001) added that Marzano’s nationwide analysis of state standards documents found that most became so lengthy that nearly two thirds of the standards would need eliminated to be adequately implemented within instructional time available during an academic school year. Lengthy standards actually proved counterproductive.

In contrast to the inefficient U.S. standards, international peers’ success is often attributed to a tighter and more condensed set of academic standards for mathematics. For example, Ginsburg, Cooke, Leinwand, Noell, and Pollock (2005), in an examination of TIMSS and PISA results, found the highest scoring countries were correlated with less mathematical content coverage, allowing teachers and students increased time for teaching and learning the concepts being taught. The Common Core Standards development team applied this knowledge to internationally benchmark the new learning standards for U.S. schools. However, the development of the new standards was not limited to aligning content to international peers, as vertical and horizontal coherence and best practices for teaching mathematics led to standards for both mathematical content and practices.

Common Core State Standards for Mathematics

Development of the Common Core State Standards was driven largely by a response to the new realities of the U.S. economy situated in an increasingly complex global economy

(Conley, 2014). Conley added that postsecondary data found that newly enrolled college students were inadequately prepared, as indicated by only one fourth of ACT test-takers reaching college readiness levels in English, reading, mathematics, and science (Conley, 2014). The newest reiteration of U.S. mathematics education reform, the Common Core Standards for Mathematics (CCSS-Mathematics), have local and national stakeholders embroiled in arguments and debates regarding implementation of the new academic standards, which threaten the most comprehensive wide-scale effort to reform to increase student performance in mathematics in the United States (Briars, 2014). However, because the CCSS-Mathematics is internationally benchmarked and developed utilizing an extensive body of knowledge regarding scientific research into the conditions necessary effective for teaching and learning mathematics, the debate certainly is confounding.

Despite major mathematical and science-based organizations' pronouncing support of the new standards, Johnsen, Assouline, and Ryser (2013) stated that "the new standards (CCSS-Mathematics) were not developed with the mathematically advanced learner as the focus, and as such are not sufficiently advanced to accommodate the needs of the highest mathematics students" (p. 6), an assessment that most other more influential authorities challenged. For example, Donovan and Branford (2005), through the supportive work of the National Academy of Sciences, the National Academy of Engineering, and Institute for Medicine, published an extensive document, *How Students Learn: Mathematics in the Classroom*, which simultaneously provided the cognitive science behind best practices for the teaching and learning mathematics and the demonstrated involvement, and total support, of the fields of science, technology, engineering, and mathematics. Donovan and Branford reviewed and substantiated the volumes of research regarding the conditions necessary for students to effectively learn mathematics at the highest levels. It is this body of research upon which the CCSS-Mathematics writing team drew from when developing the newest standards (Conley, 2011). These revised standards appeared to demonstrate an improvement over existing standards illustrated through significant support beyond the K–12 educational communities.

To date, the higher expectations described by the CCSS-Mathematics have now "been endorsed by every major mathematical society president, including the American Mathematical Society and the American Statistical Association," and both considered CCSS-Mathematics to be an "auspicious advance in mathematics education" (Friedberg, 2014, p. 1). The validation of the CCSS-Mathematics by third-party professional mathematics-focused organizations furthered American Institutes for Research Principal Researcher Steve Leinwand's (2014) assessment that the CCSS-Mathematics represented an extraordinary opportunity to finally shift the teaching and learning of mathematics in the United States.

> The fact that, for the first time, the U.S. has what is essentially a national curriculum, equivalent in quality to what is found in the highest scoring countries in the world, means the focus of leadership can finally shift from arguing about what math to teach, to how to best teach the agreed upon content to all students. (p. 4)

Although adoption of the CCSS-Mathematics is considered a significant step towards a coherent math education for U.S. students, the NCTM (2014) provided K–12 stakeholders a reminder that although "the new standards provide guidance and direction and help focus and clarify common outcomes, educators and policymakers need to understand that standards do not teach; teachers teach" (p. 1). In other words, to be truly realized, the standards must be correctly implemented in order to improve student learning of mathematics.

With respect to mathematical substance, coherence, and application, Friedberg (2014, p. 1), chair of the math department at Boston University, considered the new CCSS-Mathematics to be “neither ‘fuzzy’ or revolutionary, but a systematic and coherent set of real mathematics topics needed for math to make sense, while promoting problem solving, deep understanding, and accuracy for students.” Friedberg added that the requirements to simultaneously promote conceptual understanding, computational fluency, and problem solving are the abilities necessary to utilize, and apply, mathematics in the quantitative disciplines and, in general, to be college and career ready for the 21st century.

Standards for Mathematical Practice

The Mathematical Practice Standards (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010) are shown in Table 1, created by Common Core author Bill McCallum, head of the mathematics department at the University of Arizona. The practices are considered a critical component for allowing teachers and students to meet the content and assessment expectations of the CCSS-Mathematics, requiring teachers “to pursue, with equal intensity, three aspects of rigor: [a] conceptual understanding, [b] procedural skill and fluency, and [c] application” (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010).

Table 1

Grouping the Mathematical Practice Standards

1. Attend to precision. 2. Make sense of problems and persevere in solving them.	5. Reason abstractly and quantitatively. 6. Construct viable arguments and critique the reasoning of others.	Reasoning and Explaining
	7. Model with mathematics. 8. Use appropriate tools strategically.	Modeling and Using Tools
	9. Look for and make use of structure. 10. Look for and express regularity in repeated reasoning.	Seeing Structure and Generalizing

Note. From "Grouping the Mathematical Practice Standards," by B. McCallum, 2011. Retrieved from http://commoncoretools.me/2011/03/10/structuring-the-mathematical-practices/ Copyright 2011 by Bill McCallum. Reprinted with permission.

With respect to implementing effective mathematical teaching practices, Ball and Bass (2009) theorized that teachers must exhibit horizon knowledge, a notion that expert teaching requires mathematical *peripheral vision*, which the authors described as a broad view of the larger mathematics education landscape. Horizon knowledge constitutes four elements:

1. A sense of the mathematical environment surrounding the current location in instruction
2. Major disciplinary ideas and structures
3. Key mathematical practices
4. Core mathematical values and sensibilities

Irrespective of the overwhelming breadth of content standards U.S. teachers have been expected to teach, these four elements demonstrated the complexity for teaching mathematics necessary to produce high-level student achievement. International teaching peers may have been provided a more suitable breadth of content, permitting an increased depth of study for students.

Schmidt and Houang's (2012) study of internationally benchmarked standards for mathematics of the 1995 TIMSS determined a high correlation between the CCSS-Mathematics and the standards of the highest performing nations. Based on Schmidt, Houang, and Cogan's (2004) previous research linking U.S. poor average achievement to a lack of a common curriculum, the CCSS-Mathematics may provide greater consistency and quality across U.S. schools. Porter, McMaken, Hwang, and Yang (2011) described the Common Core State Standards as explicit in their focus on what students are to learn, describing the standards the new "content of the intended curriculum" (p. 103) and that the primary change is a move toward a greater emphasis on higher order cognitive demand. Pennsylvania school districts have received a similar message regarding the Pennsylvania Core Standards.

Pennsylvania Core Standards Implementation

The Pennsylvania Department of Education has provided Pennsylvania school districts clear communication regarding the transition to Pennsylvania Core Standards in regards to curriculum, instruction, and assessment. The Pennsylvania Core Standards brought with them two significant shifts for school leaders and teachers.

The first shift is that academic rigor is considered the defining element for the new standards, according to Williamson and Blackburn (2013), who elaborated on the concept of rigor. "Rigor is creating an environment in which each student is expected to learn at high levels, each student is supported so he or she can learn at high levels, and each student demonstrates learning at high levels" (Blackburn, 2008). McTighe and Wiggins (2012) established five ideas to assist schools and teachers with designing a coherent curriculum and assessment system for realizing the promise of the rigor inherent to the CCSS-Mathematics. Overall, the message was that academic standards reflected student learning outcomes and, as such, must be unpacked and mapped backwards from the desired learning outcomes, and that the standards most importantly "refer to the desired qualities of student work, and the degree of rigor that must be assessed and achieved" (McTighe & Wiggins, 2012, p. 1). Pennsylvania has heeded this guidance with increasing the rigor of state assessments for learning.

Assessment of the Pennsylvania Core Standards

The second significant shift regarding students demonstrating learning at high levels is the fact that the new Pennsylvania System of School Assessment items reflected new content and increased rigor, as determined by Depth of Knowledge level, when assessing the new standards (Pennsylvania Department of Education, 2013). Webb's (2002) Depth of Knowledge provided a framework for which to consider the cognitive complexity of assessment tasks. In mathematics, Webb (2002) established descriptors for each of the four Depths of Knowledge, providing a deeper understanding of the new expectations for students, as the majority of next generation assessment items will reflect Levels 3 and 4.

> Level 1 (Recall and Reproduction) includes the recall of information such as a fact, definition, term, or a simple procedure, as well as performing a simple algorithm or applying a formula. That is, in mathematics, a one-step, well-defined, and straight algorithmic procedure should be included at this lowest level. (p. 3)
>
> Level 2 (Skills and Concepts) includes the engagement of some mental processing beyond a habitual response. A Level 2 assessment item requires students to make some decisions as to how to approach the problem or activity, whereas Level 1 requires students to demonstrate a rote response, perform a well-known algorithm, follow a set procedure (like a recipe), or perform a clearly defined series of steps. (p. 4)

> Level 3 (Strategic Thinking and Reasoning) requires reasoning, planning, using evidence, and reaching a higher level of thinking than the previous two levels. In most instances, requiring students to explain their thinking is a Level 3 attribute. Activities that require students to make conjectures are also at this level. The cognitive demands at Level 3 are complex and abstract. The complexity does not result from the fact that there are multiple answers, a possibility for both Levels 1 and 2, but because the task requires more demanding reasoning. (p. 4)
>
> Level 4 (Extended Thinking) requires complex reasoning, planning, developing, and thinking most likely over an extended period of time. The extended time period is not a distinguishing factor if the required work is only repetitive and does not require applying significant conceptual understanding and higher order thinking. (p. 4)

The Siegler and Lortie-Forgues (2015) research study with preservice teachers, middle school students, and math and science university majors provided fascinating insight into the conceptual knowledge, and applied understanding of fractions in a diverse subject set. The results provided evidence that all subject groups demonstrated a strong understanding of fractional magnitudes (i.e., less than or greater than one-half, yet when asked to provide reasoning and explanations; a more rigorous Level 3 or 4 depth of knowledge task), regarding multiplication and division of fractions, the middle school students and preservice teachers were unable to do so. Although it may be concerning the focus of this study was specific to fractions, an earlier long-term longitudinal study of U.S. and U.K. students found that knowledge of fractions at age 10 is the most significant predictor of future algebraic knowledge and overall achievement in high school mathematics, exclusive of the effects of intellect, other mathematical knowledge, and socioeconomic background (Siegler et al., 2012).

Ball and Cohen (1999) discussed that a constructivist perspective for student learning supported cognitive science research findings that students' prior knowledge and beliefs influenced how they make sense of and learn new ideas, clarifying that most studies have focused only on students learning, assuming that learning occurred regardless of teaching practices. Tapia and Marsh (2004) also found that efforts to improve the teaching and learning of mathematics often involved a debate about traditional or constructivist teaching methodologies, when in fact affective considerations for students, such as attitudes, beliefs, confidence, and motivation have shown to be more relevant variables for student success. Because of the increased depth of the mathematics required by the CCSS-Mathematics presents school systems and teachers with a daunting task, the NCTM stepped in to fill the gap between the adoption of the CCSS-Mathematics, and the significant actions required by teachers and schools for successful implementation, to allow students to meet the required rigor of the content and practice standards, with its 2014 *Principles to Actions* document. As Ball and Cohen (1999), as well as Tapia and Marsh (2004) found, teacher beliefs indeed impacted instructional practices. Perhaps even more importantly, additional research revealed teacher beliefs indeed matter, as they directly impacted student beliefs, thus any attempt to change the practice of teachers must, of necessity, involve changes in the beliefs of teachers" (Beswick, 2004). Beliefs, although significant, are also abstruse.

Beliefs in Mathematics Education

Xiaoxia Newton, a postdoctoral scholar in the School of Education at Stanford University, was educated in Mainland China and has studied math teaching and learning in the United States. Newton provided a unique international perspective on mathematics having been a student in China, and studying mathematics education in the United States as an adult scholar, a unique personal and professional perspective reflected by existing research regarding beliefs about the nature and teaching of mathematics. Newton (2007) believed that cultural or personal beliefs about how mathematics should be taught profoundly influenced current reform efforts as much as curriculum or adopted teaching methods do. The NCTM 2014 publication, *Principles to Actions*, confirmed Newton's assertion by explicitly identifying beliefs as an obstacle to the current calls to action for more effective teaching of mathematics through the adoption and implementation of the CCSS-Mathematics.

Principles to Actions

The *Principles to Actions* (NCTM, 2014) overarching message is that "effective teaching is the nonnegotiable core that ensures that all students learn mathematics at high levels" (p. 1). Although many variables impact the teaching and learning that takes place at the classroom level, the NCTM's *Principles to Actions* considered a significant shift in teacher beliefs and mindsets as the first and foremost obstacle to completely realize the required programmatic and philosophical shifts for meeting the mathematical content and practice goals of the Common Core (Leinwand, 2014). Specifically, in his assessment, Leinwand (2014) and the *Principles to Action* development team considered the following research-based belief statements that fall into two categories, Productive Beliefs and Unproductive Beliefs, as the critical theoretical dichotomy necessary for appropriately putting the new standards into action. The beliefs statements actually reflected distinct dichotomous orientations for the teaching of mathematics; Table 2 listed the beliefs that parallel the two major competing pedagogical orientations for the teaching of mathematics often characterized by traditional-based versus reform-based practices, and inquiry or problem-based instruction versus direct or skill-oriented instruction. Research provided clear supporting evidence regarding the efficacy of the productive beliefs (NCTM, 2015).

Table 2

Teaching and Learning Beliefs

Productive beliefs	Unproductive beliefs
All students need to have a range of strategies and approaches from which to choose in solving problems, including, but not limited to, general methods, standard algorithms, and procedures.	Mathematics learning should focus on practicing procedures and memorizing basic number combinations.
The role of the teacher is to engage students in tasks that promote reasoning and problem solving and facilitate discourse that moves students toward shared understanding of mathematics.	The role of the teacher is to tell students exactly what definitions, formulas, and rules they should know and demonstrate how to use this information to solve mathematics problems.
Mathematics learning should focus on developing understanding of concepts and procedures through problem solving, reasoning, and discourse.	An effective teacher makes the mathematics easy for students by guiding them step-by-step through problem solving to ensure that they are not frustrated or confused.
Students can learn mathematics through exploring and solving contextual and mathematical problems.	Students can learn to apply mathematics only after they have mastered the basic skills.
An effective teacher provides students with appropriate challenge, encourages perseverance in solving problems, and supports productive struggle in learning mathematics.	The role of the student is to memorize information that is presented and then use it to solve routine problems on homework, quizzes, and tests.
The role of the student is to be actively involved in the making sense of mathematics tasks by using various strategies and representations, justifying solutions, making connections to prior knowledge or familiar contexts and experiences, and considering the reasoning of others.	Students need only learn and use the same standard computation algorithms and same prescribed methods to solve algebraic problems.

Note. From *Principles to Action: Ensuring Mathematics Success for All* (p. 11), by National Council of Teachers of Mathematics, 2014, Reston, VA, Author. Copyright 2014 by National Council of Teachers of Mathematics. Reprinted with permission.

Reform-Oriented Mathematics

In an extensive review of existing research on K–12 mathematics education, Ross, Hogaboam-Gray, and McDougall (2002) found that implementing reform-oriented approaches for teaching mathematics led to higher achievement than traditional approaches. A synthesis of existing research regarding effective elementary mathematics programs found that increased student outcomes on standardized tests and state accountability assessments is more a product of instructional differences, than of curricular differences, but that reform-oriented curricula did indicate an increase over traditional curricula (Slavin, 2008). Furthering this line of research, in studying existing research on K–12 mathematics education, Ross et al. (2002) also found consistent evidence of barriers to reform, the most significant being the difference between teacher beliefs and the research base for how students best learn math. Furthermore, Ediger (2009) added an attitudinal dimension in teaching mathematics must be considered. Teachers first must accept a philosophy of teaching that accepts research-based practices as a guide to improving teaching; this philosophy, however, is not always accepted (Ediger, 2009).

Hart (2002) asked, “Why are some teachers reluctant to change and hold fast to their traditional methods while others are embracing reform practices and changing the environment of their mathematics classroom?” (p. 162). Stigler and Hiebert (1999), in an ostensibly direct response to Hart, though at an earlier date, surmised that failures to alter accepted teaching practices was because

> The widely shared cultural beliefs and expectations that underlie teaching are so fully integrated into teachers’ worldviews that they fail to see them as mutable. . . Teachers fail to see alternatives to what they are doing in the classroom. (p. 100)

Thus, true curricular or instructional revision must first consider how teachers’ current classroom practices are rooted in, and mediated by, existing pedagogical beliefs (Ertmer, 2005).

Math Wars

Perhaps most challenging to overcome are often referred to in terms of the *Math Wars*. The *Math Wars* led to dichotomous and competing categories of teaching mathematics: a focus on teaching for deep conceptual understanding versus a focus on teaching mathematical procedures (Ross & McDougall, 2004). Stipek et al. (2001) found that teachers' instructional practices were often a product of their beliefs about the nature of mathematics. Teachers holding more traditional beliefs were associated with more traditional practices, and more progressive beliefs were associated with reform practices. However, in practice the established categories should represent ends of a continuum, rather than two distinct categories, and that expert teachers move through the continuum to meet curricular demand and students as displayed in Table 3 (McDougall et al., 2000; Ross, McDougall, Hogaboam-Gray, & LeSage, 2003).

Table 3

The Teacher's Role by Level

Level 1	Level 2	Level 3	Level 4
Sole knowledge expert. Student roles focus on tasks that require minimal cognitive effort.	Although teacher is knowledge expert, some student expertise is acknowledged. Students are assigned roles with the teacher being central to the activities.	Teacher shares the knowledge expertise role with the students. More teacher-directed tasks are provided for students with lower abilities, and more student-centered activities for higher ability students.	The teacher is a colearner with students. The teacher and all students are responsible for building a math community. The teacher ensures that each student is an integral part of the learning process.

Note. From "A Survey Measuring Elementary Teachers' Implementation of Standards-Based Mathematics Teaching," by J. A. Ross, D. McDougall, A. Hogaboam-Gray, and A. LeSage, 2003, *Journal for Research in Mathematics Education, 34*(4), p. 353. Copyright 2003 by Douglas McDougall. Reprinted with permission.

Teacher Considerations

Wayne and Youngs's (2003) meta-analytical review of 21 studies considering a correlation between teacher characteristics and student achievement gains, found compelling evidence that students learn more from teachers who have certain characteristics. Particularly, in the case of teachers' college ratings and test scores, positive relationships existed and should be investigated further to learn about the relative importance of specific college characteristics and tested skills and knowledge. Regarding "degrees, coursework, and certification, findings have been inconclusive except in secondary mathematics, where high school students clearly learned more from teachers with certification in mathematics, degrees related to mathematics, and coursework related to mathematics" (Wayne & Youngs, 2003, p. 107). Clark et al. (2014) cautioned researchers that studies utilizing categorical survey data to attempt to link human characteristics, such as age, race or gender, to teacher beliefs, behavior, and performance, failed to interpret or explain why certain effects might exist. Clark et al. "contended that teacher characteristics, teacher qualifications, and teaching contexts may differ in the degree to which teachers possess varying levels of teacher knowledge and hold specific beliefs about mathematics teaching and learning" (p. 5) and subsequently studied the influence of professional development on teacher beliefs finding that though preservice or in-service professional development indeed improved teachers' mathematical and pedagogical knowledge, teachers' beliefs about best classroom practices were not always changed.

Even more muddling is that teachers may hold certain progressive beliefs about mathematics teaching and learning regarded as positive, yet students perceptions of these same teachers indicated learning in teacher-centered traditional classrooms (Beswick, 2006). Beswick's (2012) later qualitative research also discovered that many teachers shared different beliefs about the nature of teaching mathematics and that these beliefs may explain inconsistencies among teachers' decisions regarding the teaching and learning of elementary mathematics and their subsequent commitment to contemporary mathematics teaching. Beliefs in mathematics education are complicated, particularly with regard to classroom practice.

Impact of Beliefs on Instructional Practice

For decades, beliefs have been a significant part of the discourse in the mathematics education community, as teachers' instructional decisions are considered to be a product of their beliefs (Hudson et al., 2015; Polly et al., 2013). "Long before they enroll in their first education course or math methods course, teachers have developed a web of interconnected ideas about mathematics, about teaching and learning mathematics, and about schools" (Ball, 1988, p. 4).

However, Goldin, Rösken, and Törner (2009) established the fact that there is no universal acceptance of a definition of teacher beliefs, and attempts to theoretically frame the notion of beliefs have proved difficult. Still, research continued to find that beliefs, however they are considered, influenced teacher practices in the classroom. Tatto and Coupland (2003) wrote the following regarding understanding the possible influence of teacher beliefs:

> While numerous studies have examined teachers' beliefs and thinking, studies examining beliefs within the teacher education context are less numerous, reviews of research, such as those by Nespor (1987) and Pajares (1992) brought awareness to the need to understand and address beliefs as necessary for understanding classroom practices. (p. 43)

Davidson and Mitchell (2008) discussed Ernest's description of the philosophical consideration of the nature of mathematics, specifically Ernest's two opposing perspectives as "the absolutist view of mathematical knowledge consisting of certain and unchallengeable truths" (p. 7) and "the fallibilist view that mathematical truth is fallible and corrigible, and can never be regarded as beyond revision and correction" (p. 18). As Ross, Hogaboam-Gray, and McDougall (2001) found, Davidson and Mitchell also believed that Ernest's classification was not dichotomous, as had been generally accepted, but that a continuum actually existed between each view. The National Mathematics Advisory Panel's (2008) extensive review of existing research into instructional practices for the teaching of mathematics also did not support that instruction should be either entirely student centered or teacher directed, but that evidence existed finding a balance of practices can have a positive impact under specified conditions. Yet, research does provide clear evidence that certain classroom conditions remain more favorable for the effective teaching and learning of mathematics, and "interpretations of beliefs, with implications for their role in mathematics teaching and learning, can be understood by exploring the psychological and/or epistemological consequences of the metaphors or analogies used to describe them" (Maasz & Schlöglmann, 2009, p. 43). Notably, Simon (1995) found that constructivism provided a useful framework for thinking about mathematics learning in classrooms.

Developing Student Knowledge of Mathematics

Teachers who created classroom environments consistent with the beliefs of constructivism were more likely to hold beliefs about mathematics that, in Ernest's (1989) schema, would be described as problem solving, along with corresponding student-centered views of mathematics teaching and learning (Beswick, 2007). In discussing the importance of developmentally appropriate and student-centered instruction, Van de Walle (2004) declared,

> The most widely accepted theory known as constructivism endorses that children must be active participants in the development of their own understanding. Constructivism

> provides us with insights concerning how children learn mathematics and guides us to use instructional strategies that begin with children rather with ourselves. (p. 22)

Constructivism

Phillips (1995) eloquently summarized the essence of John Dewey and William James' constructivist position:

> Dewey staunchly advocated the use of activity methods in the schoolroom-for students are potential knowers, yet traditional schooling forces students into the mold of passive receptacles waiting to have information instilled, instead of allowing them to move about, discuss, experiment, work on communal projects, pursue research outdoors in the fields and indoors in the library and laboratory, and so forth. (p. 11)

Beswick (2004) extended Van de Walle's (2004) declaration by providing a more explicit description of a student-centered classroom, describing it as follows:

> A constructivist classroom environment is considered to be one in which: students were able to act autonomously with respect to their own learning; the linking of new knowledge to existing knowledge is encouraged and facilitated; knowledge is negotiated by participants in the learning environment; and the classroom is student-centered in that students have opportunities to devise and explore problems that are of relevance to them personally. (p. 113)

A constructivist classroom requires that pedagogical practice for the teaching of mathematics, mathematical situations, and more mathematically rigorous content standards, are grounded in a teaching and learning context (Bednarz & Proulx, 2009). Ball, Lubienski, and Mewborn (2001) added that central to the quality of teaching are teachers' deep understanding of what they need to teach and the pedagogical practices that can be used to represent such understanding to students. It is this intersection of mathematics and elementary classroom pedagogy that is the essence of the specialized teaching knowledge necessary to meet students where they are, to successfully engage with, and demonstrate their understanding, of the mathematics (Hill et al., 2005).

Kirschner et al. (2006) negatively viewed constructivism, establishing it to be an instructional or pedagogical approach that merely utilized minimal guidance, rather than a construct through which to create meaningful opportunities for students to construct knowledge and to develop practices for learning mathematics. Kirschner et al. believed that constructivist, discovery, problem-based, experiential, and inquiry-based teaching to be instructional practices that promoted minimal guidance for students, and that research for these practices of minimally guided instruction are less effective than those with a strong emphasis on guidance of the student learning process.

However, other examples of classroom research provided examples of teachers creating guided instruction that shifts the locus of authority from teacher, as the keeper of the knowledge, to valuing students' mathematical ideas to socially construct knowledge within the classroom (Simon & Schifter, 1993). And in identifying effective mathematics learning environments and effective teacher behaviors, Protheroe (2007) provided an argument substantiating constructivism finding that though effective teachers required students to construct knowledge through solving challenging problems, the teacher remained largely responsible for orchestrating the learning through engaging mathematical tasks, questioning, and opportunities to communicate their ideas in an environment of respect and understanding. Kirschner et al. (2006) did not consider this level of teacher responsibility.

Beliefs and Reform Practices

Beswick, Watson, and Brown's (2006) research with elementary and middle school mathematics teachers found an interesting phenomenon that many teachers hold beliefs considered positive, yet do not necessarily report the appropriate corresponding pedagogies to translate their beliefs into practice demonstrating the complexity of beliefs linking to practice. Chapman's (2002) interpretative study of high school mathematics teachers found that attempts to reform the teaching of mathematics, also required a corresponding *re-forming* of teachers thinking. In the study, Chapman discovered teachers who were able to change their own practices from a predominantly teacher-centered perspective to a more student-centered perspective, through the opportunity to engage, as learners, with innovative curriculum materials associated with a reform-oriented mathematics curriculum, providing an opportunity to experience the learning from a learner's perspective. Chapman's research attempt to influence the beliefs of the learner is reflected in Beswick's (2012) categories of teacher beliefs, found in Table 4. Beswick's categories were drawn from Ernest (1989), "who established that a mathematics teacher's belief system has three parts; the teacher's ideas of mathematics as a subject for study, the teacher's idea of the nature of mathematics teaching, and the teacher's idea of the learning of mathematics" (p. 2). As Beswick acknowledged, individual teachers are unlikely to have beliefs that fit neatly in a single category, and it is entirely possible teachers may have beliefs that fall into more than one category and teach with one view in one context and another view in another context.

Table 4

Categories of Teacher Beliefs

Beliefs about the nature of mathematics	Beliefs about mathematics teaching	Beliefs about mathematics learning
Instrumentalist	Content focused with an emphasis on performance	Skill mastery, passive reception of knowledge
Platonist	Content focused with an emphasis on understanding	Active construction of understanding
Problem solving	Learner-focused	Autonomous exploration of own interest

Note. From "Teachers' Beliefs About School Mathematics and Mathematicians' Mathematics and Their Relationship to Practice," by K. Beswick, 2012, *Educational Studies in Mathematics, 79*(1), p. 130. Copyright 2012 by Kim Beswick. Reprinted with permission.

Ernest (1989, p. 1) declared the following regarding the institutional efforts and consideration of teacher beliefs required to reform:

> The teaching of mathematics. Such reforms depend, to a large extent, on institutional reform; changes in the overall mathematics curriculum. They depend even more essentially on individual teachers changing their approaches to the teaching of mathematics. However, the required changes are unlike those of a skilled machine operative, who can be trained to upgrade to a more advanced lathe, for example. A shift to a problem solving approach to teaching requires deeper changes. It depends fundamentally on the teacher's systems of beliefs, and in particular, on the teacher's conception of the nature of mathematics and mental models of teaching and learning mathematics. Teaching reforms cannot take place unless teachers' deeply held beliefs about mathematics and its teaching and learning change. (p. 1)

Walker (2007) established that "despite reformers' best efforts, classroom practice remains largely unchanged" (p. 113). This resistance, according to Ball (1996), is partly because teachers' personal beliefs and experience for learning mathematics shaped beliefs about math teaching that are quite difficult to overcome. In addition to the barrier of teacher beliefs is the pedagogical difference between reform-oriented pedagogy, which Ross et al. (2002) determined is more difficult for elementary level generalists to learn and to implement, versus traditional pedagogy, which often is scripted and easier to teach. Research has shown that the previous ideas and understandings about mathematics brought to classrooms by teachers are critical regarding how teachers will decide to teach math (Kajander, 2007). Ball (1988) added that, based on their individual experiences, "new teachers develop ideas about how to teach mathematics and about appropriate roles for students and teachers in mathematics classrooms" (p. 17). Researchers have found that despite reformers' best efforts, instructional practice remained the same due to teachers' holding fast to their own mathematics understandings, attitudes, and experiences (Walker, 2007).

Beswick (2012) found that most research regarding mathematics teaching and student achievement has focused on teachers' content and pedagogical knowledge and those beliefs about the nature of mathematics as a student, and as a teacher, warrant additional research. However, Beswick (2004) also determined "there is evidence that teachers' beliefs about themselves, their performance and the perceptions thereof of significant others, may be among the most crucial determinants of the extent to which teachers can change" (p. 4). Beswick's (2012) further qualitative research found that many teachers shared different beliefs about the nature of teaching mathematics and that these beliefs may explain inconsistencies among teachers' decisions regarding the teaching and learning of elementary mathematics and their subsequent commitment to contemporary mathematics teaching. Again, the consideration of beliefs when considering teacher practices is complicated.

Eichler (2008) concurred with Beswick (2004), finding that math educators "must have a much greater understanding of teachers' beliefs and the impact of these beliefs on students' knowledge and students' beliefs" (p. 6) in order to effectively shift pedagogy. Fives and Buehl's (2011) comprehensive review of the literature on teacher beliefs concluded beliefs are complex, multifaceted, and varied, and attempts to relate beliefs to teacher behaviors and instructional practice requires clarity in characterizing the specific belief or system being considered. Specific to research, application, and intervention, beliefs are found to be a manifestation of the previous ideas and understandings about mathematics brought to classrooms by teachers, which then become critical for how teachers will decide to teach math (Kajander, 2007).

Growth Mindset

Sparks (2013) characterized the challenge for teachers with fostering confidence and motivation to learn mathematics in stating, "It's one thing to say all students can learn, but making them believe it—and do it—can require [a] 180-degree shift in students' and teachers' sense of themselves and of one another" (p. 1). The psychological construct of a growth mindset versus a fixed mindset may provide teachers and students ways for allowing students, teachers, and schools to enable students to maximize their academic achievement. Mulholland (2014) reflected upon how the application of the construct of a growth mindset, in conjunction with the increased rigor of the Common Core State Standards, can potentially affect student achievement at the organizational level.

> The goal to improve schools through student achievement is inextricable from the mindset of the entire school community. The Common Core calls for change in the way instruction is delivered. If school leaders can embody the essence of the growth mindset

> and create learning communities that celebrate the effort and perseverance of one another, the sky is the limit! (para. 6)

Mathematical Mindsets

Scientific evidence indeed existed that mindset can actually influence student performance. Jo Boaler (2016), author of *Mathematical Mindsets*, has conducted research with thousands of students across a wide range of demographics and socioeconomics, in both public and private school settings, finding overwhelming evidence that students, and teachers, who hold a growth mindset for learning mathematics outperformed those with a fixed mindset. An even larger student study sample provided the most compelling evidence, specifically an analysis of the Organisation for Economic Co-Operation and Development's Program for International Student Assessment data set of 13 million students worldwide, finding those students with productive ideas and beliefs about mathematics and a growth mindset outscored those with unproductive ideas and beliefs and a fixed mindset by more than a grade equivalent (Boaler, 2016). It appeared that mindset matters, for both students and teachers.

Carol Dweck's groundbreaking research into mindset provided the foundation for Boaler's extension of considering a growth versus a fixed mindset relative to the teaching and learning of mathematics. Other researchers have drawn from Dweck's introduction of mindset to the literature. In their research exploring elementary student beliefs and understanding of elementary science and mathematics, Beghetto and Baxter (2012) added the following regarding Dweck's and Boaler's conception of mindset on student learning.

> A strong sense of confidence in one's ability to generate new and meaningful ideas seems necessary for the development of mathematical and scientific understanding. Indeed, it is doubtful that a scientist or mathematician, let alone a student of those disciplines, could

> persist on the path of scientific inquiry and mathematical problem solving without a strong self-efficacy. (pp. 944-945)

Dockterman and Blackwell (2014) established a student's ability to self-regulate and persist in the face of a challenge as a critical factor for academic and life success, which further supported Duckworth and Quinn's (2009) research findings that students with a growth mindset maintained task persistence when facing difficult work, demonstrating what has been defined as academic *grit*. Boaler's (2013) research in the fields of education and neuroscience provided foundational considerations for teachers and schools, including messages that intelligence is malleable, and learning leads to physical and functional brain change provided a concrete and practical way to understand and practice a growth mindset.

- The plasticity of the brain: Ability and intelligence grow with effort and practice.
- The importance of students' mindsets for learning: When students believe that everybody's ability can grow, their achievement improves significantly.
- The importance of teachers' mindsets for teaching: When teachers believe that everybody's ability can grow and they give all students opportunities to achieve at high levels, students achieve at high levels.
- The effects of ability grouping in all its different forms: These grouping practices communicate damaging fixed mindset beliefs to students. (p. 150)

As Boaler's (2013) list of considerations revealed, mindset is not entirely an individual matter. Peers, teachers, parents, and the wider school culture all can influence one's mindset; thus, teachers and schools must be cognizant of its potential impact for students (Dockterman & Blackwell, 2014). An example is Boaler's research findings that fixed mindset beliefs can "negatively contribute to inequalities in education, as they particularly harm minority students and girls; fixed mindsets also were found to contribute to overall low achievement and participation across all student demographics" (p. 150). Blad (2015) reported that Sun surveyed 3,400 students to gauge their mindset for learning mathematics and 40 teachers to gauge their mindsets for learning mathematics and to assess their instructional approaches. Through analysis of Sun's survey data and classroom observations, it was determined that teachers with a reform orientation for teaching mathematics were more likely to have a growth mindset for learning, providing additional support for Common Core shifts for mathematics (Blad, 2015). Ball and Forzani's (2009) qualitative study of prospective elementary math teachers observing primary students learning complicated mathematics were often surprised by their sophisticated ability to think, reason, and make sense while learning mathematics, changing their initial beliefs about young children's ability to learn—and their abilities to teach in more thoughtful ways.

Boaler's (2013) research continued to buck the notion that certain individuals have a *math brain* and others do not, finding that all students are able to learn mathematics when provided appropriate classroom learning norms. Certainly, however, mathematics is the academic area in which a mindset *makeover* is needed for both teachers and students (Boaler, 2016), as student effort is an important variable regarding the learning of mathematics (National Mathematics Advisory Panel, 2008).

Value-Added Student Growth

There appeared to exist a correlation between value-added growth indices and the development of student understanding of mathematics. Teachers with high value-added scores, as determined through state assessment scores, also promoted deeper conceptual understanding with their students. Additional testing utilizing the Balanced Assessment in Mathematics in Grades 4 through 8, found a significant correlation between teacher effects on the two assessment measures (Kane & Staiger, 2012). The Balanced Assessment in Mathematics is considered cognitively demanding and measures higher order reasoning skills and assesses understanding of core mathematical ideas that are tied to grade-level standards (Kane & Staiger, 2012), with additional evidence the instrument is more sensitive to reform-oriented instruction than a more objective formatted test.

The Pennsylvania Department of Education (2011) has differentiated between student achievement and growth, explaining that achievement data determined if students have reached proficiency levels determined by Pennsylvania's academic standards on the Pennsylvania System of School Assessment, whereas the Pennsylvania Value-Added Assessment System (PVAAS) offers insights about individual, or cohorts of students, making an academic year's worth of progress. "[PVAAS] provides an alternative approach to measure the efficacy of schools and teachers in value-added terms, based on student progress rather than the percentage of students able to meet an absolute standard" (Ballou et al., 2004, pp. 37-38). Annual student testing allows for "growth trajectory" tracking of students, with individual students and teachers serving as their own "control group" (Harris, 2008, p. 7). Sanders (2000) described the following regarding the advantages to considering value-added scores:

> Modeling student progress over time, via value-added analyses, provides accurate and trustworthy quantitative measures of student learning. These measures, then, are attributed to the professional efforts of individual educators and schools, thereby mitigating "many problems in assessment and measurement." (p. 331)

In a synthesis of current models of measuring school and teacher effectiveness, Fletcher (n.d.) established that student progress, not student achievement is most relevant for determining teaching effectiveness. Fletcher (n.d., p. 6) differentiated student learning considerations into three categories—status, growth, and relative growth, which are expanded upon in Table 5.

Table 5

Facts Regarding Achievement, Growth, and Pennsylvania Value-Added Assessment System Data

Achievement	Growth	Educator benefits of Pennsylvania Value-Added Assessment System
Measures students' performance at one single point in time.	Measures students' growth across time (i.e., across years).	Measures student achievement as a result of the impact of educational practices, classroom curricula, instructional methods, and professional development.
Highly correlated with students' demographics.	Little to no relationship to students' demographics.	Monitors the growth of all groups of students from low-achieving to high-achieving, ensuring growth opportunities for all students.
Compares student performance to a standard.	Compares students' performance to their own prior performance.	Educators can make informed, data-driven decisions about where to focus resources to help students make greater growth and perform at higher levels.
	By measuring students' academic achievement and growth, schools and districts have a more comprehensive picture of their own effectiveness in raising student achievement.	Educators can modify and differentiate instruction to address the needs of all students.

Note. From *PVAAS Key Communication Messages* (p. 1), by Pennsylvania Department of Education, 2015, Harrisburg, Author. Copyright 2015 by Pennsylvania Department of Education. Reprinted with permission.

Rubin, Stuart, and Zanutto (2004) identified that the goal of value-added is

> To estimate the "causal effects" or teachers or schools; that is, to determine how much a particular teacher (or school) has "added value" to their students' test scores. It is implied that the effects being estimated are causal effects: the effect on students of being in school 'A' (or with teacher 'T') on their test scores. (p. 104)

Although some statisticians argued against the assumption that teachers or schools are responsible for increases in student test scores in the most widely implemented value-added statistical models (Raudenbush, 2004; Rubin et al., 2004), Fletcher (n.d.) found that policy makers and school administrators generally disagreed and contended that “if quality instruction is essential for student learning, then student learning should tell us about the quality of instruction” (p. 20).

Value-Added Models

Figure 2 depicted in simple terms the statistical model utilized by the Pennsylvania Value-Added Assessment System (PVAAS), which measures student growth by modeling a series of gains in performance demonstrated by each student as well as the teachers who instructed them and the schools that provided the context for their instruction (Goldschmidt et al., 2005, p. 5). In the depictive Figure 2, the starting point for student growth is established as the variable Year_X, with Year_{X+1} representing the point at time in which students are expected to have grown 1 instructional year. Based on previous student performance data on standardized testing scores, the value-added statistical model estimates and predicts the expected value, or growth expectation, for future student achievement. The expected value is determined relative to 0, which statistically indicates the projected value representing students’ growth expectation, factoring in a standard error of measurement. Any score value greater than 0 represents that students have exceeded their growth expectation, and any score value less than 0 represents that students have missed their growth expectation. As mentioned, the figure provided a simple representation and does not include the underlying statistical formulas utilized in the actual value-added model. A more detailed description of value-added statistics can be found in Chapter 3.

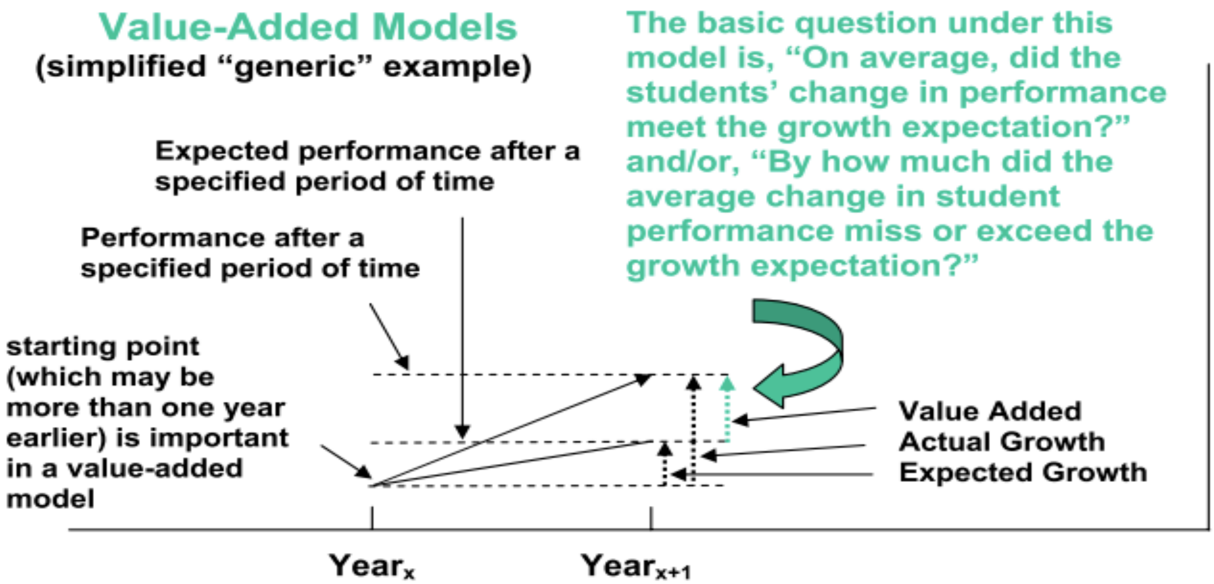

Figure 2. Value-added model (simplified generic example). From *Policymakers' Guide to Growth Models for School Accountability: How Do Accountability Models Differ?* (p. 5), by P. Goldschmidt, P. Roschewski, K. Choi, W. Auty, S. Hebbler, R. Blank, and A. Williams, 2005, Washington, DC: Council of Chief State School Officers. Copyright 2005 by Council of Chief State School Officers. Reprinted with permission.

Kupermintz (2003) described the Educational Value-Added Assessment System (EVAAS) statistical model as one that represented teacher effects as independent, additive, and linear variables, and considers student readiness for new learning by treating the previous years' test scores as a blocking variable to statistically adjust for preparedness for receiving teacher instruction so that each student serves as their own statistical control to avoid effects of external factors, "most notably race, SES, general ability, and prior achievement in the tested subjects" (Kupermintz, Shepard, & Linn, 2001, p. 3), which Kupermintz et al. (2001) challenged as statistically valid. In response to this criticism, Ballou et al. (2004) responded with explicit evidence of the strength and validity of the EVAAS model. Although the definition of *statistical validity* has been implicitly defined as the relationship between the teacher quality measure and teachers' contribution to student achievement, individual teacher value-added growth indices have indeed demonstrated statistical validity (Harris, 2008).

> Enthusiasm for this approach stems in large part from the belief that it can remove the effects of factors not under the control of the school, such as prior performance and socioeconomic status, and thereby provides a more accurate indicator of school or teacher effectiveness than is possible when these factors are not controlled. (McCaffrey et al., 2004, p. 68)

Gap in the Literature

Professor of public policy and economics at Duke University, Jacob Vigdor (2013), through his research of historical U.S. student math performance, provided a unique perspective on student achievement in mathematics, finding that U.S. education policies to increase math performance for average students—and to close achievement gaps through making the curriculum more accessible—has backfired, with fewer students reaching advanced levels of performance.

Pajares (1992) cited Fenstermacher's (1979) prediction that "the study of teacher beliefs would become the focus for teacher effectiveness research" (p. 307) and Pintrich's (1990) suggestion "that beliefs ultimately will prove the most valuable psychological construct to teacher education" (p. 308), adding that research literature for teacher beliefs was scarce at the time. Moving forward, Fives and Buehl (2011) found the published empirical research on teachers' beliefs included more than 700 articles, yet the lack of cohesion and clear definitions has limited the explanatory and predictive potential of teachers' beliefs. Nevertheless, convincing evidence in the literature, schools, and teacher education programs found that teacher beliefs matter. Ultimately, the gaps in the literature, in the case of teacher beliefs, are the overwhelmingly broad and diverse considerations for teacher beliefs, and for the purposes of this study, the resultant lack of explanatory and predictive studies regarding teacher practice or student learning (Fives & Buehl, 2011).

Fives and Buehl's (2011) comprehensive review of the literature on teacher beliefs concluded beliefs are complex, multifaceted, and varied, and attempts to relate beliefs to teacher behaviors and instructional practice required clarity in characterizing the specific belief or system being considered. Specific to research, application, and intervention, Fives and Buehl stressed the need for researchers to clarify the belief or belief system to be researched, and for educators to recognize the complexities when considering for professional development and growth. Table 6 (Fives & Buehl, 2011) synthesized the conclusions to include specific recommendation considerations for researchers, teacher educators, school leaders, and preservice and practicing teachers. These recommendations served to frame the context, methods, and survey adoption for Chapter 3. As well, these recommendations were utilized to consider an examination of the study results in Chapter 4 and the conclusions and recommendations in Chapter 5.

Table 6

Conclusions and Recommendations Regarding Teacher Beliefs

Conclusions		
Teachers' beliefs are related to their practices and student outcomes but enactment of beliefs may be hindered by individual and contextual restraints.	Different belief systems may function in different ways, as filters, frames, or guides.	
Recommendations for		
Researchers	Examine the larger context in which research activities are situated to consider the multiple influences on teachers' beliefs enactment. Explore the mechanisms by which beliefs are related to practice (e.g., filter, frame, and guide).	
Teacher educators	To affect change in beliefs and practices, a variety of beliefs must be addressed and teachers need extensive knowledge of the practice to be enacted.	Beliefs influence how reform efforts are interpreted (filtered) and implemented (guide). Effective implementation of reforms may require changes related to beliefs systems.
School leaders	Recognize the specific constraints that may hinder the implementation of beliefs and work to alleviate them.	
Preservice and practicing teachers	Identify ways beliefs and practices are or are not congruent. Recognize the need for additional knowledge and professional development to effectively implement new practices. Actively consider the influence of belief functions in the examination of new reforms, teaching approaches, and students.	

Note. From "Spring Cleaning for the 'Messy' Construct of Teachers' Beliefs: What Are They? Which Have Been Examined? What Can They Tell Us?" (p. 487) by H. Fives and M. M. Buehl, 2011. In K. R. Harris, S. Graham, T. Urdan, S. Graham, J. M. Royer, & M. Zeidner (Eds.), *APA Educational Psychology Handbook, Vol. 2: Individual Differences and Cultural and Contextual Factors*, doi:10.1037/13274-019. Copyright 2011 by American Psychological Association. Adapted with permission.

CHAPTER 3

STUDY DESIGN AND METHODOLOGY

Study Purpose and Goal

The purpose of this nonexperimental correlational relationship study was to determine the correlation between the variables of instructional practices, teacher beliefs, and intelligence mindset and the variable of value-added student growth. Value-added student growth models "isolate the effects of outside factors—such as prior performance or student characteristics—from student achievement in order to determine how much value teachers, schools, and/or programs added to students' academic growth" (Hull, 2007, p. 47). The goal of the study was to better understand how instructional practices, beliefs, and mindsets correlated to measurable student growth, in order to expand the literature on the topic of strengthening instructional practices for mathematics. This large-scale study investigated the multifaceted and complicated relationship amongst the significant variables of teacher practices, beliefs, and mindsets and academic growth for elementary students in mathematics. This chapter addressed the research methodology and procedures that framed the study.

Value-Added Student Growth

Though some researchers have identified complications with value-added modeling, particularly with regard to direct attribution of teacher effects to individual student growth (Amrein-Beardsley, 2008; Gabriel & Lester, 2013), the statistical construct of value-added analysis offers stakeholders and researchers an innovative approach to examine school and teacher effectiveness. Raudenbush (2004), who similarly cautioned against estimating school and teacher effects, nevertheless acknowledged that aggregate value-added estimates, in conjunction with other relevant data, provided an opportunity for researching the effectiveness of school and teacher practices. Jacob and Lefgren (2008) determined that previous value-added indices better predicted student achievement than did subjectively driven principal observations and evaluations, providing a more objective analysis of the everyday classroom instruction taking place. The significance of value-added is that the statistical model provides a measure of the direct effect of the effectiveness of schools, irrespective of the influence of mitigating demographic factors, such as socioeconomic status (Fallon, n.d.).

Sass (2008), in a study of quintile rankings of teacher effects in several large school systems, found that value-added measures are generally steady over a several-year period. This increase in value-added measures supported the utilization of the Average Growth Index (AGI) to isolate student growth as a dependent, or outcome, variable for exploring the relationship amongst the independent, or predictor, variables (Creswell, 2013). In studies based on the statistically sophisticated Tennessee Value-Added Assessment System (TVAAS), teacher effects were highly correlated to student performance, more so than factors such as class size (Sanders & Horn, 1998; Wright et al., 1996). Based on the research of Rowan, Correnti, and Miller (2002), it is recommended "if one really wants to assess the size of teacher effects on changes in student achievement, models of annual gains in achievement are preferable" (p. 5), solidifying the decision to consider value-added growth modeling as the criterion variable representing student learning. Pennsylvania's value-added growth model is one such model.

The Pennsylvania Value-Added Assessment System (PVAAS) contracts through SAS Institute to implement the EVAAS that built upon the Tennessee Value-Added Assessment System (TVAAS) methodology developed by Dr. William L. Sanders and his colleagues at the University of Tennessee at Knoxville (SAS Institute, 2015). Wright et al. (2006) described the EVAAS value-added methodology as "to simply use a student's past scores to predict ('project') some future score" (p. 4). The statistical model used to obtain the projections is no more complex than ordinary multiple regression, with the basic formula being, "Projected_Score = MY + b1(X1 − M1) + b2(X2 − M2) + . . . = MY + x1Tb, where MY, M1, etc., are estimated mean scores for the response variable (Y) and the predictor variables (Xs)" (Wright et al., 2006, p. 4).

Average Growth Index

> The Average Growth Index [AGI] is a measure of student progress across the tested grade levels in a school. This index is value based on the growth [measure] over grade levels, and its relationship to the standard error, so that comparison among schools is meaningful. PVAAS utilizes this index (based on the standard error) to allow for a [comparative] view across schools. If the standard error is not accounted for, users might get a skewed picture of the relative effectiveness of different schools. (Pennsylvania Department of Education, 2011, p. 2)

Table 7 further described AGI score values.

Research Variables and Procedures

Pajares (1992) conveyed that when the appropriate methodology and instrumentation are chosen and the research design is thoughtfully constructed, studies examining beliefs can become viable and effective. For this study, a quantitative approach utilizing surveys was utilized to determine the relationship between six independent variables (Social-Constructivist Orientation [SC], Transmission Orientation [T], Teacher Allowance for Student Struggle with Problems [TASSP], Teacher Modeling for Incremental Mastery [TMIM], Teachers' Awareness of their Students' Mathematical Dispositions [TASMD], and Growth Mindset [M]) and PVAAS Average Growth Index (AGI). Rowan et al.'s (2002) position is that survey researchers should be to "clarify the basis for claims about effect sizes, develop better measures of teachers' knowledge, skill, and classroom activities; and take care in making causal inferences from nonexperimental data” (p. 1526).

Table 7

Average Growth Index (AGI)

School-level Average Growth Index value	Score description
= 0	On average, the students in this school met the standard for Pennsylvania academic growth.
> 0	On average, the students exceeded the standard for Pennsylvania academic growth. The farther the Average Growth Index is above 0, the more evidence there is that, on average, students in this school exceeded the standard for Pennsylvania academic growth.
< 0	On average, the students did not meet the standard for Pennsylvania academic growth. The farther the Average Growth Index is below 0, the more evidence there is that, on average, students in this school did not meet the standard for Pennsylvania academic growth.

Note. From *PVAAS Key Communication Messages* by Pennsylvania Department of Education, 2015, Harrisburg, Author. Copyright 2015 by Pennsylvania Department of Education. Reprinted with permission.

Surveys were administered to a statistically significant aggregate group of teachers to establish the mean for each of the six aforementioned variables. “Survey research provides a quantitative or numeric description of trends, attitudes, or opinions of a population by studying a sample of that population” (Creswell, 2013, p. 12). The aggregate values of each predictor variable were correlated to the composite school Average Growth Index (AGI) to determine if a statistically significant relationship existed; the researcher hypothesized that a positive correlation existed. Hale (2011), in reviewing the importance of correlational studies, established that once a correlation coefficient score is known on one measure, more accurate predictions of other related measures can be made, with the stronger the relationship between or among variables, the more accurate the predictions. It is from this perspective the researcher proposed to correlate each variable to student growth, while investigating the relationships amongst the variables that potentially predicted student growth.

Research Questions and Null Hypotheses

This study focused on four primary research questions.

- RQ1: How does the relationship amongst school-level averages of instructional practices, teacher beliefs, and teacher mindset relate to the school value-added Average Growth Index (AGI)?
    - $H1_0$: There will be no significant prediction of Average Growth Index (AGI) by average school levels of instructional practice, teacher beliefs, and growth mindset.
- RQ2: How do school-level average instructional practices relate to school value-added Average Growth Index (AGI) when controlling for teacher beliefs and the teacher growth mindset?
    - $H2_0$: There will be no significant prediction of Average Growth Index (AGI) by average school levels of instructional practice, when controlling for teacher beliefs, and the teacher mindset.
- RQ3: How does school-level teacher beliefs relate to school value-added Average Growth Index (AGI) when controlling for instructional practices and the teacher growth mindset?
    - $H3_0$: There will be no significant prediction of Average Growth Index (AGI) by average school levels of teacher beliefs, when controlling for instructional practices and the teacher growth mindset.

- RQ4: How does school-level average teacher growth mindset relate to value-added Average Growth Index (AGI) when controlling for instructional practices and teacher beliefs?
    - $H4_0$: There will be no significant prediction of Average Growth Index (AGI) by school-level average teacher growth mindset when controlling for instructional practices and the teacher growth mindset.

Table 8 provided a matrix presenting the relationship between Research Questions 2–4, variables, survey items, and survey scale, all of which are explained in further detail in this chapter.

Study Survey Instruments

Three existing surveys are utilized to answer validity and reliability standards. Content or construct validity can be considered the most important form of validity as it determines in fact that a test measures its intended measure (Gay et al., 2008). Reliability, on the other hand, demonstrates consistency within item responses across constructs and score stability across administrations (Creswell, 2013). All three instruments have demonstrated validity and reliability, as evidence existed the instruments effectively measure what they intended, and that they did so consistently.

Table 8

Matrix of Research Questions 2–4, Variables, Survey Items, and Scales

Research Question	Variable	Survey items	Scale
2. How do school-level average instructional practices relate to school value-added Average Growth Index (AGI) when controlling for teacher beliefs and the teacher growth mindset?	Social-constructivist orientation	Mathematics Instructional Practice Survey Items 1, 2, 3, 5, 9, 12, 13, and 14	5-point frequency rating scale: Always (5), Often (4), Sometimes (3), Rarely (2), Never (1), Not Applicable (0)
	Transmission orientation	Mathematics Instructional Practice Survey Items 4, 6, 7, 8, 10, and 11	
3. How do school-level teacher beliefs relate to school value-added Average Growth Index (AGI) when controlling for instructional practices and the teacher growth mindset?	Teacher allowance for student struggle with problems	Beliefs and Awareness Survey Items 1, 5, 9, 12, 16, and 19	6-point Likert scale: Strongly agree (6), Agree (5), Mostly agree (4), Mostly disagree (3), Disagree (2), Strongly disagree (1)
	Teacher modeling for incremental mastery	Beliefs and Awareness Survey Items 2, 6, 10, 13, 17, 20, and 22	
	Teachers' awareness of their students' mathematical dispositions	Beliefs and Awareness Survey Items 3, 7, 11, 14, 18, 21, 23, and 25	
4. How does school-level average teacher growth mindset relate to value-added Average Growth Index (AGI) when controlling for instructional practices and teacher beliefs?	Intelligence mindset	Theories of Intelligence Scale—Self Form for Adults Items 4, 8, 15, and 24	6-point Likert scale: Strongly agree (6), Agree (5), Mostly agree (4), Mostly disagree (3), Disagree (2), Strongly disagree (1)

As other researchers (Beswick, 2012; Davidson & Mitchell, 2008; Ross et al., 2001) uncovered during a review of the literature, Clark et al. (2014) found mathematics teachers' beliefs about teaching and learning often fall into two categories: behaviorist transmission–oriented theories of learning and the teaching practices; and social-constructivist conceptualizations for mathematical learning and knowing, emphasizing conceptual understanding, and problem solving. Clark et al. (2014) articulated their own interpretation for each category as follows:

> Teachers who strongly hold beliefs aligned with behaviorist transmission theories of learning, therefore, may focus on mathematical facts and procedures during instruction and dedicate less time to developing students' conceptual understanding. And, teachers who hold beliefs aligned with, therefore, may engage in teaching practices that promote students' active engagement with challenging mathematical problems and tasks that lead to deepening students' conceptual understanding. (pp. 249-250)

Mathematics Instructional Practice Survey

Mathematics Instructional Practice Survey authors Carney, Brendefur, Hughes, and Thiede (2015) sought "to create a survey instrument to conceptualize and operationalize mathematics instruction for large-scale examination" (p. 14). This survey utilized a frequency rating scale, which can be used to measure a respondent's degree to which they utilize a particular practice or performance, similar to a Likert scale (Creswell, 2013; Gay et al., 2008). See Appendix A for this survey.

The original rating scale was specific to teacher considerations, as it required respondents to indicate frequency in terms of days, weeks, and months; daily, two to three times per week, two to three times per month, once per month, two to three times per year, never, and not applicable. But because traditional self-contained elementary classrooms may no longer match current scheduling configurations, the researcher chose to modify the frequency scale in an effort to seek more consistent responses. Recognizing that Carney et al. (2015, p. 28) expressed "welcome careful use, modification, and further study of this instrument and hope it serves to spark further discussion around ideas of measuring practice on a large scale," an alternative 5-

point frequency scale was utilized instead. Participants were asked to indicate the frequency with which they engage in each instructional practice in this alternative manner: *Always* (5), *Often* (4), *Sometimes* (3), *Rarely* (2), *Never* (1), *Not Applicable* (0).

In terms of utility, the instrument was developed to operationalize two major learning theory perspectives for the teaching of mathematics, with survey items written to accurately address transmission-based and social-constructivist learning theory perspectives. In describing the intensive survey construction process, Carney et al. (2015) wrote,

> Once the initial development and review process was completed, the process took on a cyclical nature of survey item administration, analysis of the data in relation to variables of interest and psychometric properties, and finally revision and review. This process occurred three times leading to the refinement of the initial set of 74 items to 30 items. (p. 16)
>
> During final refinement of the instrument, Carney et al. (2015, p. 19) executed exploratory factor analysis to determine which survey items did the best job of measuring, or were most highly correlated with, the constructs of social-constructivist and transmission-based practice, leading to eight questions that cleanly measured constructivist practices and 6 questions that cleanly measured transmission-based practices. (p. 19)

This analysis established both content and construct validity for the survey items. Carney et al. (2015) also found “internal consistency for each scale to be good to excellent for all scales across two administrations; social-constructivist (prior $\alpha = .91$; after $\alpha = .90$) and transmission-based (prior $\alpha = .84$; after $\alpha = .86$), providing strong evidence of reliability” (p. 20).

Mathematics Beliefs and Awareness Survey

Beswick's (2008) extensive study of teacher beliefs and mathematics education has determined teacher practice is closely aligned to teachers' beliefs about the nature of mathematics, mathematics teaching, and mathematics learning are recognized as relevant to their practice. It is from this perspective that the second instrument, the Mathematics Beliefs and Awareness Survey (see Appendix B), was selected to investigate the variable of teacher beliefs. Ross et al. (2003) disclosed the internal process to establish the reliability of their original self-report survey Elementary Teacher's Commitment to Mathematics Education Reform; two independent large-scale studies produced similar statistics. To create an updated beliefs instrument, to better reflect present day academic standards and assessment expectations for the teaching of mathematics, Clark et al. (2014) completely redeveloped all but four of Ross et al.'s originally constructed items. As the intent of the newly developed Beliefs and Awareness Survey was not solely to isolate beliefs aligned to certain existing theoretical paradigms, the developed items cross multiple constructs and a variety of instructional perspectives (Clark et al., 2014). An exploratory factor analysis of 459 teacher responses to the 40 improved items yielded clusters of items that loaded on three statistically interpretable variables, satisfying initial validity concerns.

1. Teacher Allowance for Student Struggle with Problems (TASSP)—"Six items that reflect the belief that mathematics teaching and learning should include periods of time when students struggle, grapple, and solve problems on their own, making sense of mathematics without relying on direct teacher intervention" (Clark et al., 2014, p. 258).
2. Teacher Modeling for Incremental Mastery (TMIM)—"Seven items that reflect the belief that memorization is critical, and instruction should emphasize the incremental

mastery of procedural skills prior to solving application problems" (Clark et al., 2014, p. 258).

3. Teachers' Awareness of their Students' Mathematical Dispositions (TASMD)—"Eight items that reflect the extent to which teachers are responsive to their students' mathematical dispositions, including the degree to which teachers claimed to highlight multiple approaches to solving a problem and to include problems that have multiple solutions in their instruction" (Clark et al., 2014, pp. 258-259).

Each of the three factors were determined to have acceptable, although not robust, internal reliability as determined by Cronbach's alpha measure of internal consistency: TASSP, .662; TMIM, .653; and TASMD, .657 (Clark et al., 2014). Participants were asked to indicate the extent to which they agree with statements associated with each of the factors. A 6-point Likert scale was utilized, with the following point values applied to each choice: *Strongly agree* (6), *Agree* (5), *Mostly agree* (4), *Mostly disagree* (3), *Disagree* (2), *Strongly disagree* (1).

Theories of Intelligence Scale

The third instrument to be administered is Dweck's (1995) original Theories of Intelligence Scale—Self Form for Adults (see Appendix C). This instrument is designed to ascertain one's personal theory of intelligence. *Theories of intelligence* refers to entity theorists as those who believed that intelligence attributes are nonmalleable and incremental theorists as those who believed intelligence to be malleable; these terminologies and constructs evolved into the widely accepted notions of embodying a "fixed or growth mindset" (Dweck, 2006, pp. 6-7). Early research using these scales found that educational efforts aimed at guaranteeing success and boosting confidence for students actually were counterintuitive and subsisted within the entity–theory (fixed mindset) framework (Dweck, 2000). Dweck's (2008) subsequent research linked student success to growth-minded teachers, maintaining that great teaching "starts with the growth mindset—about yourself and children, not just lip service to the idea that all children can learn, but a deep desire to reach in and ignite the mind of every child" (p. 202). For this reason, the researcher administered the instrument to determine a teacher's personal growth mindset.

Over six studies the theories of intelligence measures had high internal reliability, α ranged from α = .94 to α = .98, with test–retest reliability over a 2-week interval being .80 (Dweck, Chiu, & Hong, 1995). Because endorsement of one implicit theory is dependent upon the other, according to Dweck et al. (1995, p. 272), factor analysis was performed on several implicit theory measures, establishing theories of intelligence to be statistically independent and attributable to clearly separate factors, establishing construct validity. Tables 2, 3, and 4 in Dweck et al. (1995, pp. 271-272) provide detailed summary statistics regarding validity considerations. Participants were asked to indicate the extent to which they agree with statements associated with each of the factors. A 6-point Likert scale was utilized, with the following point values applied to each choice: *Strongly agree* (6), *Agree* (5), *Mostly agree* (4), *Mostly disagree* (3), *Disagree* (2), *Strongly disagree* (1).

Methods and Procedures

Lissitz (2012), in a presentation to the American Educational Research Association (AERA), offered a mostly skeptical analysis of value-added models for determining school and teacher effectiveness. Yet in his concluding remarks, as an alternative for using value-added models to determine effectiveness, Lissitz specifically recommended that researchers begin to relate value-added models to what teachers are actually doing in the classroom. Rowan et al. (2002) argued that

> Large-scale, survey research has an important role to play in contemporary educational research, especially in research domains where education policy debates are framed by questions about "what works" and "how big" the effects of specific educational practices are on student achievement. (p. 1)

Creswell (2013) considered the primary benefits of survey instruments to be the "economy of design and the rapid turnaround in data collection" (p. 146). Babbie (2010) affirmed that surveys employing Likert-type items are considered an acceptable means for testing quantitative hypotheses. All considered, a large-scale investigation of the proposed research questions utilizing well-designed survey instruments could provide a baseline of evidence for future studies that more closely examine the relationships amongst the study variables. For this study, the statistical methods employed are descriptive statistics.

Survey Administration

Surveys were administered to groups of teachers (identified per school) to establish the aggregate mean for each of the six aforementioned variables. The aggregate value was correlated to the school Average Growth Index (AGI) to determine if a statistically significant relationship existed; this researcher hypothesized that a positive correlation would exist. Teacher survey results were combined to determine school-specific average values for each of the sets of independent variables. Statistical procedures, including multiple regressions, were executed to explore the correlative and predicative relationship amongst the considered predictor or independent variables and each school's Average Growth Index (AGI), the criterion or dependent variable, for the 2014-2015 academic school year.

Data Analysis

Both univariate and multivariate analyses of correlation and regression were conducted in order to establish relationships amongst the independent and dependent variables. It is also important to note that if relationships indeed existed, it does not indicate cause and effect, although it may have suggested so. Because each data set is interval data, in quantity form, the researcher analyzed the data using primarily hierarchical multiple regression to determine the multiple correlation coefficient, *R*, amongst the dependent variable *Y* and a set of independent predictor variables *X*1, *X*2, *X*3, *X*4, *X*5, and *X*6 (Howell, 2016). Gay et al. (2008, p. 204) provided the form for a single variable prediction as, $Y = a + bX$, with the multiple regression (or multiple predictor) equation form simply extending to include two or more predictor variables that individually predict a criterion, producing a more precise prediction (Gay et al., 2008; Howell, 2016).

Statistics

Descriptive statistics, including measures of central tendencies, analyzed scores on the survey instruments quantifying teacher beliefs, instructional practices, and growth mindset. Responses were averaged for each survey category establishing the mean score for each. School-specific Average Growth Index (AGI) scores were accessed through an existing publicly available source at https://pvaas.sas.com/. A quantitative approach was utilized to determine if a significant relationship existed between the six independent variables: Social-Constructivist Orientation (SC), Transmission Orientation (T), Teacher Allowance for Student Struggle with Problems (TASSP), Teacher Modeling for Incremental Mastery (TMIM), Teachers' Awareness of their Students Mathematical Dispositions (TASMD), and the school-specific AGI.

Data Privacy and Confidentiality

Qualtrics® and SPSS were utilized for the purposes of data collection and data analysis. Explicit efforts were made to ensure the confidentiality of all identifying information obtained in connection with this study. Individual teacher data were not individually considered, or correlated, to the studied variables. The data file used for analysis was stripped of all identifying information and replaced with a random code number. The survey data was secured and collected and stored on a password-protected, encrypted website (Qualtrics.com). Qualtrics.com uses the same encryption type (Secure Sockets Layer) that online banking sites use to transmit secure information. IP addresses were not collected.

Method of Subject Selection

Third-, fourth-, and fifth-grade teachers responsible for teaching mathematics in Pennsylvania's 499 school districts within schools that specifically house students in the tested span of Grade 3 through 5 were considered to participate in this study. Six hundred fifty-seven specific schools among 196 school districts or public charters met these parameters, which matched with the tested grades considered inside this study. Through reduction sampling (Creswell, 2013), the list of potential invitees was reduced to 322 schools in 153 school districts. Superintendent site approval and consent letters were sent via e-mail to all 153 superintendents. As this study was tied directly to existing Pennsylvania System of School Assessment and PVAAS data, Pennsylvania System of School Assessment, there was no recruitment outside of Pennsylvania.

Study Site

Participants remotely participated through web-based technology systems. E-mail was utilized to initiate district level permissions and subsequent building principal and mathematics teachers' informed consent and participation. E-mail and Qualtrics® were utilized to remotely, and electronically, administer the aforementioned study instruments. Those who chose to participate could withdraw at any time. Upon their request to withdraw, all information pertaining to such participants was eradicated and destroyed. Also, participant responses were only considered in combination with those from other participants, as the variables each represented an aggregate total and mean for a particular school.

Procedures

The superintendent e-mail letter (see Appendix D) requested school district consent and site approval, providing detailed information regarding the study, including express considerations for coercion, confidentiality, and the ability to opt out, or to withdraw, from the study at any time, and for any reason. Upon receiving site approval, each identified school building principal was contacted via e-mail letter (see Appendix E) to disseminate study details, and to request assistance with determining teachers responsible for teaching mathematics during the 2014-2015 academic school year. Upon obtaining permission, a participant request letter and the survey questionnaire were distributed from official Indiana University of Pennsylvania e-mail to their official school district e-mail address. Teacher participants who agreed to participate received the secure survey link delivered to their official school district provided e-mail. Before proceeding with the survey, teacher participants were required to provide clear consent to be surveyed (see Appendix F). Those who indicated their consent at the initial Qualtrics® consent question continued to respond to the survey. For those who did not provide consent, the survey ended immediately and the teacher participant was deemed and recorded as a nonparticipant. At 5-day intervals, up to three additional reminder e-mails were sent to teacher participants.

Study results reported and discussed the relationships determined amongst the variables in aggregate only. Participating school districts, schools, and individual teachers remained completely anonymous, and were never identified in any published results of this study now, or at any time in the future. All gathered data remained confidential to avoid putting any party at risk and so that no identifying information or characteristics were revealed. The survey data was collected and stored on a password-protected, encrypted website (Qualtrics.com). Qualtrics.com uses the same encryption type (Secure Sockets Layer) that online banking sites use to transmit secure information. IP addresses were not collected. Statistical data analysis employed IBM SPSS software; all data will be destroyed at the end of a 3-year period, as per federal guidelines.

Participation in this study was absolutely voluntary; teacher participants were free to decline to participate and also were free to withdraw at any time by notifying the project director, James W. Jones, via either phone or e-mail. If teachers decided to withdraw while taking the survey, they were able to simply close the browser. Identifying information and numerical data points pertaining to a withdrawn participant were eradicated.

CHAPTER 4

RESULTS AND ANALYSIS

The purpose of this study was to determine the correlational relationship between teacher beliefs, practices, and growth mindset and the variable of value-added student growth. Operationally, the six independent variables were defined as Social Constructivist Orientation, Transmission Orientation, Teacher Allowance for Student Struggle with Problems, Teacher Modeling for Incremental Mastery, Teachers' Awareness of their Students' Mathematical Dispositions, and Growth Mindset The dependent variable was defined as Average Growth Index (AGI), a measure of academic growth derived from the Pennsylvania Value Added Assessment System. Further definitions situated in the context of the study and literature base are provided throughout Chapter 5.

Chapter 4 includes a presentation and interpretation the results of the statistical analyses conducted for this study. Initial statistical tests included measures of central tendency, Pearson correlation, as well as tests for assumptions of multiple regressions—particularly, linearity, homoscedasticity, and multicollinearity. Following this, a series of four regression analyses were conducted, with the latter three models using hierarchical linear regression to control for predetermined blocks of variables. In explaining this approach, Howell (2008) stated that "when we have multiple predictor variables, we are adjusting, or controlling for, each predictor for all other predictors in the equation" (p. 280). Each exclusive set of regression analyses served to explore this study's four research questions, along with testing their associated null hypotheses. A one-way analysis of variance (ANOVA) was also conducted to determine if there was a significant difference on the dependent variable by independent variable. One-way ANOVA is an appropriate statistical analysis when the purpose of research is to assess if mean differences exist on one continuous dependent variable by an independent variable with two or more discrete groups. The dependent variable is Average Growth Index (AGI), and the discrete groups of independent variables are instructional practices (Social Constructivist Orientation and Transmission Orientation), teacher beliefs (Teacher Allowance for Student Struggle with Problems, Teacher Modeling for Incremental Mastery, and Teachers' Awareness of their Students' Mathematical Dispositions), and teacher mindset (Growth Mindset). Three validated surveys associated with each separate block of variables were administered to quantify each variable.

The final data set consisted of 35 records, obtained via Qualtrics® web-based survey and data collection platform. Raw data sets were exported into a spreadsheet to be prepared for upload into SPSS. Publicly available school-level Average Growth Index (AGI) values were also exported into a spreadsheet to be prepared for upload into SPSS. The SPSS Statistics Syntax Editor was first employed to merge the Qualtrics® and survey files and to properly prepare the data set for the syntax required to run the four regression models. The command syntax for each of the four unique regressions models and related statistical analyses, tables, and graphs required to explore each research question were then written. Once final edits and revisions were confirmed, the syntax was run to produce the output file with the regressions, statistical tests, tables, and graphs. These results were reviewed and examined to produce the analyses found in this chapter.

Survey Instruments

Rowan et al.'s (2002) position was that survey researchers should be able to "clarify the basis for claims about effect sizes, develop better measures of teachers' knowledge, skill, and classroom activities; and take care in making causal inferences from nonexperimental data" (p.

1256). To capture the selected study variables, three existing validated surveys were identified in order to conduct this study. All elementary teachers responsible for teaching mathematics completed each survey to establish the mean for each of the six aforementioned variables. The aggregate values for the predictor variables were correlated to the composite school Average Growth Index (AGI), within the hierarchical regression model. Individual teacher responses for each unique school were averaged for each independent variable, which were then transposed into SPSS and merged with existing AGI values per associated school. A process of confirming the accuracy of all associated values was administered several times over.

Selection Method and Participants

Participants were invited to partake in the study, based on parameters determined by the schools in which they served as teachers of mathematics. Third-, fourth, and fifth-grade teachers responsible for teaching mathematics in Pennsylvania's 499 school districts within schools that service students in the tested span of Grades 3 through 5 were considered. Six hundred fifty-seven schools among 196 school districts or public charters met the parameters. Through reduction sampling (Creswell, 2013), the list of potential participant schools was reduced to 322 within 153 school districts. Site approval request and consent letters (see Appendices D–F) were sent via e-mail to all 153 superintendents.

Survey participation approval was initiated in 99 elementary schools in Pennsylvania, representing a total of 36 unique participating school districts. The survey instrument was distributed through Qualtrics® to 394 third-, fourth-, or fifth-grade teachers of elementary mathematics. Of the recruited population, at least two teachers from 35 unique schools eventually accepted and completed the survey instrument. As the study was directly linked exclusively to Pennsylvania System of School Assessment (PSSA) and Pennsylvania Value

Added Assessment System (PVAAS) data, no recruitment took place outside of the Commonwealth of Pennsylvania.

Response Rate

E-mail letters (Appendix D) were sent to all 153 identified superintendents. Thirty-six superintendents granted site approval and permissions to request building principal participation. These 36 school districts represented 99 schools fitting the expressed parameters for the study. E-mail letters (Appendix E) were sent to all 99 identified building principals. Forty principals granted site approval and express permission to contact teachers to request their participation. Survey invitations and consent letters (Appendix F) were e-mailed to 394 teachers. One hundred and thirteen teachers, representing 35 schools, responded and completed the composite survey instrument via Qualtrics®. As this was a statewide study attempt, a myriad of conceivable reasons may have precluded nonparticipation.

Data Results

Measures of Central Tendency

To illustrate the data collection and sample to be analyzed for this study, a series of descriptive statistics were first conducted. A sample size of 35 schools was considered with respect to all study variables. As all variables were continuous, the mean was calculated as a measure of central tendency, with the standard deviation being calculated as a measure of variability. The standard deviation can be considered the distance away from the mean to demonstrate the response range. Both measures were presented in Table 9.

Table 9

Descriptive Statistics

Study variable	Mean	*SD*	*N*
Average Growth Index	0.315	3.610	35
Social Constructivist Teaching Orientation	4.205	0.291	35
Transmission Teaching Orientation	3.587	0.488	35
Teacher Allowance for Student Struggle with Problems	4.146	0.462	35
Teacher Modeling for Incremental Mastery	3.424	1.536	35
Teacher Awareness of their Mathematical Dispositions	4.871	0.372	35
Teacher Mindset (Growth or Fixed)	3.320	0.324	35

Pearson Correlation

A Pearson product-moment r correlation measured the relationship amongst all six independent predictor variables. Correlation coefficients, r, vary from 0 (no relationship) to 1 (perfect linear relationship) or −1 (perfect negative linear relationship). Cohen's standard was used to evaluate the correlation coefficient, where 0.10 to 0.29 represented a weak association between the two variables, 0.30 to 0.49 represented moderate association, and 0.50 or larger represented a strong association.

Table 10 presented the results of the Pearson's correlations conducted between these variables. These analyses served to determine the bivariate associations between this set of measures, as well as to help determine the extent to which multicollinearity existed prior to conducting the set of regression analyses used for this study. As shown and described as follows, a total of five statistically significant correlations were indicated. Although a number of strong correlations were indicated amongst the six independent predictor variables, all fell between $r < -0.7$ and $r > 0.7$, indicating no major concerns of multicollinearity between the variables.

Table 10

Pearson Correlations Between Measures

Measure	1	2	3	4	5	6
Average Growth Index[1]						
Social Constructivist Teaching Orientation[2]	−0.297					
Transmission Teaching Orientation[3]	−0.264	−0.077				
Teacher Allowance for Student Struggle with Problems[4]	−0.222	0.596	−0.119			
Teacher Modeling for Incremental Mastery[5]	0.104	−0.064	0.213	−0.000		
Teacher Awareness of their Mathematical Dispositions[6]	−0.334	0.564	−0.125	0.534	0.239	
Teacher Mindset (Growth or Fixed)	−0.297	0.208	0.244	0.442	0.171	0.349

First, Social Constructivist Teaching Orientation was found to have statistically significant, positive, and strong correlations with both Teacher Allowance for Student Struggle with Problems and Teacher Awareness of their Mathematical Dispositions. Next, Teacher Allowance for Student Struggle with Problems was found to have statistically significant, positive, and strong correlation with Teacher Awareness of their Mathematical Dispositions and positive, and moderate correlation with Teacher Mindset. Lastly, Teacher Awareness of their Mathematical Dispositions was found to have a statistically significant, positive, and moderate correlation with Teacher Mindset.

Regression Models

Multiple regression models were utilized to measure the contribution of the six independent variables, Social Constructivist Orientation, Transmission Orientation, Teacher Allowance for Student Struggle with Problems, Teacher Modeling for Incremental Mastery, Teachers' Awareness of their Students' Mathematical Dispositions, and Growth Mindset, to the criterion or dependent variable, Average Growth Index (AGI). More simply, the goal was to determine how the independent variables collectively or interdependently influenced AGI scores.

For the initial multiple regression, all independent variables (predictors) simultaneously were entered into the model. Variables were evaluated for what they contributed to the prediction of the dependent variable. *R*-squared—the multiple correlation coefficient of determination—is reported and used to determine how much variance in the dependent variable can be accounted for by each disparate set of independent variables. Adjusted *R*-squared, which is used in exactly the same manner, is statistically adjusted for analyzing sample sizes smaller than are recommended (C. Maier, personal communication, June 27, 2016).

First Regression Model Analyses

Table 11 presented the results of the initial linear regression analysis conducted on these data. In this analysis, all independent variables were entered into the regression model in a single block. No predictor variables individually achieved statistical significance at the .05 alpha, or α, level. Variance inflation factor is an additional test of multicollinearity. Values greater than 10 would be of concern, but all six independent variables were far less and quite satisfactory values, at 2.021 or less.

Table 12 presented the results of the zero-order, partial, and part correlations associated with this linear regression model. As shown, none of these correlations were found to be strong, suggesting the absence of any substantial multicollinearity with respect to this linear regression model. These correlation values further supported that although the data set is moderately correlated, it was not enough to be concerned about.

Table 11

Summary of Regression Analyses for Independent Variables

Measure	*B*	*SE*	Beta	*t*	Tolerance	Variance inflation factor
(Constant)	32.988	10.617		3.107		
Social Constructivist Teaching Orientation	−1.270	2.712	−0.103	−0.469	0.521	1.918
Transmission Teaching Orientation	−2.496	1.298	−0.337	−1.923	0.813	1.230
Teacher Allowance for Student Struggle with Problems	0.437	1.755	0.056	0.249	0.495	2.021
Teacher Modeling for Incremental Mastery	0.660	0.410	0.281	1.611	0.822	1.216
Teacher Awareness of their Mathematical Dispositions	−3.558	2.136	−0.367	−1.666	0.515	1.941
Teacher Mindset (Growth or Fixed)	−1.542	2.150	−0.138	−0.717	0.672	1.489

Table 12

Linear Regression Analysis: First Regression Model: Correlations

Measure	Zero-order	Partial	Part
Social Constructivist Teaching Orientation	−0.088	−0.088 (0.77%)	−0.074 (0.55%)
Transmission Teaching Orientation	−0.342	−0.342 (11.70%)	−0.304 (9.24%)
Teacher Allowance for Student Struggle with Problems	0.047	0.047 (0.22%)	0.039 (0.15%)
Teacher Modeling for Incremental Mastery	0.291	0.291 (8.47%)	0.255 (6.50%)
Teacher Awareness of their Mathematical Dispositions	−0.300	−0.300 (9.00%)	−0.263 (6.92%)
Teacher Mindset (Growth or Fixed)	−0.134	−0.134 (1.80%)	−0.113 (1.28%)

Figure 3 presented the histogram conducted on the regression standardized residuals resulting from the linear regression analysis. Linear regression assumes normality of these residuals, and the histogram indicated no gross violations of normality. Whereas marginally high kurtosis was also suggested on the basis of this figure, two conditions related to the study likely are exemplified. One, the limited sample size of 35 school AGI values, relative to the population size of 471 such schools, is extremely small. Two, is the that an AGI of 0.0 represented the expected growth value for students and schools, which is what one would expect to be considered normal or the center of the possible data points. The histogram for the entire population would most likely tend to appear closer to a model normal distribution.

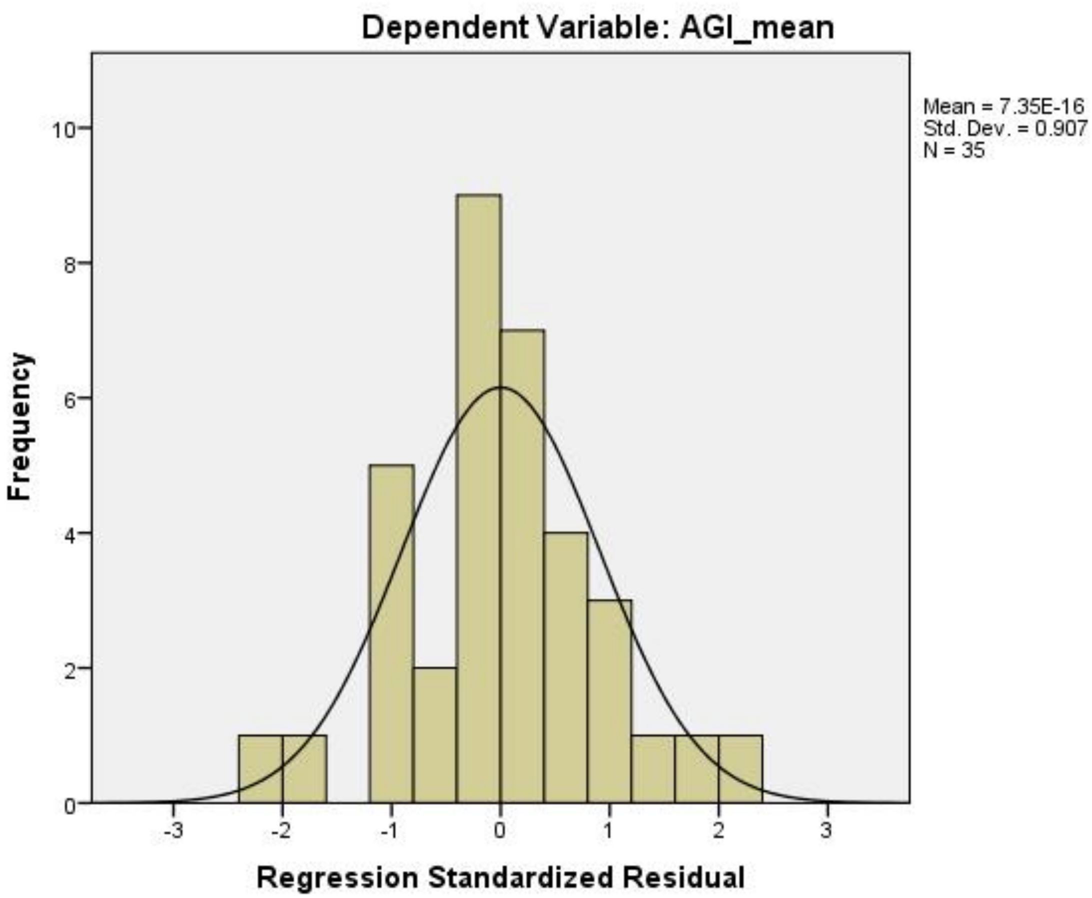

Figure 3. First regression analysis: Histogram of regression standardized residuals.

Next, Figure 4 presented the normal probability-probability plot of the regression standardized residuals, which also helped to ascertain the extent of normality. As shown, the deviation of the plotted data from the superimposed 45-degree line is relatively minimal, suggesting normality with respect to the regression standardized residual values.

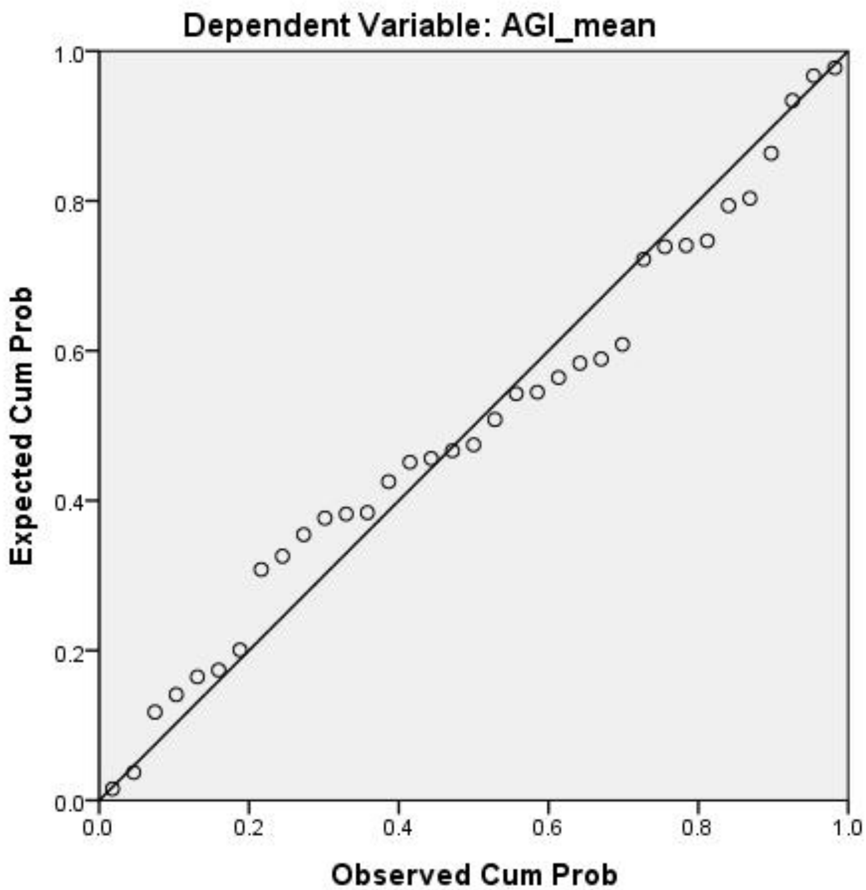

Figure 4. First regression analysis: Normal P-P plot of regression standardized residuals.

Additionally, Figure 5 presented a scatterplot which incorporated the regression standardized predicted values alongside the regression standardized residuals, with the purpose of this plot being to determine whether substantial heteroscedasticity existed with respect to these data. Along with the assumption of normality of the residuals associated with regression analysis, the linear regression model also assumed the lack of heteroscedasticity. As shown in Figure 5, the plotted data initially appeared clustered slightly to the right, but the predicted value axis is actually centered at 0. The scatterplot generally suggested heteroscedasticity, with only an outlier value beyond −3 that may have contributed to an imperfect model.

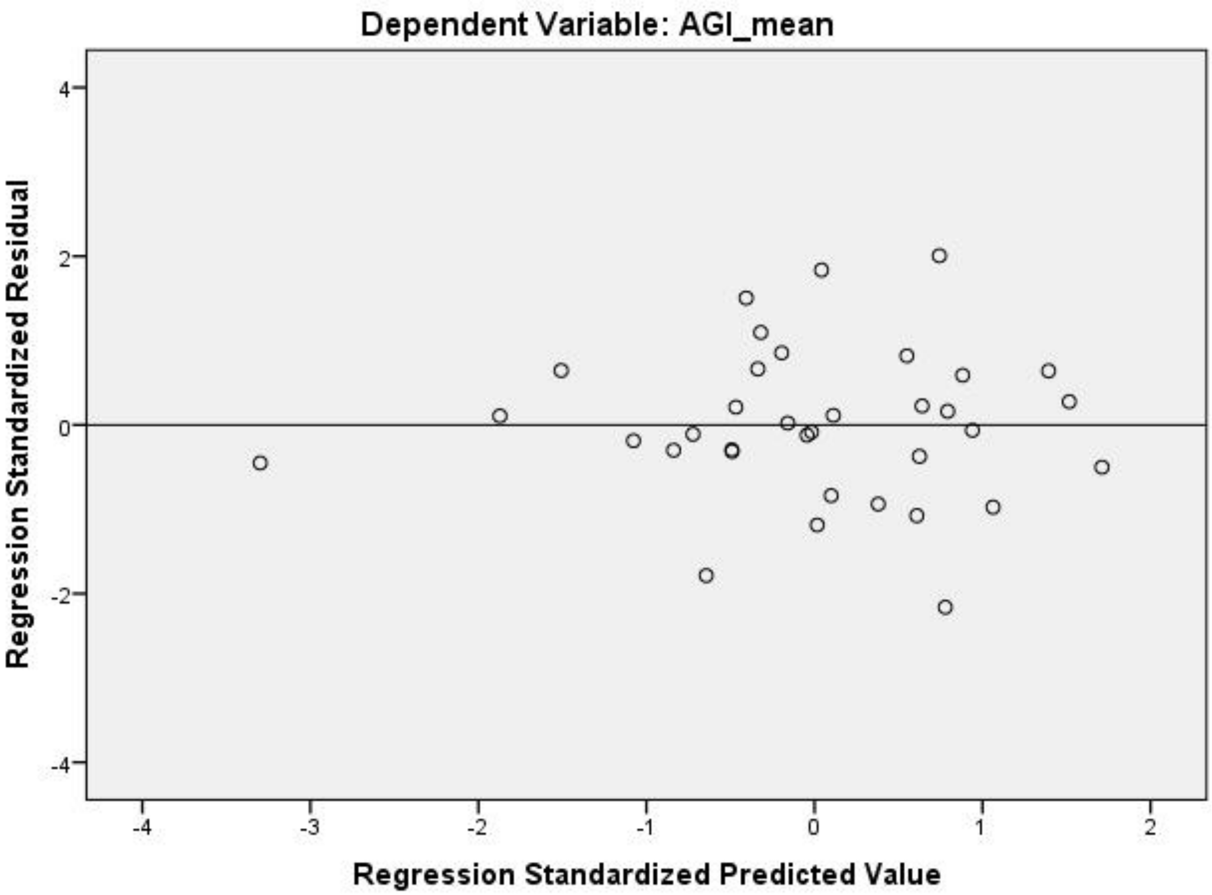

Figure 5. First regression analysis: Scatterplot of regression standardized predicted values and regression standardized residuals.

Regression Model Summaries

Table 13 provided the four regression model summaries. It is from this data set that each research question is analyzed as per each research question design.

Table 13

Regression Model Summaries

					Change statistics				
Model	*R*	*R* squared	Adjusted *R* squared	Std error of the estimate	*R* squared change	*F* change	df^1	df^2	Sig. *F* change
1	.548	.300	.150	3.33	.300	2.00	6	28	.099
2	.442	.195	.088	3.45	.195	1.82	4	30	.151
3	.447	.200	.123	3.38	.200	2.59	3	31	.071
4	.536	.287	.164	3.30	.287	2.34	5	29	.067

First, a regression was conducted to predict the dependent variable, AGI, by all six independent predictor variables. The model was not a significant unique predictor of AGI: F (6,28) = 2.00, p = 0.99, which may be due to overlap with other variables in the model.

Second, a hierarchical regression was conducted to predict the dependent variable, AGI, by instructional practices (Social Constructivist Orientation and Transmission Orientation), when controlling for teacher beliefs and teacher mindset. The model was not a significant unique predictor of AGI: F (4,30) = 1.82, p = .151, which may be due to overlap with other variables in the model.

Third, a hierarchical regression was conducted to predict the dependent variable, AGI, by teacher beliefs (Teacher Allowance for Student Struggle with Problems, Teacher Modeling for Incremental Mastery, and Teachers' Awareness of their Students' Mathematical Dispositions, when controlling for instructional practices and teacher mindset. The model was not a significant unique predictor of AGI: F (3,31) = 2.56, p = 0.71, which may be due to overlap with other variables in the model.

Fourth, a hierarchical regression was conducted to predict the dependent variable, AGI, by teacher mindset (Growth Mindset), when controlling for instructional practices and teacher beliefs. The model was not a significant unique predictor of AGI: F (5,29) = 2.34, p = 0.67, which, again, may be due to overlap with other variables in the model.

None of these independent variables were found to achieve statistical significance within either of the regression models.

Research Questions and Analyses

Research Question 1

The first research question, along with its associated null hypothesis, consisted of the following:

- How does the relationship amongst school-level averages of instructional practices, teacher beliefs, and teacher mindset relate to the school value-added Average Growth Index (AGI)?
- H_0: There will be no significant prediction of AGI by average school-levels of instructional practice, teacher beliefs, and growth mindset.

With $p > .05$, the H_0 failed to be rejected, demonstrating that not enough evidence is available to suggest the null is false at the 95% confidence level.

A multiple regression was conducted to determine to what extent school-level averages of instructional practices, teacher beliefs, and teacher mindset predicted AGI. Social Constructivist Orientation, Transmission Orientation, Teacher Allowance for Student Struggle with Problems, Teacher Modeling for Incremental Mastery, Teachers' Awareness of their Students' Mathematical Dispositions, and Growth Mindset were all included. The dependent variable was defined as Average Growth Index (AGI).

The regression model failed to achieve statistical significance on the basis of the ANOVA conducted, Model 1: $F(6, 28) = 2.00$, $p = 0.99$, determining no unique statistically significant differences between group means. The adjusted R-squared value of .150 indicated that the first regression model predicted 15% of the AGI.

Research Question 2

Next, the second research question and its associated null hypothesis consisted of the following:

- How do school-level average instructional practices relate to school value-added Average Growth Index (AGI) when controlling for teacher beliefs and the teacher growth mindset?
- H_0: There will be no significant prediction of AGI by average school levels of instructional practice, when controlling for teacher beliefs and teacher mindset.

With $p > .05$, the H_0 failed to be rejected, demonstrating that not enough evidence is available to suggest the null is false at the 95% confidence level.

A hierarchical multiple regression was conducted to determine to what extent school-level instructional practices predicted the AGI. When controlling for teacher beliefs and mindset, the regression model found Social Constructivist Orientation and Transmission Orientation resulted in an adjusted R-squared effect size of .088, which means that the second regression model predicted 8.8% of the AGI.

The regression model failed to achieve statistical significance on the basis of the ANOVA conducted, Model 2: $F(4, 30) = 1.82$, $p = .15$, determining no unique statistically significant differences between group means. The adjusted R-squared value of .088 indicated that the first regression model predicted 8.8% of the AGI.

Research Question 3

The third research question included in this study along with its associated null hypothesis consisted of the following:

- How do school-level teacher beliefs relate to school value-added Average Growth Index (AGI) when controlling for instructional practice and growth mindset?
    - H_0: There will be no significant prediction of AGI by average school levels of teacher beliefs, when controlling for instructional practices and the teacher growth mindset.

With $p > .05$, the H_0 failed to be rejected, demonstrating that not enough evidence is available to suggest the null is false at the 95% confidence level.

A hierarchical regression was conducted to determine to what extent school-level teacher beliefs predicted the AGI. When controlling for instructional practices and mindset, the regression model found Teacher Allowance for Student Struggle with Problems, Teacher Modeling for Incremental Mastery, and Teachers' Awareness of their Students' Mathematical Dispositions resulted in an adjusted R-squared effect size of .123, which means these variables predicted 12.3% of the AGI. The regression model failed to achieve statistical significance on the basis of the ANOVA conducted, Model 3: $F(3, 31) = 2.59$, $p = .071$, determining no unique statistically significant differences between group means.

Research Question 4

Next, the fourth and final research question included within this study consisted of the following:

- How does school-level average teacher growth mindset relate to value-added Average Growth Index (AGI) when controlling for instructional practices and teacher beliefs?

- H_0: There will be no significant prediction of AGI by school-level average teacher growth mindset, when controlling for instructional practices and the teacher growth mindset.

With $p > .05$, the H_0 failed to be rejected, demonstrating that not enough evidence is available to suggest the null is false at the 95% confidence level.

A hierarchical multiple regression was conducted to determine to what extent school-level teacher growth mindset predicted the AGI. When controlling for instructional practices and teacher beliefs, the regression model found Teacher Mindset resulted in an adjusted *R*-squared effect size of .164, which means this variable predicted 16.4% of the AGI.

The regression model failed to achieve statistical significance on the basis of the ANOVA conducted, Model 4: F (5, 29) = 2.34, $p = .07$, determining no unique statistically significant differences between group means.

Chapter Summary

This chapter reported data results and analyses for each of the aforementioned research questions. Multiple regression techniques were applied and analyzed to determine the variance in the Average Growth Index (AGI) that could be explained by the six independent predictor variables, independently and interdependently grouped as instructional practices, teacher beliefs, and growth mindset. Initial diagnostics indicated no substantial issues regarding the assumptions of linear regression. Because the same variables were entered for each regression model, the diagnostics were only applied once.

Chapter 5 discussed the findings and conclusions. Study considerations and discussion were focused by the context of the current influences in the K–12 educational arenas. The current research base regarding the teaching and learning of mathematics framed the discussion and practical recommendations for teachers and students. Study limitations and recommendations for future research are also presented.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Khaliqi (2016) poignantly described the beginning of the transition to Common Core State Standards for Mathematics in 2010, declaring that “a wave began to sweep across the United States that heretofore had been unseen” (p. 212), due to its unprecedented initial adoption level nationwide. As of 2015, 43 states have adopted Common Core State Standards for Mathematics (CCCS-Mathematics), intended to provide more rigor and depth of mathematics for students (Swars & Chestnett, 2016). Jason Zimba (2014), lead author of CCCS-Mathematics, embraced the fact that the new standards “more accurately portray rigor and excellence in math as a combination of three things: mastery of procedures, understanding of math concepts, and the ability to apply math to solve problems” (p. 5). Because of increased rigor and expectations for mathematics, students, teachers and administrators are faced with the great challenge of modifying curriculum, instruction, and assessment to meet both the new content and practice standards.

This study explored several key considerations for providing elementary educators with knowledge and understandings to overcome these timely challenges. In addition, the study exclusively explored alternative growth-oriented value-added measures for recognizing student achievement, which have gained traction and acceptance in recent years. As discussed in Chapter 2, research existed that teachers with higher value-added scores also promote deeper conceptual understanding of mathematics with their students (Kane & Staiger, 2012). Boaler (2016) challenged long-held notions that certain mathematical concepts or skill sets cannot be learned unless students have reached a certain developmental or age-readiness level, finding rather that readiness to learn is simply a product of needing to learn certain foundational or prerequisite mathematics. With respect to the classroom, it is clearly important for teachers to identify their students' strengths and weakness, and to react accordingly. To a seasoned educator, this could be considered common sense; however, this concept is far more complicated in practice.

Despite these evident insights into student learning, little is known regarding the beliefs, mindsets and practices that correlate exclusively to value-added student growth (not relative achievement), and few studies have attempted to explore correlation or prediction of such variable sets. Though the variables can be operationalized in various ways, this study focused on instructional practices, teacher beliefs, and growth mindset for elementary mathematics teachers. It was recognized that beliefs and mindsets may play interdependent or independent effects on student learning; thus, the study was constructed to explore the considerable complexities and relationships amongst the variables. An emphasis on promoting expected yearly student growth (and consequently, achievement) was the principal consideration for this study, so as to celebrate student growth, rather than achievement relative only to arbitrary grade level standards. Moving students along their personal learning continuums is far more important of a consideration for evaluating the impact of teacher variables on student learning. Otherwise, students who are learning a year, or more, of curricula can effectively be deemed to be underachieving in mathematics. Subsequently, teachers are likewise identified as ineffective, despite making significant growth with students who were already below grade-level expectations the previous year. Recognizing and valuing student growth must be considered, for the sake of schools, teachers, and students alike.

The purpose of this study was to determine the extent that instructional practices, teacher beliefs, and teacher growth mindset contributed to the variable of value-added student growth. Instructional practices, teacher beliefs, and teacher growth mindset were derived and quantified from three preexisting survey instruments. The goal was to identify and measure potential predictors of students' growth; and, formatively, to utilize the results to understand the relationships and to identify and investigate plausible paths for improvement, or further research. Because, determining what is most impactful for teachers and students has often been so elusive in school mathematics.

This chapter summarized and discussed the study findings within the context of the existing literature and educational landscape. Practical recommendations and suggestions grounded by the study results and existing research base are presented. Study limitations and recommendations for future research are discussed as well.

Discussion

The goal of this study was to better understand how instructional practices, beliefs, and mindsets were attributable to measurable student growth in mathematics. The study expressly investigated the relationship amongst the variables of teacher practices, beliefs, and mindsets and academic growth for elementary students in mathematics. Although the statistical measures did not demonstrate the required significance levels required to reject the null hypotheses, the resultant data sets were able to be interpreted using alternative measures of effect size. The results of this study were largely limited by a sample size that fell short of the recommended minimum suggested for the statistical tests proposed in Chapter 3. Despite this limitation, the statistical results nearly approached significance for each regression model, and consequently, interpretable measures were considered in the context of the study. The results for all four regressions provided evidence that each predictor variable may be positively influencing student growth as measured by the Average Growth Index (AGI) scores. Considering the small sample size and subsequent lack of meeting the desired levels of significance, the disparities between the values could actually have been nominal if the data set were more robust statistically.

Research Question 1

Research Question 1 was, How does the relationship amongst school-level averages of instructional practices, teacher beliefs, and teacher mindset relate to the school value-added Average Growth Index (AGI)?

The hierarchical regression involving all six predictor variables together predicted a moderately significant percentage of impact on the AGI, resulting in an adjusted *R*-squared effect size of .15, which means these variables collectively predicted 15% of the AGI.

Ottmar, Rimm-Kaufman, Larsen, and Berry (2015) established that effective teachers bring a range of skills and attributes to the classroom that need further exploration:

> Teachers and classroom conditions vary; thus, there is a need to explore what occurs *inside* of the classroom during mathematics instruction and understand how certain teacher strengths and classroom contextual factors can improve teacher practice and produce mathematical learning in students. (p. 2)

Ottmar et al.'s (2015) words do an uncanny job of expressing the notions and ideas considered when conceptualizing this study—particularly, that teacher beliefs and mindsets potentially influence behaviors and practices that ultimately impact students, either positively or negatively. Because what individuals believe professionally or philosophically influences the curricular, instructional, and assessment strategies they choose for their classroom and how they are implemented with their students in the classroom. These very notions are exemplified by this study's results.

These initial regression results showed that teaching matters, just not perhaps exactly what matters, although it can be gleaned that teacher beliefs, practices, and mindset are certainly influential predictors of value-added academic growth. The results also certainly provided evidence that beliefs, practices, and mindsets are interrelated and predictive of value-added student growth. Teaching and learning is complicated, with a multitude of variables existing that impact and predict student learning. Because of this, a value-added measure of student learning was chosen to represent student learning, in order to factor out these outside influences. With this in mind, it is apparent that the predictor variables of teacher beliefs, instructional practices, and teacher mindset indeed influenced, or predicted, student growth within this study.

Each successive regression allowed for inferential consideration of the impact upon value-added student growth revealed by each adjusted *R*-squared value. It is certainly imperative to consider the results in the context of the myriad complexities of variables inside and outside of the classroom that surely impact student learning. Of course, outside of a controlled laboratory setting, controlling for all of the influences on student growth and achievement is an impossibility. But such is the reality for educational research. For this study, quantitative research and inferential statistics were leveraged to explore these potential influences on student growth as best possible.

Research Question 2

Research Question 2 was, How do school-level average instructional practices relate to school value-added Average Growth Index (AGI) when controlling for teacher beliefs and the teacher growth mindset?

When controlling for teacher beliefs and mindset, the regression model found levels of Social Constructivist and Transmission Orientation resulted in an adjusted *R*-squared effect size of .088, which means these variables predicted 8.8% of the Average Growth Index (AGI).

Of the three blocks of independent variables considered for this study, instructional practices were determined to be the least influential predictor of AGI. That is not to indicate insignificant, however, as the block indeed contributed to the AGI. Nonetheless, it was notable that teachers reported classroom practices were less predicative than either teacher beliefs or teacher mindset. This result, however, may be explained by the disconnect between the simplicity of the traditional instructional practices for the teaching of mathematics considered in this study, versus the complexities of the instructional practices now required by the CCCS-Mathematics. Although existing research has shown that perhaps social-constructivist instructional practices are more desirable than transmission-oriented practices, it has become increasingly clear that beliefs and mindsets are more important than ever before realized, as was also supported by this study's results. Beliefs matter as they allow teachers to fully embrace and implement more focused and effective mathematical practices in the classroom.

Boaler (2016) asserted that an often-overlooked contribution of the CCCS-Mathematics is their inclusion of mathematical practices—"the actions that are important to mathematics, in which students need to engage as they learn mathematics knowledge" (p. 195). These practices, of course, will never come to fruition without teachers explicitly planning for and incorporating into their pedagogical practice. Classroom teachers must provide students the stage, and learning tasks, necessary for incorporating the practices in the context of the content standards for mathematics. Which, brings into question the manner in which student learning is being assessed with respect to CCSS-Mathematics and Pennsylvania Core Standards for Mathematics. On this assessment front, encouraging progress is being made as Pennsylvania continues to revamp the Pennsylvania State System of Assessment, as detailed in Chapter 2.

Improved assessments are attempting to integrate, and assess, the practices within the newest assessment items. Of course, the fact that the majority of PSSA test items are selected response makes incorporating all of the practices difficult, if not impossible. However, to this end, the newly designed items offer a vast improvement upon previously published items. “By definition, high-quality instructional interactions include how teachers provide feedback and use language to promote learning, higher-order thinking and understanding of concepts” (Ottmar, Decker, Cameron, Curby, & Rimm-Kaufman, 2014, p. 244). These improved pedagogical practices, combined with more rigorous assessment expectations, are a welcomed and long-overdue transformation.

Though increasingly obvious, educators are more likely than ever to embrace the notion of providing individualized and tailored learning opportunities for students. Doing so require teachers to adeptly reconcile curriculum and instruction with student needs, which can be a daunting task for classrooms with a wide-range of mixed readiness level students. In terms of getting to know students, Tomlinson (2003) encouraged responsive teaching through the practice of differentiated instruction for many years. Differentiated instruction required that teachers get to know students’ readiness, interests, and learning profiles, with an end goal of adjusting content, process, and products to meet the student needs (Tomlinson, 2001).

Research Question 3

Research Question 3 was, How do school-level teacher beliefs relate to school value-added Average Growth Index (AGI) when controlling for instructional practices and the teacher growth mindset?

When controlling for instructional practices and the teacher growth mindset, the regression model found teacher beliefs measured by Teacher Allowance for Student Struggle with Problems, Teacher Modeling for Incremental Mastery, and Teacher Awareness of Their Mathematical Dispositions resulted in an adjusted R-squared effect size of .123, which means these variables predicted 12.3% of the Average Growth Index (AGI).

These results revealed that teacher beliefs matter, particularly beliefs reflective of practices that are known to positively impact student learning of mathematics. Overcoming previously learned or formed beliefs is both difficult and challenging for teacher educators. Teachers are inherently creatures of habit and bring strong convictions and philosophies regarding how students best learn mathematics. Unfortunately, these personal notions do not always coincide with research on how students best learn math. The old adage, *If it isn't broken, why fix it?* is often exemplified through comments such as *I have always done it this way—and my kids learn!* emphatically dismissing suggestions for new and improved ways of teaching and learning mathematics. Failure of previous standards-based initiatives can be linked with this abstentious belief.

Of course, many students were indeed able to learn math in this manner. However, this approach often is ineffective for many students, actually increasing perceptions that certain students are math minded whereas others are not. It would make far more sense to explore multiple methods and paths for learning, to reach as many students as possible, which is the essence of accessibility and equity recommendations first espoused by the National Council of Teachers of Mathematics over 35 years ago. It can be inferred that changing deeply rooted beliefs may be critical for fully realizing this vision.

These results revealed that teacher beliefs predicted 12.3% of value-added student growth, supporting that teacher beliefs aligned with behaviors and practices associated with notions of equity and accessibility for learning mathematics impacted student learning. Each of the variables considered, Teacher Allowance for Student Struggle with Problems, Teacher Modeling for Incremental Mastery, and Teacher Awareness of their Mathematical Dispositions, are directly associated with notions of instilling grit, meeting students exactly where they are, and getting to know students as learners. Ultimately, it was validated that teachers who believe that it is important for students to struggle through solving difficult problems, that students should incrementally master difficult concepts, and that getting to know how students learn best, positively influenced student learning of mathematics.

Research Question 4

Research Question 4 was, How does school-level average teacher growth mindset relate to value-added Average Growth Index (AGI) when controlling for instructional practices and teacher beliefs?

When controlling for instructional practices and teacher beliefs, the regression model found Teacher Mindset resulted in an adjusted *R*-squared effect size of .164, which means this variable predicted 16.4% of the Average Growth Index (AGI).

Of the three hierarchical regressions, this effect size associated with growth mindset revealed the most significant prediction of AGI. This conclusion is certainly significant, as it revealed that the learning of mathematics was predicted more so by teacher mindset, rather than by highly regarded research-based teaching practices and refined models of teaching beliefs for the teaching of mathematics. This result is validated by others exploring the impact of a growth mindset for teachers and students.

Evidence existed to support that growth mindset for teachers is directly correlated to student mindsets and levels of achievement (Dweck, 2006). Of the correlations explored in this study, Teacher Mindset (T) was found to independently predict AGI at the highest level. More importantly, then, perhaps, is for educators to not only consider approaches for developing a growth mindset with students but also to explore ways for developing a growth mindset for teachers. Dweck (2008) found an inextricable and positive correlation between students with a growth mindset and student achievement in mathematics and science. Additionally, Dweck (2008) and Boaler (2016) both found teacher professional development to promote a growth mindset and growth-oriented teaching methodologies increased student achievement in mathematics. Of all the specialized mathematics beliefs and practices operationalized within the two beliefs-oriented survey instruments, a simple yet robust four-question survey instrument to measure teacher mindset best predicted value-added student growth. Existing and ongoing research on the power and influence of a growth mindset versus a fixed mindset corroborated this study's findings. Evidently teacher mindset matters in much the same way student mindset does.

Consider the following: "Growth mindset teachers tell students the truth and then give them the tools to close the gap" (Dweck, 2006, p. 199). Though some may consider the following snippet to be harsh, the fact is that the teacher and student recognized the opportunity and that *work* is the required action to do so. Dweck (2006) shared the following exchange that inner-city teacher Marva Collins had with a boy who was clowning around in class:

> You are in sixth grade and your reading level is 1.1. I don't hide your scores in a folder. I tell them to you so you know what you have to do. Now your clowning days are over. Then they got to work. (p. 200)

Collins (Dweck, 2016) certainly was to the point and exemplified the notion of instilling grit, or perseverance to tasks, with students. Although this example is one involving a developing reader, the goal of developing students' perseverance, or grit, actually applies to Common Core State Standards for both English Language Arts and Mathematics. Within reason, hard work, effort, and a growth mindset lead to academic gains for students.

Implications

With respect to honoring and implementing previous reforms for the teaching and learning of mathematics, teachers arbitrarily and unceremoniously declared themselves experts in elementary mathematics teaching and learning, continuing to teach mathematics in the very same way they were taught, replicating the practices in their classrooms, thus perpetuating the status quo. The advent of CCSS-Mathematics and its corresponding assessments, and increased acceptance of value-added growth measures, will soon make this an impossibility for teachers to continue to ignore. Also, the notion that students bring a special aptitude or ability for learning mathematics to the classroom can no longer be accepted, as all students are capable of learning mathematics under the right conditions. Teachers with a growth mindset, who believe this to be true, positively impacted student learning of mathematics.

Gardner and Smith (2016) found when investigating the teaching and learning expectations for CCCS-Mathematics and CCSS-English Language Arts, that certain expectations are directly transferrable between the two sets of standards. With respect to developing grit, Kraft and Grace (2016, p. 9) defined such behavior as social–emotional competencies and stated that emerging research suggested that teachers can indeed influence and develop these skills, attitudes, and mindsets for children. Teachers who instill these attributes provide children tools and skills for successes in academics, career, and life.

In providing an overview of Every Student Succeeds Act shifts classroom educators need to know, Fennell (2016) reported that evidence of student achievement can now include student growth, rather than only static achievement relative to grade-level academic standards. This in itself is an important step toward acknowledging that valuing student growth is important and needs to be recognized. Over nearly the same period of time, educators came to realize that student achievement relative to meeting arbitrary academic standards, alone, fell short in terms of determining the efficacy of schools and determining if teachers, schools, and students met academic standards. Seeking alternative means to measure, and to evaluate, student learning introduced the idea of value-added student growth. Student growth and accountability are two key considerations that must be reconciled.

The implications of this study are firmly rooted in today's ever changing educational landscape, which presently is shifting to the Every Student Succeeds Act. Darling-Hammond et al. (2016) summarized the significance of the Every Student Succeeds Act authorization. One implication is regarding expectations for the teaching and learning of school mathematics, specifically for expectations with respect to college and career readiness. The CCSS-Mathematics are designed to help students reach academic standards that prepare them for college and careers, and that require teachers to rethink current practices (Osborne, 2015, p. 23), a similar shift that the National Council of Teachers of Mathematics first proposed in 1989. Another implication is regarding school accountability, with the pending movement away from testing for mostly evaluative, or *Race to the Top* purposes, to a focus on gathering and utilizing student data for the reasons of gathering formative data to demonstrate and inform student instruction. In this respect, a renewed emphasis is for growing students academically. A third implication, and perhaps the utmost consideration, is for educators to never, ever lose sight of developing the whole child. Children are inherently inquisitive and bring a natural curiosity for learning to the mathematics classroom. Educators certainly wish to harness these attributes while also developing the skills, attitudes, and mindsets to allow students to become self-driven and independent learners. Of course, this requires a balancing act, more so than ever before, with deference to more rigorous academic standards, requiring students to reach higher levels of understanding and application.

Hamilton et al. (2016) found that CCSS-Mathematics have raised student objectives and rigor in terms of both curriculum and instruction, requiring many teachers to shift their instructional strategies incorporate and meet the expectations. Also, Schoenfield (2015) contended that successful implementation of CCSS-Mathematics and Standards for Mathematical Practices will hinge upon the quality of the assessments used to assess student achievement. These high-stakes state assessments now drive classroom teaching and learning more than ever, “shaping how the curriculum comes to life in America classrooms” (Schoenfield, 2015, p. 192). With respect the Standards for Mathematical Practice, a certain dynamic must be brought to life with respect to classroom actions of teachers and students alike. Calkins, Ehrenworth, and Lehman (2012) warned that long-term success with implementing Common Core Standards would require not only “ratcheting up the level of instruction” (p. 15) but also teachers and administrators working together to establish better systems for teaching to higher expectations than ever before.

With little support whatsoever for pervasive, flawed notions that certain individuals are math minded while others are not, it is fair to concede that mathematics can be quite challenging for some children. This also can be substantiated through the researcher’s own trials and tribulations with school mathematics from kindergarten to postgraduate school, and also as a mathematics coach or intervention specialist for the past 10 plus years.

Recommendations for Future Research

First and foremost, the most obvious recommendation is to replicate this exact study with the required sample size of $n = 79$ schools. Because the data analysis provided evidence that approached significance, it would be worthy of replication to more conclusively consider the relationship amongst the six predictor variables and Average Growth Index (AGI). Of course, this would be an ambitious task, as was discovered through this study. However, if it were approached applying the lessons learned since conducting this study, it could be replicated and expanded to provide a more robust and substantial data set. The study results, successes, and failures, do speak to other conceivable recommendations as well.

Secondly, conceptualizing and modifying the study to correlate individual teacher responses may warrant additional considerations. Alternative analyses applying similar methodological approaches suggested statistically significant predictions of the AGI. Specifically, correlating the independent variables individually, or cogitating alternate sets of variables, to the AGI using multiple regressions would be a practical alternative worthy of consideration.

Lastly, it would be educative to conceptualize the study to quantify the independent variables for instructional practices by means of observational instruments, rather than self-reported ones. Adding a teacher interview instrument to gather qualitative data regarding teacher beliefs and mindset would provide a rich data set to closely explore the nuances of teacher beliefs and mindsets, and the interactions at play, with instructional practices and their correlation to student growth. A mixed-methods study of this design would be difficult to undertake, but would certainly be a valuable recommendation for future research.

Summary of Findings

As a disclaimer regarding the study findings, the magnitude of uncertainty associated with the deficient statistical significance for all four regression models cannot be precisely quantified. With respect to all reported alternative effects and correlations, the researcher conceded this constraining statistical weakness for all reported analyses.

This study investigated the correlation between elementary math teacher beliefs, practices, and mindset on elementary student growth in mathematics. Student growth was considered as the Average Growth Index (AGI), a value-added metric derived from the Pennsylvania System of School Assessment (PSSA). The study exclusively focused on Pennsylvania elementary schools responsible for teaching mathematics in Grades 3, 4, and 5 only. Publicly available AGI scores for the 2014-2015 school year were identified as the measure of student growth in mathematics. School district superintendents, elementary school principals, and classroom teachers were identified and linked to preexisting AGI scores. Three existing, validated surveys, designed to quantify school-wide levels of instructional practices, teacher beliefs, and growth mindset were administered to elementary teachers who provided permission and agreed to participate in the study. Results were correlated to AGI using statistical regression models to ascertain the extent each independent, and interdependent block of variables, was predictive of AGI.

Data were collected during the spring of 2016 from teachers who were identified as those who taught Grade 3, 4, and 5 elementary mathematics during the 2014-2015 academic school year. Verification of teaching assignments were provided exclusively from building principals.

Assigned building principals confirmed and validated teaching assignments, and also served as site liaison by directly providing teacher names, teaching assignments, and official district approved e-mail addresses. To further assure proper attribution of teacher and Pennsylvania Value Added Assessment System scores, teaching assignments were confirmed via an identifying question at the onset of the Qualtrics® survey instrument. These results were associated and verified with principal provided information.

Quantitative methodologies were employed to collect and analyze the existing and collected data sets. Regression models were chosen to establish the relationship between and amongst the independent and dependent variables being studied. The goal of the study was to better understand how instructional practices, teacher beliefs, and growth mindset correlated to measurable student growth, in order to expand the literature on the topic of strengthening instructional practices and students' achievement in mathematics. This study investigated the relationships amongst the independent predictor variables of teacher practices, beliefs, and mindsets and academic growth for elementary students in mathematics. Observational and statistical findings from this study indicated the following:

- Although the sample size fell short of the recommended size for the statistics utilized, the data set showed little indication of failing to meet assumptions of linearity, homoscedasticity, and multicollinearity.
- Because of the normality of the sample, it can be inferred that a more robust sample size may have reached significance for some or all of the regression analyses.
- Pearson's correlations revealed several important positive relationships existed among the six independent variables identified for this study.

- For all four research questions, the null hypothesis failed to be rejected, demonstrating that not enough evidence was available to suggest the null were false at the 95% confidence level.
- Despite establishing unsatisfactory statistical significance and failing to reject the null hypothesis, all four regressions approached a discernable level of significance (RQ1 = .099, RQ2 = .151, RQ3 = .071, RQ4 = .067, respectively for each regression model).
- Analysis of variance (ANOVA) results determined an adjusted *R*-squared effect size of .15, finding that teacher beliefs, instructional practice, and teacher mindset, in aggregate, predicted 15% of the AGI.
- ANOVA results determined an adjusted *R*-squared effect size of .088, finding that when controlling for teacher beliefs and teacher mindset, instructional practices predicted 8.8% of the AGI.
- ANOVA results determined an adjusted *R*-squared effect size of .123, finding that when controlling for instructional practices and teacher mindset, teacher beliefs predicted 12.3% of the AGI.
- ANOVA results determined an adjusted *R*-squared effect size of .164, finding that when controlling for instructional practices and teacher beliefs, teacher mindset predicted 16.4% of the AGI.

From the reported adjusted *R*-squared effect size for each research question ANOVA, it can be gleaned the six independent variables studied were positively correlated to student growth in mathematics. To varying degrees, instructional practices (Social Constructivist Orientation and Transmission Orientation), teacher beliefs (Teacher Allowance for Student Struggle with Problems, Teacher Modeling for Incremental Mastery, and Teachers' Awareness of their

Students' Mathematical Dispositions), and teacher mindset (Growth or Fixed Mindset) were either interdependently, or independently, positively correlative and predictive of AGI.

In predictive rank order, a growth mindset individually was most predictive of AGI at 16.4%, followed aggregately by teacher mindset at 15%, teacher beliefs at 12.3%, and instructional practices at 8.8%. Based on the results, it can be inferred that all of the variables positively correlated to student growth, albeit to varying degrees of influence. Together, each discrete set of variables showed to predict student growth. Noteworthy is that teacher beliefs and mindset were more predictive of student growth than teacher reported instructional practices. These results implied that teacher beliefs and mindset bear more influence upon learning than self-reported instructional practices, which supported research showing that students who hold a growth mindset are also more likely to grow academically. It can be conjectured that perhaps teacher beliefs and mindsets are also transmitted to students independent of the instructional practices considered for this study.

Final Thoughts: A Personal Note

Admittedly the subject of mathematics has personally been perplexing and challenging at various times. Math was difficult, to be honest. In retrospect, as a professional in the field, it was eventually understood that things did not need to be this way. Because of this unique experience, investment in this study was driven with personal and professional hopes of contributing to literature base for improved student access to the learning of mathematics. Personally, failures and challenges with school mathematics were able to be overcome, due in large part to eventually developing conceptual understandings and an ability to see mathematics in novel contexts. Rather than seeing lots of numbers out of context and being required to do procedures that made little sense, understanding mathematical concepts and opportunities to think mathematically increased aptitude for the subject. This connected perspective increased confidence and ability to eventually learn more difficult and rigorous concepts. As an elementary and middle school math teacher, content-focused mathematics coach, and most recently as an elementary mathematics specialist and interventionist, seeing math taught in context, with a focus on reasoning, was both radical and momentous for the professional work that was ahead. Intimately knowing and understanding the feelings of frustration, struggle, and failure have also allowed for empathetically approaching work with students and teachers alike. This is not to suggest such experience is a requisite for more effective math teaching, but merely to illustrate it has further substantiated advocating for research-based practices and instilling positive mindsets and productive beliefs for the teaching of elementary mathematics. For teachers, students, and parents alike.

Professionally, working with struggling learners, parents, and teachers to intervene and to provide academic support in various ways over the years has largely defined the researcher's career. Unquestionably, if asked what is the most impactful and important approach, stance, or method, to improve student-learning outcomes for mathematics, it would be an instructional approach that develops deep conceptual understandings of major mathematical concepts, and opportunities to think naturally and intuitively, to communicate mathematically, and to solve problems. These practices lead to increased confidence, which eventually leads to students actualizing their academic and intellectual potential for learning mathematics. Meeting students where they are, providing accessible learning opportunities, and building from successes is a recipe for student learning and growth. All of these mentioned practices, along with being respectful of students' individual pace of learning, are indeed effective; develop confidence, positive beliefs, and mindsets; and warrant serious consideration for classroom implementation.

Students first deserve a mathematics classroom grounded in current research, supporting conceptual understanding, and that is differentiated to meet diverse readiness levels. Through fair and equitable learning opportunities that foster depth of understanding and application, elementary students can feel valued and respected for their current level of understanding so that they might be able to develop confidence, perseverance, and the ability to continue to grow mathematically, while also meeting the depth and rigor of current math standards. Most important is that students are met where they are so that they may develop the prerequisite knowledge, skills, and understandings necessary for learning more advanced concepts.

References

Amrein-Beardsley, A. (2008). Methodological concerns about the education value-added assessment system. *Educational Researcher*, *37*(2), 65–75. doi:10.3102/0013189x08316420

Babbie, E. (2010). *The practice of social research* (International ed.). Belmont, CA: Wadsworth Cengage Learning.

Ball, D. L. (1988). *Research on teaching mathematics: Making subject matter knowledge part of the equation*. Retrieved from ERIC database. (ED301467)

Ball, D. L. (1996). Teacher learning and the mathematics reform: What we think we know and what we need to learn. *Phi Delta Kappan*, *77*(7), 500–508. Retrieved from ERIC database. (EJ519759)

Ball, D. L., & Bass, H. (2009, March). *With an eye on the mathematical horizon: Knowing mathematics for teaching to learners' mathematical futures*. Paper based on keynote address at the 43rd Jahrestagung für Didaktik der Mathematik, Oldenburg, Germany.

Ball, D. L., & Cohen, D. K. (1999). Developing practice, developing practitioners: Toward a practice-based theory of professional education. In L. Darling-Hammond & G. Sykes (Eds.), *Teaching as the learning profession: Handbook of policy and practice* (pp. 3–22). San Francisco, CA: Jossey-Bass.

Ball, D. L., Hill, H. H., & Bass, H. (2005). Knowing mathematics for teaching: Who knows mathematics well enough to teach third grade, and how can we decide? *American Educator, 29*(3), 14–46. Retrieved from Education Research Complete database. (Accession No. 18369597)

Ball, D. L., & Forzani, F. M. (2009). The work of teaching and the challenge for teacher education. *Journal of Teacher Education*, *60*(5), 497–511. doi:10.1177/0022487109348479

Ball, D. L., Lubienski, S. T., & Mewborn, D. S. (2001). Research on teaching mathematics: The unsolved problem of teachers' mathematical knowledge. In V. Richardson (Ed.), *Handbook of research on teaching* (4th ed., pp. 433–456). New York, NY: Macmillan.

Ball, D. L., Thames, M. H., & Phelps, G. (2008). Content knowledge for teaching: What makes it special? *Journal of Teacher Education, 59*(5), 389–407. doi:10.1177/0022487108324554

Ballou, D., Sanders, W., & Wright, P. (2004). Controlling for student background in value-added assessment of teachers. *Journal of Educational and Behavioral Statistics, 29*(1), 37–65. doi:10.3102/10769986029001037

Bednarz, N., & Proulx, J. (2009). Knowing and using mathematics in teaching: Conceptual and epistemological clarifications. *For the Learning of Mathematics, 29*(3), 11–17. Available from http://www.jstor.org/stable/25594560

Beghetto, R. A., & Baxter, J. A. (2012). Exploring student beliefs and understanding in elementary science and mathematics. *Journal of Research in Science Teaching, 49*(7), 942–960. doi:10.1002/tea.21018

Beswick, K. (2004). The impact of teachers' perceptions of student characteristics on the enactment of their beliefs. *Instrumentalist, 2*(1980), 111–118.

Beswick, K. (2006). The importance of mathematics teachers' beliefs. *Australian Mathematics Teacher, 62*(4), 17–22. Retrieved from ERIC database. (EJ765836)

Beswick, K. (2007). Teachers' beliefs that matter in secondary mathematics classrooms. *Educational Studies in Mathematics, 65*(1), 95–120. doi:10.1007/s10649-006-9035-3

Beswick, K. (2008). Influencing teachers' beliefs about teaching mathematics for numeracy to students with mathematics learning difficulties. *Mathematics Teacher Education and Development*, *9*, 3–20. Retrieved from ERIC database. (EJ822098)

Beswick, K. (2012). Teachers' beliefs about school mathematics and mathematicians' mathematics and their relationship to practice. *Educational Studies in Mathematics, 79*(1), 127–147. doi:10.1007/s10649-011-9333-2

Beswick, K., Watson, J., & Brown, N. (2006). Teachers' confidence and beliefs and their students' attitudes to mathematics. *29th Annual Conference of the Mathematics Education Research Group of Australasia: Identities, Cultures and Learning Spaces, 1*(2000), 68–75.

Betebenner, D. W. (2009). *Growth, standards and accountability*. Retrieved from http://www.nciea.org/publications/growthandStandard_DB09.pdf

Bishop, W., Clopton, P., & Milgram, R. (2012). A close examination of Jo Boaler's railside report. *Nonpartisan Education Review, 8*(1), 1–20. Retrieved from http://educationpolicy.info/Review/Articles/v8n1.pdf

Blackburn, B. (2008). *Rigor is not a four-letter word*. Larchmont, NY: Eye On Education.

Blad, E. (2015). Teachers nurture growth mindsets in math. *Education Week, 35*(3), 1–11. Retrieved from Education Research Complete database. (Accession No. 109482593)

Boaler, J. (2005). The 'psychological prisons' from which they never escaped: The role of ability grouping in reproducing social class inequalities. *Forum, 47*(2/3), 135–144. doi:10.2304/forum.2005.47.2.2

Boaler, J. (2013). Ability and mathematics: The mindset revolution that is reshaping education. *Forum, 55*(1), 143–152. doi:10.2304/forum.2013.55.1.143

Boaler, J. (2016). *Mathematical mindsets: Unleashing students' potential through creative math, inspiring messages and innovative teaching*. San Francisco, CA: Jossey-Bass.

Briars, D. J. (2014). Core truths. Retrieved from https://www.nctm.org/News-and-Calendar/Messages-from-the-President/Archive/Diane-Briars/Core-Truths/

Brown, C. P., Feger, B. S., & Mowry, B. (2015). Helping others understand academic rigor in teachers' developmentally appropriate practices. *YC Young Children*, *70*(4), 62.

Brousseau, B. A., Book, C., & Byers, J. L. (1988). Teacher beliefs and the cultures of teaching. *Journal of Teacher Education, 39*(6), 33–39. doi:10.1177/002248718803900607

Calkins, L., Ehrenworth, M., & Lehman, C. (2012). *Pathways to the Common Core: Accelerating achievement*. Portsmouth, NH: Heinemann.

Carney, M. B., Brendefur, J. L., Hughes, G. R., & Thiede, K. (2015). Developing a mathematical instructional practice survey: Considerations and evidence. *Mathematics Teacher Educator*, *4*(1), 93–118. doi:10.5951/mathteaceduc.4.1.0093

Chapman, O. (2002). Belief structure and inservice high school mathematics teacher growth. In G. C. Leder, E. Pehkonen, & G. Törner (Eds.), *Beliefs: A hidden variable in mathematics education?* (pp. 177–194). Dordrecht, The Netherlands: Kluwer.

Clark, L. M., DePiper, J. N., Frank, T. J., Nishio, M., Campbell, P. F., Smith, T. M., & Choi, Y. (2014). Teacher characteristics associated with mathematics teachers' beliefs and awareness of their students' mathematical dispositions. *Journal for Research in Mathematics Education, 45*(2), 246–284. doi:10.5951/jresematheduc.45.2.0246

Common Core State Standards Initiative. (2010a). *Common Core State Standards for Mathematics*. Retrieved from http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf

Common Core State Standards Initiative. (2010b). Key shifts in mathematics. Retrieved from http://www.corestandards.org/other-resources/key-shifts-in-mathematics/

Conley, D. T. (2011). Building on the Common Core. *Educational Leadership, 68*(6), 16–20. Retrieved from http://www.ascd.org/publications/educational_leadership/

Conley, D. T. (2014). *The Common Core State Standards: Insight into their development and purpose*. Washington, DC: Council of Chief State School Officers.

Creswell, J. W. (2013). *Research design: Qualitative, quantitative, and mixed methods approaches* (4th ed.). Thousand Oaks, CA: Sage.

Cuban, L. (1988). A fundamental puzzle of school reform. *Phi Delta Kappan, 69*(5), 341–344. Retrieved from ERIC database. (EJ364789)

Darling-Hammond, L., Bae, S., Cook-Harvey, C. M., Lam, L., Mercer, C., Podolsky, A., & Stosich, E. L. (2016). Pathways to new accountability through the Every Student Succeeds Act. Retrieved from https://learningpolicyinstitute.org/sites/default/files/product-files/Pathways_New-Accountability_Through_Every_Student_Succeeds_Act_04202016.pdf

Davidson, D. D., & Mitchell, J. E. (2008). How is mathematics education philosophy reflected in the math wars? *The Montana Mathematics Enthusiast, 5*(1), 143–154. Retrieved from EBSCOhost database. (Accession No. 27730005)

Davis, J. (2015, December 10). President Obama signs into law a rewrite of No Child Left Behind. *The New York Times*. Retrieved from http://www.nytimes.com/2015/12/11/us/politics/president-obama-signs-into-law-a-rewrite-of-no-child-left-behind.html?_r=0

Dee, T. S., & Jacob, B. (2009). *The impact of No Child Left Behind on student achievement* (Working Paper 15531). Retrieved from http://www.nber.org/papers/w15531.pdf

Dockterman, D., & Blackwell, L. (2014). *Growth mindset in context: Content and culture matter too*. Retrieved from http://www.leadered.com/pdf/GrowthMindset.pdf

Donovan, M. S., & Bransford, J. D. (Eds.). (2005). *How students learn: History, mathematics, and science in the classroom*. Washington, DC: The National Academies Press.

Doran, H. C., & Fleischman, S. (2005). Research matters / Challenges of value-added assessment. *Educational Leadership, 63*(3), 85–87. Retrieved from http://www.ascd.org/publications/educational_leadership/

Duckworth, A. L., & Quinn, P. D. (2009). Development and validation of the Short GRIT Scale (GRIT–S). *Journal of Personality Assessment, 91*(2), 166–174. doi:10.1080/00223890802634290

Dweck, C. S. (2000). *Self-theories: Their role in motivation, personality, and development*. New York, NY: Psychology Press.

Dweck, C. S. (2006). *Mindset: The new psychology of success*. New York, NY: Random House.

Dweck, C. S. (2008). Can personality be changed? The role of beliefs in personality and change. *Current Directions in Psychological Science*, *17*(6), 391–394. doi:10.1111/j.1467-8721.2008.00612.x

Dweck, C. S., Chiu, C. Y., & Hong, Y. Y. (1995). Implicit theories and their role in judgments and reactions: A word from two perspectives. *Psychological Inquiry*, *6*(4), 267–285. doi:10.1207/s15327965pli0604_1

Ediger, M. (2009). Mathematics: Content and pedagogy. *College Student Journal, 43*(3), 714–717. Retrieved from Education Research Complete database. (Accession No. 43969271)

Edwards, V. B. (Ed.). (2016). Called to account: New directions in school accountability: Quality counts. *Education Week, 35*(16). Retrieved from ERIC database. (ED564139)

Eichler, A. (2008). Teachers' classroom practice and students' learning: A joint ICMI/IASE study: Teaching statistics in school mathematics. Challenges for teaching and teacher education In *Proceedings of the ICMI Study* (p. 18).

Ernest, P. (1989). The impact of beliefs on the teaching of mathematics. Mathematics teaching: In P. Ernest (Ed.), *The state of the art* (pp. 249–254). London, England: Falmer Press.

Ertmer, P. A. (2005). Teacher pedagogical beliefs: The final frontier in our quest for technology integration? *Educational Technology Research and Development, 53*(4), 25–39. doi:10.1007/bf02504683

Fallon, D. (n.d.). *Case study of a paradigm shift (The value of focusing on instruction)*. Retrieved from http://research.mathmeister.com/Documents/FallonTeacherEffect.rtf

Fennell, M. (2016). What educators need to know about ESSA. *Educational Leadership, 73*(9), 62–65. Retrieved from http://www.ascd.org/publications/educational-leadership/jun16/vol73/num09/What-Educators-Need-to-Know-about-ESSA.aspx

Fenstermacher, G. D. (1979). Educational accountability: Features of the concept. *Theory Into Practice, 18*(5), 330–335. doi:10.1080/00405847909542854

Fives, H., & Buehl, M. M. (2011). Spring cleaning for the "messy" construct of teachers' beliefs: What are they? Which have been examined? What can they tell us? In K. R. Harris, S. Graham, T. Urdan, S. Graham, J. M. Royer, & M. Zeidner (Eds.), *APA educational psychology handbook, Vol. 2: Individual differences and cultural and contextual factors* (pp. 471–499). doi:10.1037/13274-019

Fletcher, P. R. (n.d.). *Growth, value-added and teacher effectiveness measures*. Retrieved from http://researchnetwork.pearson.com/wp-content/uploads/growthvalueaddedandteachereffectivenessmeasures.pdf

Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (1993). *How to design and evaluate research in education* (Vol. 7). New York, NY: McGraw-Hill.

Friedberg, S. (2014, September 15). Common Core math is not fuzzy: Column. *USA Today*. Retrieved from http://www.usatoday.com/

Gabriel, R. E., & Lester, J. N. (Eds.). (2013). *Performances of research: Critical issues in K–12 education*. New York, NY: Peter Lang.

Gardner, N. S., & Smith, N. (2016). Math and ELA meet at the Common Core. *Phi Delta Kappan, 97*(6), 5356. doi:10.1177/0031721716636874

Gay, L. R., Mills, G., & Airasian, P. W. (2008). *Educational research: Competencies for analysis and interpretation* (9th ed.). Upper Saddle River, NJ: Prentice Hall.

Ginsburg, A., Cooke, G., Leinwand, S., Noell, J., & Pollock, E. (2005). *Reassessing U.S. international mathematics performance: New findings from the 2003 TIMSS and PISA*. Retrieved from ERIC database. (ED491624)

Goldin, G., Rösken, B., & Törner, G. (2009). Beliefs – No longer a hidden variable in mathematical teaching and learning processes. In J. Maaß & W. Schlöglmann (Eds.), *Beliefs and attitudes in mathematics education: New research results* (pp. 9–28). Rotterdam, The Netherlands: Sense.

Goldschmidt, P., Roschewski, P., Choi, K., Auty, W., Hebbler, S., Blank, R., & Williams, A. (2005). *Policymakers' guide to growth models for school accountability: How do accountability models differ*. Washington, DC: Council of Chief State School Officers.

Green, E. (2014, July 27). Why do Americans stink at math? *The New York Times Magazine*, p. MM22. Retrieved from http://www.nytimes.com/

Hale, J. (2011, July 18). The importance of correlational studies [Blog post]. Retrieved from http://psychcentral.com/blog/archives/2011/07/18/the-importance-of-correlational-studies/

Hamilton, L. S., Kaufman, J. H., Stecher, B. M., Naftel, S., Robbins, M., Thompson, L. E., . . . & Opfer, V. D. (2016). *What supports do teachers need to help students meet Common Core State Standards for Mathematics?* Santa Monica, CA: RAND.

Hancock, M. (2005). Taking on the challenge of mathematics for all: Strategies to improve mathematics achievement for every child. *NCA CASI e-News, 4*(3).

Harris, D. N. (2008). The policy uses and "policy validity" of value-added and other teacher quality measures. In D. Gitomer (Ed.), *Measurement issues and assessment for teacher quality* (pp. 99–130). Thousand Oaks, CA: Sage.

Hart, L. (2002). A four-year follow-up study of teachers' beliefs after participating in a teacher enhancement project. In G. Leder, E. Pehkonen, & G. Torner (Eds.), *Beliefs: A hidden variable in mathematics education* (pp. 161–176). Norwell, MA: Kluwer Academic.

Hechinger, J. (2006, September 12). New report urges return to basics in teaching math. *The Wall Street Journal*, p. 12. Retrieved from http://www.wsj.com/articles/

Hill, H. C., Ball, D. L., & Schilling, S. (2004). Developing measures of teachers' mathematics knowledge for teaching. *Elementary School Journal, 105*(1), 11–30. doi:10.1086/428763

Hill, H. C., Rowan, B., & Ball, D. L. (2005). Effects of teachers' mathematical knowledge for teaching on student achievement. *American Educational Research Journal, 42*(2), 371–406. doi:10.3102/00028312042002371

Howell, D. C. (2016). *Fundamental statistics for the behavioral sciences* (9th ed.). Boston, MA: Cengage.

Hudson, R., Cross Francis, D., Rapacki, & Lee, M. (2015, April). *Teachers beliefs as portrayed in NCTM's "Principles to actions."* Paper presented at the Annual Meeting of the National Council of Teachers of Mathematics Research Pre-Session, Boston, MA.

Hull, T. (2007). Manager to instructional leader: Developing teachers as leaders. *Journal of Mathematics Education Leadership, 9*(2), 45–55.

Husen, T. (1967). *International study of achievement in mathematics*. Retrieved from ERIC database. (ED015130)

Jacob, B. A., & Lefgren, L. (2008). Can principals identify effective teachers? Evidence on subjective performance evaluation in education. *Journal of Labor Economics*, *26*(1), 101–136. doi:10.1086/522974

Jerald, C. (2008). *Benchmarking for success: Ensuring U.S. students receive a world-class education*. Retrieved from ERIC database. (ED504084)

Johnsen, S. K., Assouline, S., & Ryser, G. R. (2013). *Teacher's guide to using the Common Core State Standards with mathematically gifted and advanced learners*. Waco, TX: Prufrock Press.

Kajander, A. (2007). Unpacking mathematics for teaching: A study of preservice elementary teachers' evolving mathematical understandings and beliefs. *Journal of Teaching and Learning, 5*(1), 33–54. Retrieved from http://ojs.uwindsor.ca/ojs/leddy/index.php/JTL/

Kamenetz, A. (2014, October 11). It's 2014. All children are supposed to be proficient. What happened? Retrieved from http://www.npr.org/sections/ed/2014/10/11/354931351/it-s-2014-all-children-are-supposed-to-be-proficient-under-federal-law

Kane, T. J., & Staiger, D. O. (2012). *Gathering feedback for teaching: Combining high-quality observations with student surveys and achievement gains*. Seattle, WA: Bill & Melinda Gates Foundation.

Khaliqi, D. (2016). How common is the Common Core? A global analysis of math teaching and learning. *School Science and Mathematics*, *116*(4), 199–211. doi:10.1111/ssm.12170

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist, 41*(2), 75–86. doi:10.1207/s15326985ep4102_1

Kraft, M. A., & Grace, S. (2016). *Teaching for tomorrow's economy? Teacher effects on complex cognitive skills and social-emotional competencies*. Retrieved from http://scholar.harvard.edu/files/mkraft/files/teaching_for_tomorrows_economy_-_final_public.pdf

Kupermintz, H. (2003). Teacher effects and teacher effectiveness: A validity investigation of the Tennessee Value Added Assessment System. *Educational Evaluation and Policy Analysis, 25*(3), 287–298. doi:10.3102/01623737025003287

Kupermintz, H., Shepard, L., & Linn, R. (2001). *Teacher effects as a measure of teacher effectiveness: Construct validity considerations in TVAAS (Tennessee Value Added Assessment System)*. Retrieved from ERIC database. (ED458295)

Labaree, D. F. (2014). Let's measure what no one teaches: PISA, NCLB, and the shrinking aims of education. *Teachers College Record, 116*(9), 1-14.

Layton, L. (2015, December 10). Obama signs new K–12 education law that ends No Child Left Behind. *The Washington Post*. Retrieved from https://www.washingtonpost.com/

Leatham, K. R. (2006). Viewing mathematics teachers' beliefs as sensible systems. *Journal of Mathematics Teacher Education, 9*(1), 91–102. doi:10.1007/s10857-006-9006-8

Leinwand, S. (2014, April). "*Principles to actions": What's exciting about NCTM's new blueprint?* Presentation at the Annual Meeting of the National Council of Teachers of Mathematics, New Orleans, LA.

Leinwand, S., Huinker, D., & Brahier, D. (2014). "*Principles to actions"*: Mathematics programs as the core for student learning. *Mathematics Teaching*, *19*(9), 516–519. doi:10.5951/mathteacmiddscho.19.9.0516

Lissitz, R. W. (2012, April). *The evaluation of teacher and school effectiveness using growth models and value added models: Hope versus reality*. Presentation to American Educational Research Association Division H, Vancouver, British Columbia, Canada.

Lomax, E. D., & Kuenzi, J. J. (2012). *Value-added modeling for teacher effectiveness* (Congressional Research Service Report 7-5700). Retrieved from https://fas.org/sgp/crs/misc/R41051.pdf

Maasz, J., & Schlöglmann, W. (2009). *Beliefs and attitudes in mathematics education: New research results*. Rotterdam, The Netherlands: Sense.

Marzano, R., Pickering, D., & Pollack, J. (2001). *Classroom instruction that works: Research-based strategies for increasing student achievement*. Washington, DC: Association of Supervision and Curriculum Development.

McCaffrey, D. F., Lockwood, J., Koretz, D., Louis, T. A., & Hamilton, L. (2004). Models for value-added modeling of teacher effects. *Journal of Educational and Behavioral Statistics, 29*(1), 67–101. doi:10.3102/10769986029001067

McCallum, B. (2011, March 10). Structuring the mathematical practices [Blog post]. Retrieved from http://commoncoretools.me/2011/03/10/structuring-the-mathematical-practices/

McTighe, J., & Wiggins, G. (2012). *From Common Core Standards to curriculum: Five big ideas*. Retrieved from http://grantwiggins.files.wordpress.com/2012/09/mctighe_wiggins_final_common_core_standards.pdf

Mraz, H., & Hertz, C. (2015) A mindset for learning: teaching the traits of joyful, independent growth. Portsmouth, NH: Heinemann.

Mulholland, J. (2014). The growth mindset and the Common Core. Retrieved from http://mymassp.com/content/growth_mindset_and_common_core

National Center for Education Statistics. (n.d.). Trends in International Mathematics and Science Study (TIMSS): Overview. Retrieved from https://nces.ed.gov/timss/

National Center for Education Statistics. (n.d.). National Assessment of Educational Progress (NAEP): Overview. Retrieved from http://nces.ed.gov/nationsreportcard/

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

National Council of Teachers of Mathematics (NCTM). (2006). *Curriculum focal points.* Reston, VA: Author.

National Council of Teachers of Mathematics (NCTM). (2014). *Principles to actions: Ensuring mathematics success for all*. Reston, VA: Author.

National Governors Association Center for Best Practices & Council of Chief State School Officers. (2010). *Common core state standards for mathematics.* Washington, DC: Authors.

National Mathematics Advisory Panel. (2008). *Foundations for success: The final report of the National Mathematics Advisory Panel*. Washington, DC: U.S. Department of Education.

Newton, X. (2007). Reflections on math reforms in the U.S. *Education Digest, 73*(1), 4–9. Retrieved from ERIC database. (EJ798925)

Osborne, J. H. (2015). The charge is ours: Teaching elementary school mathematics through best practices and Common Core initiatives. *Delta Kappa Gamma Bulletin*, *82*(1), 23–25. Retrieved from EBSCOhost database. (Accession No. 110364693)

Ottmar, E. R., Decker, L., Cameron, C., Curby, T., & Rimm-Kaufman, S. (2014). Classroom instructional quality, exposure to mathematics instruction and mathematics achievement in fifth grade. *Learning Environments Research*, *17*(2), 243–262. doi:10.1007/s10984-013-9146-6

Ottmar, E. R., Rimm-Kaufman, S. E., Larsen, R. A., & Berry, R. Q. (2015). Mathematical knowledge for teaching, standards-based mathematics teaching practices, and student achievement in the context of the responsive classroom approach. *American Educational Research Journal*, *52*(4), 787–821. doi:10.3102/0002831215579484

Pajares, M. F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research, 62*(3), 307–332. doi:10.3102/00346543062003307

Pennsylvania Department of Education. (2011). *PVAAS key communication messages*. Harrisburg: Author.

Pennsylvania Department of Education. (2013). *Response to PVAAS misconceptions*. Harrisburg: Author.

Pennsylvania Department of Education. (2014). *Educator effectiveness administrative manual*. Harrisburg: Author.

Pennsylvania Department of Education. (2015). *PVAAS key communication messages*. Harrisburg: Author.

Phillips, D. C. (1995). The good, the bad, and the ugly: The many faces of constructivism. *Educational Researcher, 24*(7), 5–12. doi:10.2307/1177059

Polly, D., McGee, J. R., Wang, C., Lambert, R. G., Pugalee, D. K., & Johnson, S. (2013). The association between teachers' beliefs, enacted practices, and student learning in mathematics. *Mathematics Educator, 22*(2), 11–30. Retrieved from ERIC database. (EJ1013943)

Porter, A., McMaken, J., Hwang, J., & Yang, R. (2011). Common Core Standards the new U.S. intended curriculum. *Educational Researcher, 40*(3), 103–116. doi:10.3102/0013189x11405038

Protheroe, N. (2007). What does good math instruction look like? *Principal, 7*(1), 51–54. Retrieved from https://www.naesp.org/resources/2/Principal/2007/S-Op51.pdf

Raudenbush, S. W. (2004). What are value-added models estimating and what does this imply for statistical practice? *Journal of Educational and Behavioral Statistics, 29*(1), 121–129. doi:10.3102/10769986029001121

Rose, M. (2014). School reform fails the test. *American Scholar*, *84*(1), 18–30. Retrieved from EBSCOhost database. (Accession No. 99970640)

Ross, J. A., Hogaboam-Gray, A., & McDougall, D. (2001). Measuring the effects of elementary school reform in mathematics: Final report of MET Transfer Grant.

Ross, J., Hogaboam-Gray, A., & McDougall, D. (2002). Research on reform in mathematics education, 1993–2000. *Alberta Journal of Educational Research, 48*(2), 122–130. Retrieved from http://ajer.journalhosting.ucalgary.ca/index.php/ajer

Ross, J. A., McDougall, D., Hogaboam-Gray, A., & LeSage, A. (2003). A survey measuring elementary teachers' implementation of standards-based mathematics teaching. *Journal for Research in Mathematics Education, 34*(4), 344–363. doi:10.2307/30034787

Ross, J. A., & McDougall, D. (2004). Mathematics. In K. Leithwood, P. McAdie, N. Bascia, & A. Rodrigue (Eds.), *Teaching for deep understanding: Towards the Ontario curriculum that we need* (pp. 33–39). Toronto, Canada: Elementary Teachers' Federation of Ontario.

Roth McDuffie, A. M., & Mather, M. (2006). Reification of instructional materials as part of the process of developing problem-based practices in mathematics education. *Teachers and Teaching: Theory and Practice*, *12*(4), 435–459. doi:10.1080/13450600600644285

Rowan, B., Correnti, R., & Miller, R. J. (2002). What large-scale, survey research tells us about teacher effects on student achievement: Insights from the Prospects Study of Elementary Schools. *Teachers College Record, 104*(8), 1525–1567. doi:10.1111/1467-9620.00212

Rubin, D. B., Stuart, E. A., & Zanutto, E. L. (2004). A potential outcomes view of value-added assessment in education. *Journal of Educational and Behavioral Statistics, 29*(1), 103–116. doi:10.3102/10769986029001103

Sanders, W. L. (2000). Value-added assessment from student achievement data: Opportunities and hurdles. *Journal of Personnel Evaluation in Education, 14*(4), 329–339. doi:10.1023/A:1013008006096

Sanders, W. L., & Horn, S. P. (1998). Research findings from the Tennessee Value-Added Assessment System (TVAAS) database: Implications for educational evaluation and research. *Journal of Personnel Evaluation in Education*, *12*(3), 247–256. doi:10.1023/A:1008067210518

Sass, T. R. (2008). *The stability of value-added measures of teacher quality and implications for teacher compensation policy* (Brief 4). Retrieved from ERIC database. (ED508273)

Scherer, M. (2001). How and why standards can improve student achievement: A conversation with Robert J. Marzano. *Educational Leadership, 59*(1), 14–18. Retrieved from http://www.ascd.org/publications/educational-leadership/

Schmidt, W. H., & Burroughs, N. A. (2013). How the Common Core boosts quality and equality. *Educational Leadership, 70*(4), 54–58. Retrieved from http://www.ascd.org/publications/educational-leadership/

Schmidt, W. H., & Houang, R. T. (2012). Curricular coherence and the Common Core State Standards for Mathematics. *Educational Researcher, 41*(8), 294–308. doi:10.3102/0013189x12464517

Schmidt, W., Houang, R., & Cogan, L. (2002, Summer). A coherent curriculum. *American Educator*, 1–17. Retrieved from http://www.aft.org/sites/default/files/periodicals/curriculum.pdf

Schmidt, W. H., Houang, R., & Cogan, L. S. (2011). Preparing future math teachers. *Science*, *332*(6035), 1266-1267. doi:10.1126/science.1193855

Schmidt, W. H., Houang, R., & Cogan, L. (2004). A coherent curriculum: The case of mathematics. *Journal of Direct Instruction, 4*(1), 13–28. Retrieved from ERIC database. (EJ755131)

Schmoker, M., & Marzano, R. J. (1999). Realizing the promise of standards-based education. *Educational Leadership, 56*(6), 17–21. Retrieved from http://www.ascd.org/publications/educational_leadership/

Schoenfeld, A. H. (2015). Summative and formative assessments in mathematics supporting the goals of the Common Core Standards. *Theory Into Practice*, *54*(3), 183–194. doi:10.1080/00405841.2015.1044346

Siegler, R. S., Duncan, G. J., Davis-Kean, P. E., Duckworth, K., Claessens, A., Engel, M., & Chen, M. (2012). Early predictors of high school mathematics achievement. *Psychological Science, 23*(7), 691–697. doi:10.1177/0956797612440101

Siegler, R. S., & Lortie-Forgues, H. (2015). Conceptual knowledge of fraction arithmetic. *Journal of Educational Psychology, 107*(3), 909–918. doi:10.1037/edu0000025

Simon, M. (1995). Reconstructing mathematics pedagogy from a constructivist perspective. *Journal for Research in Mathematics Education, 26*(2), 114–145. doi:10.2307/749205

Simon, M., & Schifter, D. (1993). Toward a constructivist perspective: The impact of a mathematics teacher inservice program on students. *Educational Studies in Mathematics, 25*(4), 331–340. doi:10.1007/bf01273905

Slavin, R. E. (2008). Effective programs in elementary mathematics: A best-evidence synthesis. *Education, 78*(3), 427–515. doi:10.3102/0034654308317473

Sparks, S. (2013). 'Growth mindset' gaining traction as ed. strategy. *Education Week, 33*(3), 1, 21. Retrieved from Education Research Complete database. (Accession No. 90249276)

Statistics Solutions. (2013). Data analysis plan: Bivariate (Pearson) Correlation [WWW Document]. Retrieved from http://www.statisticssolutions.com/academic-solutions/member-resources/member-profile/data-analysis-plan-templates/data-analysis-plan-bivariate-pearson-correlation/

Statistics Solutions. (2013). Data analysis plan: Multiple Linear Regression [WWW Document]. Retrieved from http://www.statisticssolutions.com/academic-solutions/member-resources/member-profile/data-analysis-plan-templates/data-analysis-plan-multiple-linear-regression/

Statistics Solutions. (2013). Data analysis plan: One Way ANOVA [WWW Document]. Retrieved from http://www.statisticssolutions.com/academic-solutions/member-resources/member-profile/data-analysis-plan-templates/data-analysis-plan-one-way-anova/

Stigler, J. W., & Hiebert, J. (1999). *The teaching gap: Best ideas from the world's teachers for improving education in the classroom*. New York, NY: Free Press.

Stipek, D. J., Givvin, K. B., Salmon, J. M., & MacGyvers, V. L. (2001). Teachers' beliefs and practices related to mathematics instruction. *Teaching and Teacher Education, 17*(2), 213–226. doi:10.1016/s0742-051x(00)00052-4

Swars, S. L., & Chestnutt, C. (2016). Transitioning to the Common Core State Standards for Mathematics: A mixed methods study of elementary teachers' experiences and perspectives. *School Science and Mathematics*, *116*(4), 212–224. doi:10.1111/ssm.12171

Tapia, M., & Marsh, G. E. (2004, Summer). An instrument to measure mathematics attitudes. *Academic Exchange Quarterly, 8*(2), 16–21. Retrieved from http://www.rapidintellect.com/AEQweb/cho25344l.htm

Tatto, M., & Coupland, D. (2003). Teacher education and teachers' beliefs. In J. Raths & A. C. McAninch (Eds.), *Teacher beliefs and classroom performance: The impact of teacher education* (pp. 123–184). Charlotte, NC: Information Age.

Tomlinson, C. A. (1999). *The differentiated classroom: Responding to the needs of all learners*. Alexandria, VA: Association for Supervision and Curriculum Development.

Tomlinson, C. A. (2001). *How to differentiate instruction in mixed-ability classrooms*. Alexandria, VA: Association for Supervision and Curriculum Development.

Tomlinson, C. A. (2003). *Fulfilling the promise of the differentiated classroom: Strategies and tools for responsive teaching*. Alexandria, VA: Association for Supervision and Curriculum Development.

Tomlinson, C. A., & Javius, E. L. (2012). Teach up for excellence. *Educational Leadership, 69*(5), 28–33. Retrieved from ERIC database. (EJ982170)

U.S. Department of Education. (2015). *Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2015 mathematics assessments*. Washington, DC: National Assessment Governing Board.

U.S. Department of Education. (2016). *Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 1990–2013 mathematics assessments*. Washington, DC: National Assessment Governing Board.

U.S. Department of Education. (n.d.). Every Student Succeeds Act (ESSA). Retrieved from http://www.ed.gov/essa

Van de Walle, J. A. (2004). *Elementary and middle school mathematics: Teaching developmentally*. Boston, MA: Pearson Education.

Vigdor, J. (2013). Solving America's math problem. *Education Next, 13*(1), 42–49. Retrieved from ERIC database. (EJ1008228)

Walker, E. N. (2007, Summer). Rethinking professional development for elementary mathematics teachers. *Teacher Education Quarterly, 34*(3), 113–134. Retrieved from ERIC database. (EJ795178)

Wayne, A. J., & Youngs, P. (2003). Teacher characteristics and student achievement gains: A review. *Review of Educational Research, 73*(1), 89–122. doi:10.3102/00346543073001089

Webb, N. L. (2002). *Depth-of-knowledge levels for four content areas*. Retrieved from http://schools.nyc.gov/NR/rdonlyres/2711181C-2108-40C4-A7F8-76F243C9B910/0/DOKFourContentAreas.pdf

Williamson, R., & Blackburn, B. (2013). *Rigorous schools and classrooms: Leading the way*. New York, NY: Routledge.

Wright, S. P., Sanders, W. L., & Rivers, J. C. (2006). Measurement of academic growth of individual students toward variable and meaningful academic standards. In R. Lissitz (Ed.), *Longitudinal and value added models of student performance* (pp. 1–11). Maple Grove, MN: JAM Press.

Wu, H. (1997). The mathematics education reform: Why you should be concerned and what you can do. *The American Mathematical Monthly*, *104*(10), 946–954. doi:10.2307/2974477

Yates, S. M. (2006). Elementary teachers' mathematics beliefs and teaching practices after a curriculum reform. In J. Novotná, H. Moraová, M. Krátká, & N. Stehlíková (Eds.), *Proceedings of the 30th Conference of the International Group for the Psychology of Mathematics Education* (Vol. 5, pp. 433–440). Prague, Czech Republic: Psychology of Mathematics Education.

Zimba, J. (2014). The development and design of the Common Core State Standards for Mathematics. *New England Journal of Public Policy*, *26*(1), 1–11. Retrieved from Business Source Complete database. (Accession No. 99746975)

Appendix A

Mathematics Instructional Practice Survey

Carney, M. B., Brendefur, J. L., Hughes, G. R., & Thiede, K. (2015). Developing a mathematical instructional practice survey: Considerations and evidence. *Mathematics Teacher Educator*, *4*(1), 93–118. doi:10.5951/mathteaceduc.4.1.0093

Please indicate for each statement the frequency you engage in the particular instructional practice. A 5-point frequency scale will determine participant responses.

<u>As the classroom teacher, I:</u>

1. Emphasize the use of multiple models for recording and communicating student thinking. (SC)
2. Encourage discussion of the connections between various models and strategies. (SC)
3. Facilitate discussion about the underlying mathematical concepts (e.g. composing or decomposing number. (SC)
4. Present one standard method of solving a task or performing an algorithm. (T)
5. Facilitate small group or whole class discussion on student thinking. (SC)
6. Explain the steps to a procedure or algorithm when I introduce new topics. (T)
7. Demonstrate for the class the correct way to use a particular procedure or model before they start solving problems. (T)
8. Avoid student errors and misconceptions when a topic is first introduced by explaining how to solve a problem before they start (T)

<u>Students:</u>

9. Analyze the connections between various models and procedures. (SC)
10. Take notes on how to perform each step in a procedure or algorithm. (T)
11. Learn by copying down examples from a teacher demonstration. (T)
12. Solve problems that allow for different approaches. (SC)

<u>Classroom tasks and activities:</u>

13. Are based on their potential to encourage discussions of students' mathematical ideas. (SC)
14. Are selected because the provide opportunities for students to explain the mathematics behind an answer. (SC)

Subject: **Re: Survey Instrument Inquiry - Doctoral Dissertation**
From: Michele Carney <[redacted]>
Date: 11/15/15 03:11 PM
To: James W Jones <[redacted]
Cc: Jonathan Brendefur <[redacted]

Attached Files
- Appendix C.JPG (103 KB)

Hi Jim,
It is good to hear our work may be of some use in your study and you definitely have our permission to use it. The two instrument scales are provided in Appendix C of the article (and attached).

One concern that was expressed in the paper was whether the survey scale from 1=Never to 7=Daily was appropriate given the skew following our professional development (Appendix F). I only mention this in case you have some reason to suspect your sample may contain teachers who are more or less pedagogical oriented towards mathematics reform practices. If not, the scale will probably be fine but something to consider. I would anticipate that you would be using our two scales in conjunction with other survey scales to examine multiple factors. Given the lack of validation work that has been done on these scales outside of our group, I would recommend its use as a component but not the only component.

I would be very interested in hearing the results if you decide to use the scales and am happy to converse further by email or phone if you have additional questions or thoughts.

Thanks.
Michele

On Sat, Nov 14, 2015 at 8:32 PM, James W Jones <[redacted]> wrote:

> Dear Dr. Carney and Dr. Brendefur,
>
> I hope my e-mail finds both of you well - If I could have a moment of your time to discuss my doctoral dissertation study, I would be most grateful.
>
> My research goal is to study the relationship, if any, between Pennsylvania's K-5 elementary school academic growth, to teacher beliefs, dispositions and standards-based reform instructional practices for teaching mathematics. My proposed study is very large scale, as I hope to administer the instrument to a large sample of K-5 elementary schools, to correlate with Pennsylvania's value-added growth model data. PVAAS factors out demographics, other extraneous variables, etc., to allow me to address equity considerations as well.
>
> Realizing much existing research is focused on preparation, professional development, knowledge of content and pedagogy, etc., I want to refocus on beliefs, dispositions and instructional practices for teaching mathematics. Big picture I see a research gap and the results could be significant to informing pre-service teacher preparation and in-service teacher professional development for our state's schools.
>
> I had first considered many older instruments, many discussed in your article. Specifically, my methodology included Ross/McDougall

Appendix B

Mathematics Beliefs and Awareness Survey

Clark, L. M., DePiper, J. N., Frank, T. J., Nishio, M., Campbell, P. F., Smith, T. M., & Choi, Y. (2014). Teacher characteristics associated with mathematics teachers' beliefs and awareness of their students' mathematical dispositions. *Journal for Research in Mathematics Education, 45*(2), 246–284. doi:10.5951/jresematheduc.45.2.0246

Please indicate the extent to which you agree or disagree with each of the following statements.
A 5-point Likert scale will determine participant responses.

1. During mathematics class, students should be asked to solve problems and complete activities by relying on their own thinking without teachers modeling an approach. (TASSP)

2. Students learn mathematics best by paying attention when their teacher demonstrates what to do, by asking questions if they do not understand, and then by practicing. (TMIM)

3. I learn about my students' perceptions of what "doing mathematics" means through explicitly asking them (e.g., students write about it, one-on-one discussions, group discussions). (TASMD)

4. You have a certain amount of intelligence, and you really can't do much to change it. [Reverse-scored] (M)

5. Students can figure out how to solve many mathematics problems without being told what to do. (TASSP)

6. Mathematics skills are mastered incrementally, so instruction should only focus on one skill at a time, ordered by difficulty, and not move on until most students have mastered that skill. (TMIM)

7. I learn about my students' perceptions of connections between mathematics and their everyday lives through explicitly asking them (e.g., students write about it, one-on-one discussions, group discussions). (TASMD)

8. You can always substantially change how intelligent you are. (M)

9. During mathematics class, I do not necessarily answer students' questions immediately but rather let them struggle and puzzle things out for themselves. (TASSP)

10. I like my students to master basic mathematical operations before they tackle complex problems. (TMIM)

11. I learn about my students' perceptions of their mathematical ability through explicitly asking them (e.g., students write about it, one-on-one discussions, group discussions). (TASMD)

12. Students learn mathematics best by working to solve accessible problems that entail a solution process that has not been demonstrated to them. (TASSP)

13. Learning mathematics requires a good memory because you must remember how to carry out procedures and, when solving an application problem, you have to remember which procedure to use. (TMIM)

14. For the majority of my students, I have a good sense of their motivations for wanting to succeed in mathematics. (TASMD)

15. You can learn new things, but you can't really change your basic intelligence. [Reverse-scored] (M)

16. To teach mathematics, first model the activity, then provide some practice and immediate feedback, and, finally, clarify what the assignment is and how it is to be completed. [Reverse-scored] (TASSP)

17. A lot of things in mathematics must simply be accepted as true and remembered. (TMIM)

18. For the majority of my students, I have a good sense of whether or not they see how the mathematics we do in class connects to their everyday lives. (TASMD)

19. During mathematics class, discussion should focus on students' ideas and approaches, no matter whether their answers are correct or incorrect. (TASSP)

20. When planning mathematics lessons, teachers need to focus explicitly on rules and procedures. (TMIM)

21. In order to prepare students for assessments, when students are working on a problem in mathematics, I highlight more than one approach to solving that problem. (TASMD)

22. Students should be homogeneously grouped for instruction and assigned to a curriculum on the basis of their prior mathematical performance. (TMIM)

23. I like to use mathematics problems that can be solved in many different ways. (TASMD)

24. You can change even your basic intelligence level considerably. (M)

25. I have a good sense of what my unsuccessful students perceive as challenges to their mathematical performance. (TASMD)

Subject:	**Re: Survey Instrument Inquiry - Doctoral Dissertation**
From:	Patricia Campbell [redacted]
Date:	12/21/15 03:43 PM
To:	James W Jones [redacted]>
Cc:	[redacted]

Attached Files
- Belief 3-12-09 LCPC.doc (136 KB)

Dear Jim,

Okay it has been over a month since you wrote, so I must apologize. I have no good excuse for my tardiness-- just too much work to do (as is the case with everyone) and emails scrolling up where I don't see them anymore.

In any case, I am attaching the complete beliefs and awareness survey that we administered in the MAC-MTL study. While this survey has 40 items, all 40 items did not "make it through" a factor analysis. In the article below, you can read about the factor analysis and the resulting interpretation, as well as see which factors the items loaded on by examining the items in the appendix to this article.

Clark, L. M., DePiper, J. N., Frank, T. J., Nishio, M., Campbell, P. F., Smith, T. M., Griffin, M. J., Rust, A. H., Conant, D. L., & Choi, Y. (2014). Teacher characteristics associated with mathematics teachers' beliefs and awareness of their students' mathematical dispositions. *Journal for Research in Mathematics Education*, *45*, 246-284.

At this time, the survey is not available through an electronic link, but that is something that we may be pursuing in the future. If you do use this survey, or items from it, please do cite the reference above.

Again, I do apologize for being tardy in replying to your original message.

Pat Campbell

Patricia F. Campbell, Ph.D.
Professor, Center for Mathematics Education
Department of Teaching and Learning, Policy and Leadership
Room 2226 Benjamin Building
University of Maryland
3942 Campus Drive
College Park, MD 20742

On 11/10/15 6:43 PM, James W Jones wrote:

> Dear Dr. Campbell & Dr. Clark:
>
> Thank you for your time, in advance. I certainly appreciate your time to review my inquiry.
>
> My doctoral research interest lies in attempting to quantitatively study the relationship, if any, between PA's highest "growing" K-5 elementary schools, as measured by Pennsylvania's value-added growth model data (PVAAS factors out demographics, other

Appendix C

Theories of Intelligence Scale (Embedded in Mathematics Beliefs and Awareness Survey)

Dweck, C. S., Chiu, C. Y., & Hong, Y. Y. (1995). Implicit theories and their role in judgments and reactions: A word from two perspectives. *Psychological Inquiry*, *6*(4), 267–285. doi:10.1207/s15327965pli0604_1

Please indicate the extent to which you agree or disagree with each of the following statements. A 5-point Likert scale will determine participant responses.

4. You have a certain amount of intelligence, and you really can't do much to change it. [Reverse-scored] (M-Fixed)

8. You can always substantially change how intelligent you are. (M-Growth)

15. You can learn new things, but you can't really change your basic intelligence. [Reverse-scored] (M-Fixed)

24. You can change even your basic intelligence level considerably. (M-Growth)

Re: Survey Instruments Inquiry [MWSup]

February 20, 2015 at 5:00 PM

From Sylvia Rodriguez

To James Jones

Hi James,

Great! The mindset survey was developed by Carol Dweck, I would just cite her in any of your written or presention-based work when you reference the scale (Dweck, 1999). I believe the same goes for the PALS inventory (we don't own those surveys) but I believe it suffices to cite Midgley et al. for any surveys you use from there.

Completely understand wanting to hold off on including too many variables! They should certainly make sense from a theoretical and also from a practical perspective.

Happy to answer any questions down the road. Good luck, forward to keeping in touch!

All the best,
Sylvia

Sylvia Rodriguez, Ph.D.
Director of Research & Implementation
Mindset Works, Inc.
www.mindsetworks.com

On Fri, Feb 20, 2015 at 3:02 PM, James Jones <james_jones@me.com> wrote:

> Sylvia,
>
> Thanks so much for your reply and interest in helping me to clarify my study. Thank you!
>
> I love this survey, which certainly is assessing the aspects I am interested in studying. Can you grant permission to utilize, or would I need to contact the PALS team for written permission?
>
> At this point, I need to be careful to not redundantly gather data. Or, to have too many variables introduced that I am unable to clearly connect in a meaningful way. Mmmm. I may need to tease out the various measured factors in each of the surveys, and map a theoretical framework for how they interact.
>
> Ultimately, I do want to know the "greater growth mindset" of teachers, but also want to know the more nuanced beliefs and/or practices situated within the context of mathematics.

Appendix D

Superintendent Contact Letter

Indiana University of Pennsylvania

Department of Professional Studies in Education
724-357-2400
Internet: *http://www.iup.edu*
Davis Hall, Room 303
570 S. Eleventh Street
Indiana, Pennsylvania 15705-1087

March 17, 2016

«Superintendent_Name»
«District_Name»
«Address»
«City», «State» «Zip»

Dear «First_Name» «Last_Name»:

I am writing to seek approval from the «District_Name» to conduct research for my dissertation study at Indiana University of Pennsylvania titled, *Relating School-Wide Instructional Practices, Teacher Beliefs, and Intelligence Mindset to Value-Added Student Growth for Elementary Mathematics in Grades 3-5.* The purpose of this non-experimental correlational relationship study is to relate teacher beliefs, practices, and growth mindset and the variable of value-added student growth. A summary of the data and my findings will be provided to you upon your request.

As a current elementary mathematics specialist, and former K–8 mathematics coach, I recognize that curriculum, instruction, and assessment shifts involved with adopting Common Core Standards for Mathematics are significant. This study's findings will provide timely and relevant evidence to better understand the variables that best relate to value-added student growth in mathematics. Through an improved understanding, school leaders will be better able to provide relevant, research-based professional development to address the most impactful considerations for student growth.

To conduct my study, I propose to survey via email 3rd, 4th, and 5th grade teachers responsible for teaching mathematics in the following school buildings:

«Schools»

If provided site approval, each identified building principal will be contacted via email to disseminate study details, and to determine teachers responsible for teaching mathematics during the 2014-2015 academic school year. Identified teachers will then be contacted via email inviting them to participate in this study by being surveyed; teacher participants who agree to participate will receive the secure survey link via email. At 5-day intervals, up to 3 additional reminder emails will be sent to teacher participants.

Three existing survey instruments, determined to be valid and reliable, will be combined and constructed into one unique online survey instrument, which will take approximately 30 minutes to complete. Survey items describe teacher instructional practices for teaching mathematics, teacher beliefs about the teaching of mathematics, and teacher growth mindset. The survey is attached for your consideration.

Teacher survey results will be combined to determine school-specific average values for each of the independent variables. Statistical procedures, including multiple regressions, will be executed to explore the relationship amongst the considered variables and each school's Average Growth Index (AGI) for the 2014-2015 academic school year.

Study results will report and discuss the relationships determined amongst the variables in aggregate only. Participating school districts, schools, and individual teachers will remain completely anonymous, and will never be identified in any published results of this study now, or at any time in the future. All gathered data will remain confidential to avoid putting any party at risk and so that no identifying information or characteristics are revealed. The survey data will be collected and stored on a password-protected, encrypted website (Qualtrics.com). Qualtrics® uses the same encryption type (SSL) that on-line banking sites use to transmit secure information. IP addresses will not be collected. Statistical data analysis will employ IBM SPSS software; all data will be destroyed at the end of a 3-year period, as per federal guidelines.

Participation in this study is absolutely voluntary; teacher participants are free to decline to participate, and also are free to withdraw at any time by notifying the Project Director, Mr. James W. Jones via either phone or email. If a teacher decides to withdraw while taking the survey, he or she may simply closer the browser. Identifying information and numerical data points pertaining to a withdrawn participant will be eradicated. Also, the information obtained in the study may be published in educational research journals or presented at professional meetings in the future, but identifying characteristics will always remain strictly confidential.

Your time and thoughtful consideration is appreciated. In short, through selected principals, I would like to contact certain teachers via email to ask them to voluntarily participate in this study. Should you provide permission to conduct the described research study in «District_Name» please provide written permission on official district letterhead to satisfy Institutional Review Board (IRB) approval. If you prefer, an attached PDF of your letter sent via an email reply will suffice. Outside of providing your permission, no additional contribution on your part is required.

Should you have any questions or concerns regarding my request, please contact me at your convenience. I sincerely believe that the participation of «District_Name» will contribute significantly to my study.

Thank you, «First_Name» «Last_Name».

Respectfully,

Project Director:
Mr. James W. Jones
Doctoral Student, Indiana University of Pennsylvania
Department of Professional Studies in Education
Davis Hall
Indiana, PA 15705
Phone: [redacted]
E-mail: [redacted]

Dissertation Advisor:
Dr. Valeri R. Helterbran
Professor and Dissertation Advisor
Department of Professional Studies in Education
323 Davis Hall
Indiana, PA 15705
Phone: [redacted]
E-mail: [redacted]

This project has been approved by the Indiana University of Pennsylvania Institutional Review Board for the Protection of Human Subjects (Phone: 724/357-7730).

Appendix E

Principal Contact Letter

Indiana University of Pennsylvania

Department of Professional Studies in Education
724-357-2400
Internet: *http://www.iup.edu*
Davis Hall, Room 303
570 S. Eleventh Street
Indiana, Pennsylvania 15705-1087

April 28, 2016

«Principal_Name»
«School Building_Name»
«District_Name»
«Address»
«City», «State» «Zip»

Dear «Principal_Name»:

Recently, your district superintendent, «Superintendent_Name», granted permission to conduct my dissertation research, *A Quantitative Study: The Relationship Between School-Wide Instructional Practices, Teacher Beliefs, and Intelligence Mindset to Value-Added Student Growth in Elementary Mathematics for Grades 3-5*, in your building.

The purpose of this non-experimental correlational relationship study is to relate teacher beliefs, practices, and intelligence mindset to the variable of value-added student growth. To conduct my study, I propose to survey via email 3rd, 4th, and 5th grade teachers responsible for teaching mathematics in your building. Survey items describe teacher instructional practices for teaching mathematics, teacher beliefs about the teaching of mathematics, and teacher growth mindset.

To proceed, I respectfully request your cooperation to determine teachers responsible for teaching mathematics in 2014-2015, and to also inform those identified of the pending study and to expect my email communication. Specifically, I will require a list of all teachers with instructional responsibility for teaching mathematics during the 2014-2015 academic year, along with their official district email addresses. Identified teachers will then be invited to participate in this voluntary study via email. Those who agree to participate will receive a secure survey link via their official district email address. At 5-day intervals, up to 3 additional reminder emails will be sent to teacher participants in order to encourage survey completion. To facilitate your cooperation, I have attached a form letter text for your convenience to contact teachers.

Teacher survey results will be combined to determine school-specific average values for each of the independent variables. Statistical procedures, including hierarchical multiple regression, will be executed to explore the relationship amongst the considered variables and each school's Average Growth Index (AGI) for the 2014-2015 academic school year. Statistical results will report and discuss the relationships determined amongst the variables in aggregate only. Survey responses and associated data sets for participating school districts, schools, and individual teachers will remain completely confidential and anonymous.

Participation in this study is absolutely voluntary; teacher participants are free to decline to participate, and also are free to withdraw at any time by notifying the Project Director, Mr. James W. Jones, via either phone or email.

I sincerely believe that the participation of «School_Name» will contribute significantly to my study. Should you have any questions or concerns regarding my request, please contact me at your convenience.

Thank you.

Yours in education,

Project Director:
Mr. James W. Jones
Doctoral Student, Indiana University of Pennsylvania
Department of Professional Studies in Education

Davis Hall
Indiana, PA 15705
Phone: [redacted]
E-mail: [redacted]

Dissertation Advisor:
Dr. Valeri R. Helterbran
Professor and Dissertation Advisor
Department of Professional Studies in Education
323 Davis Hall
Indiana, PA 15705
Phone: [redacted]
E-mail: [redacted]

This project has been approved by the Indiana University of Pennsylvania Institutional Review Board for the Protection of Human Subjects (Phone: 724/357-7730).

Appendix F

Teacher Consent Letter

Indiana University of Pennsylvania

Department of Professional Studies in Education
Davis Hall, Room 303
570 S. Eleventh Street
Indiana, Pennsylvania 15705-1087

724-357-2400
Internet: *http://www.iup.edu*

Dear Esteemed Grade 3-5 Pennsylvania Educator:

You are invited to participate in this research study:

A Quantitative Study: The Relationship Between School-Wide Instructional Practices, Teacher Beliefs, and Intelligence Mindset to Value-Added Student Growth in Elementary Mathematics for Grades 3-5

You are eligible to participate because your principal identified you as a 3rd, 4th, or 5th-grade mathematics teacher in Pennsylvania. The purpose of this study is to relate instructional practices for teaching elementary mathematics, teacher beliefs, and intelligence mindset and value-added student growth (PVAAS).

Your participation will require that you thoughtfully complete an online survey regarding your instructional practices, beliefs, and mindsets regarding elementary mathematics, mathematics instruction, and student learning. The researcher believes that your participation will contribute significantly to this study.

It is the researcher's hope that you consider giving of your time to partake in this timely and worthwhile academic endeavor. The survey will require approximately 20 minutes of your time. There are no known risks or discomfort associated with this research study. This study does not involve any more than minimal risks encountered in everyday life.

Participants who consent to, and complete, the survey will be eligible to be entered into a drawing for the chance to win a $50 gift card. A total of 10 winners will be chosen from the pool of participants. Choices of gift cards will include Walmart, Target, Amazon, Sheetz, or GetGo. To participate, you will be required to indicate your intent within the actual survey. Should you choose to participate, this requested personal information will be completely disassociated from your actual survey responses.

Additional details and Informed Consent will be provided in advance of the actual survey.

To participate, please follow this secured, anonymous link to the survey.

www.iamasecuredsurveylink.com

Or copy and paste the URL below into your Internet browser:

www.iamasecuredsurveylink.com

Project Director:
Mr. James W. Jones
Doctoral Student, Indiana University of Pennsylvania
Department of Professional Studies in Education
Davis Hall
Indiana, PA 15705
Phone: [redacted]
E-mail: [redacted]

Dissertation Advisor:
Dr. Valeri R. Helterbran
Professor and Dissertation Advisor
Department of Professional Studies in Education
323 Davis Hall
Indiana, PA 15705
Phone: [redacted]
E-mail: [redacted]

This project has been approved by the Indiana University of Pennsylvania Institutional Review Board for the Protection of Human Subjects (Phone: 724/357-7730).

Appendix G

Table 1 Copyright Permission

Subject: Re: Grouping Math Practice Standards Inquiry
From: William McCallum <[redacted]>
Date: 09/11/16 07:26 PM
To: James W Jones <[redacted]

Dear James,

You have my permission to reformat this document as a table.

Regards,

Bill McCallum

On Sun, Sep 11, 2016 at 10:19 AM, James W Jones <[redacted] wrote:

> Dear Dr. McCallum,
>
> In my dissertation, I have referenced your "Grouping the Mathematical Practice Standards" and would like to also include them in a table format.
>
> In order to meet university and ProQuest requirements, I require your express written permission to do so.
>
> If you would be so inclined to grant this permission for my dissertation use only, it would be sincerely appreciated.
>
> Thank you kindly for your time and consideration.
>
> Respectfully,
>
> James Jones
> Doctor of Education Candidate
> Indiana University of Pennsylvania

Appendix H

Table 2 Copyright Permission

Subject: **RE: NCTM PTA Productive/Unproductive Beliefs**
From: Leinwand, Steve <[redacted]>
Date: 09/11/16 02:19 PM
To: James W Jones <[redacted]

Hi James,

As chair of NCTM's Principles to Actions Writing Team, I am pleased to grant you permission to present the productive/unproductive beliefs in the table format. The APA citation is accurate.

Hope this is helpful.

Steve Leinwand

From: James W Jones [[redacted]]
Sent: Sunday, September 11, 2016 1:59 PM
To: Leinwand, Steve
Subject: NCTM PTA Productive/Unproductive Beliefs

Dear Dr. Leinwald,

In my dissertation, I have referenced the PTA Productive & Unproductive Beliefs and would like to also include them in a table format.

In order to meet university and ProQuest requirements, I require your express written permission to do so. Attached is the table that I am requesting to include.

If you would be so inclined to grant this permission for my dissertation use only, it would be sincerely appreciated. And if my APA citation and/or copyright is in error, please let me know.

Thank you kindly for your time and consideration.

Respectfully,

James Jones
Doctor of Education Candidate
Indiana University of Pennsylvania

Appendix I

Table 3 Copyright Permission

Subject: **RE: APA & ProQuest Table Inquiry & Permissions**
From: Doug McDougall <[redacted]>
Date: 09/12/16 11:07 PM
To: James W Jones <[redacted]

Hi James
You have my permission to use the table in your dissertation.
Doug

Dr. Douglas McDougall, OCT, B. Math (Hons), B.Ed., M.Ed., Ed.D.
Professor and Associate Dean, Programs
Ontario Institute for Studies in Education
University of Toronto
252 Bloor Street West
Toronto, Ontario
M5S 1V6
Room 12-106
[redacted]

From: James W Jones [redacted]
Sent: Sunday, September 11, 2016 3:28 PM
To: [redacted] Doug McDougall
Subject: APA & ProQuest Table Inquiry & Permissions

Dear Dr. McDougall & Dr. Ross:

In my dissertation draft, I have referenced the attached table.

In order to meet university and ProQuest requirements, I require your express written permission to do so. Attached is the table that I am requesting to include.

If you would be so inclined to grant this permission for my dissertation use only, it would be sincerely appreciated.

And if my APA citation and/or copyright is in error, please let me know. I believe this table to perhaps be an evolution of the original, yet I have lost track of the specific reference. Any guidance would be appreciated.

Thank you kindly for your time and consideration.

Respectfully,

James Jones
Doctor of Education Candidate
Indiana University of Pennsylvania

Appendix J

Table 4 Copyright Permission

Subject: **RE: "Categories of Teacher Beliefs" Inquiry**
From: Kim Beswick <[redacted]
Date: 09/11/16 07:40 PM
To: 'James W Jones' [redacted]>

Dear James

I'm happy for you to use the table as attached. I'm assuming that this is OK with the journal?

All the best with your thesis.
Kim

-----Original Message-----
From: James W Jones [mailto:[redacted]]
Sent: Monday, 12 September 2016 5:46 AM
To: Kim Beswick <[redacted]
Subject: "Categories of Teacher Beliefs" Inquiry

Dear Dr. Beswick,

In my dissertation, I have referenced the attached table, "Categories of Teacher Beliefs" and would like to also include in my dissertation in this form.

In order to meet university and ProQuest requirements, I require your express written permission to do so. Attached is the table that I am requesting to include.

If you would be so inclined to grant this permission for my dissertation use only, it would be sincerely appreciated. And if my APA citation and/or copyright is in error, please let me know.

Thank you kindly for your time and consideration.

Respectfully,

James Jones
Doctor of Education Candidate
Indiana University of Pennsylvania

Appendix K

Table 5 Copyright Permission

Subject: FW: PVAAS Table Dissertation Permission Request
From: Reigelman, Nicole <[redacted]>
Date: 09/19/16 05:53 PM
To: [redacted]

Attached Files
- Growth Table.docx (75 KB)

James,

You have permission to use the attached table in your dissertation. As long as the Pennsylvania Department of Education is cited as the source, that is fine.

Nicole Reigelman | Press Secretary & Communications Director
Pennsylvania Department of Education | Press & Communications Office
333 Market Street | Harrisburg, PA 17126
717-705-8642 | www.education.pa.gov
@PADeptofEd | www.facebook.com/PADepartmentofEducation

-----Original Message-----
From: Kristen Lewald [mailto:[redacted]
Sent: Monday, September 12, 2016 8:27 AM
To: Reigelman, Nicole
Subject: FW: PVAAS Table Dissertation Permission Request

-----Original Message-----
From: James W Jones [mailto:[redacted]]
Sent: Sunday, September 11, 2016 4:18 PM
To: Kristen Lewald <[redacted]
Subject: PVAAS Table Dissertation Permission Request

Dear Kristen,

In my dissertation, I have referenced the attached table and would like to include in my dissertation in this form.

In order to meet university and ProQuest requirements, I require express written permission to do so. Attached is the table that I am requesting to include.

If you would be so inclined to grant this permission for my dissertation use only, it would be sincerely appreciated. And if my APA citation and/or copyright is in error, please let me know.

Thank you kindly for your time and consideration.

Respectfully,

James Jones
Doctor of Education Candidate

Appendix L

Figure 2 Copyright Permission

Subject: **RE: Value-Added Model Image Permission**
From: Goldschmidt, Pete G <[redacted]>
Date: 09/11/16 11:01 PM
To: James W Jones <[redacted]>

Hi James,

Yes, You have permission to use the chart you indicated in your email.

Thanks,
- Pete

Pete Goldschmidt, Ph.D.
Professor
Michael D. Eisner College of Education
California State University Northridge

-----Original Message-----
From: James W Jones [mailto:[redacted]]
Sent: Sunday, September 11, 2016 4:42 PM
To: Goldschmidt, Pete G
Subject: Value-Added Model Image Permission

Dear Dr. Goldschmidt,

In my dissertation, I have referenced the attached figure from the following document:

Policymakers' guide to growth models for school accountability: How do accountability models differ?

In order to meet university and ProQuest requirements, I require your express written permission to do so. Attached is the figure in the exact manner I intend to include.

If you would be so inclined to grant this permission for my dissertation use only, it would be sincerely appreciated. And if my APA citation and/or copyright is in error, please let me know.

Thank you kindly for your time and consideration.

Respectfully,

James Jones
Doctor of Education Candidate
Indiana University of Pennsylvania

Appendix M

Table 6 Copyright Permission

From http://www.apa.org/about/contact/copyright/index.aspx:

3. Permission is Not Required for the Following:

- A maximum of three figures or tables from a journal article or book chapter
- Single text extracts of less than 400 words
- Series of text extracts that total less than 800 words

No formal requests to APA or the author are required for the items in this clause.

Appendix N

Table 7 Copyright Permission

Subject: FW: AGI Table Permission
From: Reigelman, Nicole <[redacted]>
Date: 09/19/16 05:54 PM
To: 'j.w.jones@iup.edu' [redacted]>

Attached Files
- Average Growth Index Table.docx (57 KB)

This one is ok too.

Nicole Reigelman | Press Secretary & Communications Director
Pennsylvania Department of Education | Press & Communications Office
333 Market Street | Harrisburg, PA 17126
717-705-8642 | www.education.pa.gov
@PADeptofEd | www.facebook.com/PADepartmentofEducation

-----Original Message-----
From: PDE PVAAS [mailto:[redacted]
Sent: Monday, September 12, 2016 4:04 PM
To: Reigelman, Nicole
Subject: FW: AGI Table Permission

-----Original Message-----
From: James W Jones [mailto:[redacted]
Sent: Sunday, September 11, 2016 5:53 PM
To: PDE PVAAS <[redacted]>
Subject: AGI Table Permission

Dear Staff:

In my dissertation, I have referenced the attached table and would like to include in my dissertation in this form.

In order to meet university and ProQuest requirements, I require express written permission to do so. Attached is the table that I am requesting to include.

If you would be so inclined to grant this permission for my dissertation use only, it would be sincerely appreciated. And if my APA citation and/or copyright is in error, please let me know.

Thank you kindly for your time and consideration.

Respectfully,

James Jones
Doctor of Education Candidate
Indiana University of Pennsylvania