April 2016

Motivation for Mathematics: The Development and Initial Validation of an Abbreviated Instrument

Kenneth Lee Butler
University of South Florida, butlerk1@usf.edu

Follow this and additional works at: http://scholarcommons.usf.edu/etd

Part of the Cognitive Psychology Commons, Educational Assessment, Evaluation, and Research Commons, and the Science and Mathematics Education Commons

Scholar Commons Citation

This is brought to you for free and open access by the Graduate School at Scholar Commons. It has been accepted for inclusion in Graduate Theses and Dissertations by an authorized administrator of Scholar Commons. For more information, please contact scholarcommons@usf.edu.
Motivation for Mathematics: The Development and Initial Validation of an Abbreviated Instrument

by

Kenneth L. Butler

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Mathematics Education Department of Teaching and Learning College of Education University of South Florida

Major Professor: Eugenia Vomvoridi-Ivanovic, Ph.D.
Robert Dedrick, Ph.D.
Ruthmae Sears, Ph.D.
Samuel Eskelson, Ed.D.

Date of Approval:
April 26, 2016

Keywords: Intermediate, Algebra, Developmental, Education, Survey, Intrinsic, Mastery, Performance, Expectancy

Copyright © 2016, Kenneth L. Butler
DEDICATION

To my life partner and fellow researcher.
I would like to thank Eugenia Vomvoridi-Ivanovic for her support throughout this process, Robert Dedrick for pushing me to work towards a topic that may be beneficial to future researchers, and Ruthmae Sears for being focused on quality writing and rigorous research. I would also like to thank Anna Foster Butler for taking up my slack when I needed to work, and my children for giving me hope for the future.
# TABLE OF CONTENTS

List of Tables ....................................................................................................................... iv

List of Figures ....................................................................................................................... v

Abstract ................................................................................................................................... vi

Chapter One: Introduction ..................................................................................................... 1
   Background ......................................................................................................................... 1
   Statement of Problem ......................................................................................................... 6
   Purpose of Study ................................................................................................................ 10
   Research Questions .......................................................................................................... 11
   Significance of Study ......................................................................................................... 14
   Definitions .......................................................................................................................... 15
      Engagement ..................................................................................................................... 15
      Motivation ....................................................................................................................... 15
      Motivational Relationships and Structures .................................................................. 16
      Motivation for Mathematics ......................................................................................... 17
   Assumptions ....................................................................................................................... 17
   Limitations ........................................................................................................................ 18
   Traditional Concerns ....................................................................................................... 19
   Summary ............................................................................................................................. 20

Chapter Two: Literature Review ............................................................................................ 22
   Motivation ........................................................................................................................ 23
      Self-Efficacy ................................................................................................................... 25
      Self-Determination ....................................................................................................... 26
      Achievement Goal Orientations .................................................................................. 28
      Similarities between Frameworks ................................................................................ 31
      Attribution Theory ....................................................................................................... 31
   Motivational Relationships .............................................................................................. 32
      Achievement Goal Structures ...................................................................................... 32
      Expectancy-Value ......................................................................................................... 33
      ARCS .............................................................................................................................. 35
   Questions for Mathematical Educators .......................................................................... 37
      What Motivates Mathematics Students? .................................................................... 38
      What Pedagogical Strategies Are Motivational? ....................................................... 40
      What Types of Curricula Are Motivational? ............................................................ 43
      What Types of Assessments Are Motivational? ....................................................... 44
What Are the Relationships Between Student Motivation and Equity in Mathematics Classrooms? .......................................................... 48
What Professional Development Is Needed to Train Educators in Motivational Structures Known to Improve Student Engagement? ........... 52
Theoretical Framework ........................................................................ 54
Usher and Pajares (2009): Validation Study for a Motivation Related Instrument ......................................................... 57
Summary ............................................................................................... 59

Chapter Three: Method ........................................................................ 62
Sources of Validity Evidence ................................................................. 62
Three Phase Systematic Approach ......................................................... 66
  Phase 1 in Detail .................................................................................. 68
    Participants and Data Collection for Phase 1 .................................... 70
    Data Analysis for Phase 1 ................................................................. 72
  Phase 2 in Detail .................................................................................. 74
    Participants and Data Collection for Phase 2 ................................. 74
    Data Analysis for Phase 2 ................................................................. 76
    The coding process ........................................................................ 78
    Selection of Items .......................................................................... 80
  Phase 3 in Detail .................................................................................. 81
    Participants and Data Collection for Phase 3 ................................. 81
    Data Analysis for Phase 3 ................................................................. 83
Summary ............................................................................................... 85

Chapter Four: Results ........................................................................... 87
Phase 1 ................................................................................................. 88
  Expert Replies to Emails ................................................................. 89
  Expert Comments to Survey Sections ............................................ 91
  Popularity of Items by Factor ......................................................... 98
Phase 2 ................................................................................................. 99
  Phase 2 Participants ....................................................................... 100
  Emergent Categories ..................................................................... 102
  Selection of Items .......................................................................... 109
Phase 3 ................................................................................................. 114
  Descriptive Statistics .................................................................... 114
  Exploratory Factor Analysis ......................................................... 118
  Confirmatory Factor Analysis ...................................................... 121
  Relationships between Motivation, Gender, and Achievement ...... 122

Chapter Five: Discussion ..................................................................... 128
Validity Evidence .............................................................................. 131
  Evidence Based on Content ......................................................... 131
  Evidence Based on Relationships to Other Variables ................. 134
  Evidence Based on Internal Structure ........................................ 135
Limitations .......................................................................................... 137
LIST OF TABLES

Table 1: Summary of Research by Phase.................................................................68
Table 2: Codes Used in Analysis........................................................................80
Table 3: Items Removed from the Phase 1 Instrument........................................112
Table 4: Descriptive Statistics for Phase-three instruments...............................115
Table 5: Internal Consistency for Phase 3 Four Factor Instrument .....................116
Table 6: Internal Consistency for Phase 3 Intrinsic Motivation Instrument..........117
Table 7: Internal Consistency for Phase 3 Mastery Orientation Instrument...........117
Table 8: Internal Consistency for Phase 3 Performance Orientation Instrument....117
Table 9: Pattern Matrix from Exploratory Factor Analysis...............................120
Table 10: Structure Matrix from Exploratory Factor Analysis...........................120
Table 11: Summary Table for Measurement Invariance......................................124
Table 12: Regression of Achievement on Latent Variables Moderated by Gender...125
Table B1: Sources of Items and Participants from Original Validation...............164
Table D1: Effect Sizes for Survey Comments.....................................................171
Table E1: Effect Sizes per Code per Item.........................................................172
Table F1: Percentage Endorsement per Item.....................................................178
LIST OF FIGURES

Figure 1: Scree plot displaying the result of an exploratory analysis of items from the phase three administration of the MMAI ......................................................119

Figure 2: Parallel analysis plot demonstrating the four factor structure of the 16 relevant items from the phase three administration of the MMAI. .........................119

Figure 3: Four factor confirmatory factor analysis for the MMAI........................................122

Figure 4: Structural equation model showing relationship between latent factors measuring motivation and achievement .........................................................123

Figure 5: Regression equations for achievement (A) on intrinsic motivation (im), mastery orientations (mo), performance orientations (po), and expectancy (ex).................................................................126
This study outlines the development and initial validation of an abbreviated instrument intended to measure motivation for mathematics of university students in developmental algebra courses. I look across many of the predominant theories on motivation with the aim of representing several of these theories as latent constructs in a single instrument that is short enough to be administered in a reasonable amount of time, but inclusive enough that it could incorporate subscales representing multiple distinct latent factors. This study answers a call by researchers expressing a need to investigate relationships between disparate theories on motivation and is a response to recent studies that have used several subscales from many published instruments in whole or in part as lengthy combined instruments to measure motivation across theories. The practice of utilizing many separate instruments to measure across theoretical frameworks may be unwieldy leading to validity concerns based on response processes, and the practice of taking individual items from separate instruments may potentially be incomplete leading to validity concerns based on the internal structure of the instrument and underrepresentation of the intended construct.

To answer these concerns and develop a tool for future research, I conducted a three phase study. Phase one of this study asked experts in motivation to comment on and pick the best items from a pool of 122 items sourced from several popular previously published instruments that contained factors associated with self-determination, self-efficacy, achievement goals, and
expectancy-value. The commentary by experts gave insight into item alignment with theory, and all items with at least 40% endorsement by experts proceeded to phase two.

In phase two, cognitive interviews of students and instructors provided insight into the cognitive processes employed in responding to the 53 items endorsed in phase one. Two researchers coded these qualitative interview data with a grounded theory approach and quantified the data using intra-respondent matrices. Effect sizes of each code provided evidence of content validity of preferred items, and concerns over social dynamics, misrepresentation of factors associated with poor wording, and the use of words like “very much” that forced students to quantify their cognitive processes provided evidence against non-preferred items.

During phase three I administered an instrument containing the surviving 34 items from phase two to 186 participants from twelve developmental algebra courses. Concerns over the broadness of the domain of mathematics led to the removal of self-efficacy and task-value items, and concerns over the abbreviated nature of the instrument led to the removal of items associated with extrinsic motivation. Concerns over the multilevel nature of achievement structured items led to their removal. Thus an exploratory and confirmatory factor analyses of the remaining 16 items representing intrinsic motivation, mastery orientations, performance orientations, and expectancy led to a four factor model that discriminated along theoretical lines and was a good fit for the data. A regression of achievement on the four latent factors from this model revealed expectancy to be the only significant predictor of achievement. With gender included as a moderating variable, performance and expectancy were both significant indicators of achievement for females, but expectancy was the only significant indicator for males. The latent factors from the instrument developed for this study had strong bivariate correlations to subscales from previously published instruments that represented similar constructs.
Several sources provided evidence of content validity. Qualitative data provided evidence in the form of commentary from experts and cognitive interview data from students and instructors. A structural equation model provided evidence of validity based on relationships to other variables. For this model the dependent variable achievement was regressed upon the latent motivation variables with gender included as a moderating variable. Exploratory and confirmatory factor analyses provided validity evidence based on the internal structure. Validity based on consequences and response processes was controlled by using an anonymous process where participation was blind to instructors and researchers, and the administration of an abbreviated measure in a familiar paper and pencil face-to-face format reduced construct irrelevant variance.

This process produced a four factor 16 item Motivation for Mathematics Abbreviated Instrument measuring intrinsic motivation, mastery orientation, performance orientation, and expectancy while accumulating validity evidence for three out of five sources of validity. The result of this inquiry was a psychometric instrument that may be used by researchers, practitioners, and grant writers who desire a tool to measure motivation for mathematics across several of the predominant theories on motivation.
CHAPTER ONE:  
INTRODUCTION

Being mathematically literate is important to being a productive citizen in a democracy, and all healthy and abled people are capable of becoming mathematically literate (NCTM, 2000). To improve motivation for mathematics, educators should work to encourage engagement with mathematics. I dream of students coming home from school excited about mathematics. To make this a reality, researchers need to produce generalizable knowledge about methods that improve the mathematics experience for all people, and to aid in this pursuit, this study focuses on developing an instrument with some evidence of validity that can be used to measure motivation for mathematics across several of the predominant theories on motivation. As it is important not to leave any student behind, this study focuses on developmental mathematics students at a university and calls on future researchers to generalize this instrument for use with a wider audience.

Background

Being fluent in mathematics is not only necessary to a career in science or engineering, but is also necessary for being an informed citizen in a democracy (Miller, 2012). From 1950 to 2009 the science and engineering workforce has increased from 182,000 to 5.4 million. This 5.9% annual growth rate was much higher than the 1.2% growth rate for the total workforce, and careers that require mathematics literacy also led to higher salaries with the median salary
($73,290) for science and engineering occupations being more than double the median salary ($33,840) for the United States population in general (National Science Foundation & National Center for Science and Engineering Statistics, 2012). Even with science and engineering careers in demand and many of these careers leading to higher pay, the United States of America is not producing enough STEM majors to fill the need (Kuenzi, 2008).

The National Council of Teachers of Mathematics (NCTM, 2000) expressed that people who have mathematical abilities have significantly enhanced opportunities and options, and mathematics cannot be contained to the classroom. Students must learn mathematics for everyday life as well as for the workplace, and the need to be mathematically literate will only increase with time. Unfortunately, research shows that mathematical achievement of students in the United States lags behind many other countries (Miller, Kelly, & Zhou, 2005), and although the U. S. has not traditionally led internationally, progress has been made. In the 2011 Trends in International Mathematics and Science Study (TIMSS), the average score for fourth graders in the United States was higher than the international average. In fact, the U. S. was among the top 15 educational systems with only eight systems significantly better. During this same period eighth graders in the U. S. underperformed 11 of these other international systems (National Center for Education Statistics, 2012). Even as the results for the U. S. have improved since 1995, it is important to remember that the mandate in the U. S. to educate all citizens may be different than mandates in other countries. According to the NCTM (2000), all people in the U. S. should have access to high quality mathematics programs, and it is imperative for a democracy to have an educated populace so that voters can be knowledgeable of the issues facing the nation.
The importance of being mathematically literate in the U. S. has led many researchers and educators to ask the question; why are some people motivated to engage in mathematics and not others? To answer this question, much research has used quantitative data in the form of psychometric surveys to provide evidence of participants’ cognitive and affective states associated with motivation. These surveys have been informed by some of the most widely researched theories on motivation, which include theories of self-efficacy, achievement goal theory, self-determination, and expectancy-value.

Many studies have reported that self-efficacy is a strong predictor of mathematics achievement, and Pajares and Miller (1994) used the Mathematics Self-Confidence Scale created by Dowling (1978) to measure this construct. In another study, Hackett and Betz (1989) used a self-efficacy scale developed by Betz and Hackett (1983) to explore gender differences in mathematics self-efficacy. Zimmerman and Martinez-Pons (1990) created a scale measuring self-efficacy related to verbal comprehension and mathematical problem solving by listing 10 words and 10 math problems, and asking participants to rate their efficacy. Lent, Lopez, and Bieschke (1991) developed a 40-item measure specific to their study with 10 items measuring each of the four sources of self-efficacy as proposed by Bandura (1988). More recently, out of concerns over the use of instruments that did not align with Bandura’s four sources of self-efficacy, Usher and Pajares (2009) developed and validated the Sources of Self-efficacy Scales measuring Bandura’s four sources of self-efficacy.

Another construct associated with motivation for mathematics is achievement goal theory. One of the earliest attempts at an instrument to measure these goals was by Ames and Archer (1988) with their creation of an instrument intended to measure students’ perceptions of classroom goal structures associated with performance and mastery. Skaalvik (1997) also created
a custom instrument for a study separating achievement goals into task, self-enhancing ego, self-defeating ego, and avoidance to measure these orientations. More recently much of the research on achievement goals has relied on the Patterns of Adaptive Learning Scales (PALS) developed and validated by Midgley, Kaplan, Middleton, Maehr, Urdan, Anderman, and Roeser (1998). This instrument is well documented and composed of sub-scales representing the separate orientations and structures associated with achievement goal theory.

Self-determination theory defines motivation as a continuum from intrinsic motivation through various types of extrinsic motivation to amotivation, and many scales have been developed to measure these types of motivation. Gottfried (1985) used the Children's Academic Intrinsic Motivation Inventory (CAIMI) developed by Gottfried (1986) to measure motivation across academic subjects. Pintrich, Smith, Garcia, and McKeachie’s (1992) Motivated Strategies for Learning Questionnaire and Miller, DeBacker, and Greene’s’ (1999) Perceived Instrumentality and Academics are other examples of instruments developed to measure motivation as framed by self-determination theory as it relates to expectancy-value in education. Although many scales were in existence at the time, two scales endorsed by Deci, Vallerand, Pelletier, and Ryan (1991) were the Academic Self-Regulation Questionnaire (ASRQ) (Ryan & Connell, 1989), and the Academic Motivation Scale (AMS) (Vallerand, Blais, Brière, & Pelletier, 1989). The ASRQ was designed to be used with students in late elementary school and the AMS was designed to be used with college aged students. Currently there are 17 scales located on the selfdeterminationtheory.org website that have been used to measure motivation framed as self-determination. These 17 instruments have various foci and levels of validation, and all have been used in academic research.
Feather (1988) used an instrument developed by Rokeach (1973) and several custom items to explore how course enrollment was related to expectancy-value, and although they did mention the need for future studies using previously validated instruments, they did not mention the validity of the instrument utilized. Wigfield (1994) used a 12-item custom measure to illustrate his ideas on competency beliefs, expectations of success, and task-values. Wigfield and Eccles (2000) developed an 11-item custom instrument to explore aspects of their theories on expectancy and achievement motivation. Although they admit to needing further research to validate their theory, they did not mention instrument validation. Keller’s ARCS model is a theory of motivational design based in expectancy-value that has been widely studied, and several of these studies that focused on this ARCS model employ the Course Interest Survey (CIS) developed by Keller (2009). Although he originally validated this survey for content and clarity with 10 graduate students and tested for internal consistency by administering the survey to 200 college students (Keller, 2010), little has been done to develop a validity argument outside of this initial study.

Attitudes towards mathematics are closely related to the concept of utility. Chouinard, Karsenti, and Roy (2007) using pieces from Fennema and Sherman’s’ (1976) Mathematics Attitude Scales (MAS) compare social agent support, competency beliefs, utility, and achievement goals to examine student effort. This scale, according to Hyde, Fennema, Ryan, Frost, and Hopp (1990) is the most widely used instrument to measure mathematics attitudes; however, little has been done in the way of validation. Broadbooks, Elmore, Pedersen, and Bleyer (1981); and Melancon, Thompson, and Becnel (1994) both address structural validity through factorial analyses; however, little has been done concerning other sources of validity. Using a French version of this instrument, Vezeau, Chouinard, Bouffard, and Couture (1998) did
some work towards a validity argument, and Liau, Kassim, and Liau (2007) used a Malaysian version for another validity argument. The widespread use of the MAS, these separate validity arguments, and the acceptance by most researchers provides a rationale for using this instrument.

**Statement of Problem**

Learning mathematics requires concerted effort for most students, and this necessity for effort and engagement has led to a large amount of research on constructs concerning motivation and on motivational relationships associated with mathematics instruction. Much of this research has involved the use of various psychometric scales for measuring disparate constructs associated with mathematics (McAuley, Duncan, & Tammen, 1987; Pintrich et al. 1992; Midgley, Kaplan, Middleton, Maehr, Urdan, Anderman, & Roeser, 1998; Miller, DeBacker, & Greene, 1999; Pelletier, Fortier, Vallerand, Tuson, Briere, & Blais, 1995; Usher & Pajares, 2009), several of these scales have been used extensively, and several have been shown to be internally valid and consistent for the populations being measured. Usher and Pajares (2009) found the need for a validated instrument to measure the four sources of self-efficacy aligned with Bandura’s (1986) theory, and in turn, called into question much of the earlier research on sources of self-efficacy because of the reliance on instruments with little evidence of validity. Similar issues surround much of the research on other constructs concerning motivation. There is a great deal of literature demonstrating how individual psychological constructs are related to motivation for and engagement with mathematics, and although there have been recent studies linking several of these constructs together investigating relationships across constructs, most of the literature has focused on one or two specific theories concerning motivation and several have relied on instruments with little evidence of validity.
With the notable exceptions of the Sources of Self-efficacy instrument developed and validated by Usher and Pajares (2009) and the Patterns of Adaptive Learning Scales developed and validated by Midgley, Kaplan, Middleton, Maehr, Urdan, Anderman, and Roeser (1998), many of the instruments used in educational research have not gone through a thorough validation process. Several instruments such as the Fennema and Sherman’s Mathematics Attitude Scales (MAS) and to a lesser extent Keller’s Course Interest Survey (CIS) have been utilized so often that they have gained a level of validation through popularity. When an instrument is utilized multiple times in diverse settings the results gain some level of generalizability as they can be compared with results from earlier studies. However, there is still the question, what is the instrument measuring? These two instruments as well as many others were developed by the authors of the theories they were meant to measure, and this gives them some level of credibility.

Besides issues with validity of instruments, the focus on individual theories and constructs in much of the research may lead to concerns about underrepresentation. By focusing on specific theories on motivation and only administering questions aligned with that specific theory, important aspects that would be crucial for a researcher or an educator to understand about student engagement with mathematics may be missed. Certainly, it is impossible to represent all facets of a construct such as motivation completely; however, it may be possible to measure many of the theoretical factors related to motivation for mathematics in a single instrument. Although, a single instrument would not lead to a complete accounting of all factors that promote engagement for all students, a more complete representation with some evidence of validity may be valuable for researchers as well as educators who desire a better understanding of student behavior when they work to engage students in mathematical dialogue.
Typically there have been two solutions to the problem of construct underrepresentation. The first solution is to administer several previously developed instruments to the same participants, and although this solution may produce credible results when the participants are engaged in the research and the instruments have been validated (Schwarz, 1999), there is an issue with validity concerning response processes for this type of study. The Standards for Educational and Psychological Testing (American Educational Research Association, 2014) describes one of the sources of validity evidence as evidence based on response processes, and Berry, Wetter, Baer, Larsen, Clark, and Monroe (1992) demonstrated that responses tend to become more random towards the end of longer surveys. By administering several long surveys in succession to measure separate cognitive constructs, issues relating to the length of the administered surveys may be exacerbated.

Friedel, Cortina, Turner, and Midgley’s (2007) study is an example of research looking across constructs that administers several instruments simultaneously. In this study they used the PALS to measure perceived teacher achievement goals, personal goal orientations, and academic self-efficacy. The Academic Coping Inventory developed by Tero and Connell (1984) was used to measure coping strategies, and perceived parental achievement goals were measured with items from an earlier study by Hruda and Midgley (1997). The researchers subjected the seventh grade students participating in this study to a 145-item survey, and they read each item aloud as the students recorded their responses. The total survey took approximately 45 minutes to administer. Although the PALS was a well-documented and validated measure, the validation of the other measures was never mentioned, and there was also no mention of how the validity of the combined measure was affected by the length of the administration process.
A second solution for construct underrepresentation is to take a few items from several different surveys and combine these items into one new survey. On its face this may be reasonable; however, by breaking apart existing scales to create a new combined survey, at least two types of validity evidence may be lost. By ignoring items previously validated as important measures of a construct, the distinct factor being measured may be underrepresented, and therefore, content validity may be questionable. Secondly, evidence of construct validity of the measure no longer exists as the structure has changed. Thus, the validity based on the internal structure of these types of combined instruments is unknown, and therefore, results of studies using these types of abbreviated instruments may not be credible.

Murayama, Pekrun, Lichtenfeld, and vom Hofe’s (2013) research into relationships between mathematics achievement, intelligence, motivation, and cognitive strategies is an example of a study that utilized an abbreviated measure of motivation. In this study, they measured intelligence with a 25-item German adaptation of Thorndike’s Cognitive Abilities Test (Heller & Perleth, 2000). They measured mathematics achievement, deep learning strategies, and surface learning strategies by utilizing subscales from the PALMA study (Pekrun, vom Hofe, Blum, Frenzel, Goetz, & Wartha, 2007). They measured perceived control with a Perceived Academic Control scale (Pekrun et al., 2007). As these scales were administered in their complete versions it may be reasonable to assume the previous validity studies applied; however, validity based on response processes may be questionable as this complete survey as composed was never validated. Also, they measured motivation by utilizing three items from Pekrun’s (1993) Intrinsic Motivation Scale, and they measured extrinsic motivation utilizing four items from Pekrun’s (1993) Extrinsic Motivation Scale. Although Murayama et al. (2013) stated that earlier validity studies apply to these abbreviated subscales, there is no mention of validity
evidence of the subscales as implemented. By only utilizing some of the original items from these two scales, underrepresentation and validity based on the internal structure of the instrument may be a concern.

**Purpose of Study**

The purpose of this study was to develop and validate an abbreviated combined instrument that looks across theories and simultaneously measures several constructs associated with motivation for mathematics. This study attempted to combine items based on self-determination theory, achievement goal theory, self-efficacy, and expectancy-value into one survey. Items for this instrument were modified versions of items previously employed by other popular instruments including Usher and Pajares’ (2009) *Sources of Self-efficacy scales*; Miller, DeBacker, and Greene’s (1999) *Perceived Instrumentality Survey*; Midgley, Maehr, Hruda, Anderman, Anderman, Freeman, Urdans’ (2000) *Patterns of Adaptive Learning Scale*; Pintrich et al.’s (1992) *Motivated Strategies for Learning Questionnaire*; McAuley, Duncan, and Tammens’ (1987) *Intrinsic Motivation Inventory*, and items inspired by Pelletier, Fortier, Vallerand, Tuson, Briere, & Blais, (1995) *Sport Motivation Survey*. The target audience was college students enrolled in developmental algebra courses and the resultant instrument – the Motivation for Mathematics Abbreviated Instrument (MMAI) – was intended to be used by practitioners to measure motivation in developmental college mathematics classrooms and in educational research.
Research Questions

The MMAI is intended to be a valid measure of motivation for mathematics across several pertinent theories on motivation. Expert selection of items may lend evidence towards content validity. Cognitive interviews may lend evidence towards content validity, validity based on response processes, and validity based on relationships with other variables. Both external and internal construct validity may be evident as items are shown to converge within constructs and discriminate between constructs. Evidence of external convergent and discriminant validity may be found by comparing constructs within the developed instrument to previously published subscales of related constructs, and evidence of internal convergent and discriminant validity may be found through exploratory and confirmatory factor analyses. Relationships between motivation and achievement may also lend evidence towards external construct validity and validity based on relationships with other variables. Moderating effects associated with demographic variables may also lend evidence for validity based on relationships to other variables.

For this study the overarching general question was, “To what extent is the Motivation for Mathematics Abbreviated Instrument (MMAI) a valid measure of student motivation?” To answer this question, I asked the following:

1. To what extent do the items in the Motivation for Mathematics Abbreviated Instrument represent their intended constructs?
2. To what extent can a latent factor measurement model that represents the included constructs in the Motivation for Mathematics Abbreviated Instrument be found to fit response data from developmental algebra college students?

3. What relationships exist between the factors representing the included constructs from the Motivation for Mathematics Abbreviated Instrument and previously published subscales representing intrinsic motivation, mastery goals, and performance goals?

4. What relationships exist between the included factors in the Motivation for Mathematics Abbreviated Instrument, gender, and self-reported student achievement; and how are these relationships similar to previously reported relationships in educational research?

Question one addresses content validity, question two addresses internal structural validity, question three addresses concurrent validity, and question four addresses relationships to other variables. To answer these questions I used, online expert surveys, cognitive interviews, and the administration of a preliminary instrument to build a validity argument for a final resultant survey. Considering validity to be a non-ending process and considering that sources of validity cannot be viewed in isolation, this argument directly addressed three of the five sources of validity --content, response processes, internal structure, relationships with other variables, and consequences-- listed in the Standards for Educational and Psychological Testing (American Educational Research Association, 2014). Typically, validity based on response processes concerns how the response is related to the construct being measured. Padilla and Benítez (2014) describe several concerns over response processes. The items in an assessment should reflect the
cognitive operations being measured. As an example, trying to measure reasoning and proof with questions that can be answered with memorized facts might raise validity concerns. However, validity concerns may also be raised because of construct irrelevant variance. To mitigate construct irrelevant variance and thus minimize validity concerns over issues involving response processes, an impetus of this study was to make an abbreviated instrument. Understanding that responses towards the end of longer surveys may be less reliable (Berry, Wetter, Baer, Larsen, Clark, & Monroe, 1992), and striving to reduce construct irrelevant variance, fifteen minutes was arbitrarily selected as a reasonable time for survey administration. Finally, validity based on consequences was addressed indirectly by administering this instrument in an anonymous manner and thus removing any quid pro quo consequences.

The first research question was answered in several ways. First, I collected evidence during selection of the most popular items based on expert opinion obtained from online surveys. Expert comments and cognitive interviews of a few selected teachers and students also provided evidence for this question. A fellow researcher and I analyzed the qualitative data used to answer this question with the unit of measure being the concept phrases we extracted from the expert commentary and the interview transcripts. An exploratory and confirmatory factor analysis and a structural equation model provided evidence for the second research question. A correlational analysis of the factors from the structural equation model and sub scales from previously published surveys intended to measure the similar constructs provided evidence for the third research question. To bolster evidence of concurrent validity, the factors from the MMAI should be correlated with subscales from the previously published surveys intended to measure similar constructs. For the fourth question, factors from the confirmatory analysis were included in a structural equation model with achievement as a dependent variable and gender as a moderating
variable. This analysis provided evidence for relationships between the factors from the MMAI, and gender and achievement variables by replicating results from previous studies. Meece, Anderman, and Anderman (2006) found no significant relationship between mastery orientations and achievement (Meece, Anderman, & Anderman, 2006). Butler (2014) found females had higher achievement, and males had higher intrinsic motivation for mathematics. By replicating these findings with the MMAI, evidence for validity based on relationships to other variables may be bolstered.

**Significance of Study**

As Pintrich (2003) state, there may be more utility in examining how disparate constructs concerning motivation are related to one another than in creating new constructs or theories. This was one impetus for developing a more comprehensive instrument that was multifaceted and looked across some of the major theories on motivation. Several recent studies have looked across constructs; however by combining several existing measures either wholly or in part, questions concerning the validity of the evidence arose.

Researchers and educators need an abbreviated instrument that combines the major theories on motivation and motivational relationships. Researchers need a valid means of looking across these constructs and theories so relationships between constructs may be explored in a way that is convincing and generalizable, and educators need a means to measure the motivations of learners that is informative, relatively comprehensive, and administrable in a reasonable amount of time.
Definitions

Operational definitions are needed to clarify concepts stated throughout the study. As engagement and motivation are not defined consistently in the literature, there is some value to clarifying these terms.

Engagement

As defined by Skinner (1991), and Connell and Wellborn (1991) engagement “refers to the intensity and emotional quality of children’s involvement in initiating and carrying out learning activities” (Skinner & Belmont, 1993, p. 572). With this definition, engagement has both a physical and an emotional component, and students who are engaged show “sustained behavioral involvement” (Skinner & Belmont, 1993, p. 572). For this study engagement has to do with the quality of involvement a student has with a task, and this involvement can be in the physical or affective domain. Engagement may be physically measurable such as when a student manipulates objects, or engagement may take the form of sustained attention to a task without any outward activity. When engagement is cognitive or affective it may be measured as a latent construct.

Motivation

After examining definitions that refer to internal mechanisms, that refer to functional processes, or that are either restrictive or comprehensive, Kleinginna and Kleinginna (1981) define motivation as those “energizing/arousing mechanisms with relatively direct access to the final common motor pathways, which have the potential to facilitate and direct some motor circuits while inhibiting others” (p. 272). These same authors state that the term motivation may
be unnecessary as researchers need to focus on directly measurable actions. For this study a
distinction between motivation and motivational relationships is useful. Motivation in this study
is discussed in the context of three prominent theories. Self-determination as developed by Ryan
and Deci (2000), achievement goal orientations as developed by Elliott and Church (1997), and
self-efficacy as developed by Bandura (1986). These three theories have motivation as an
internal impetus within students that prods them into engaging with a task. Self-determination
uses the familiar terms intrinsic and extrinsic motivation, and discusses how autonomy,
relatedness, and competence can move students towards the intrinsic end of a motivation
continuum. Achievement goal theory describes students’ mastery and performance orientations
as being influential to academic achievement. Self-efficacy describes how students’ beliefs in
their competency within a domain affect their engagement within that domain. Although the
domain with which the student engages is central to understanding these theories there is no
causal link between a task within the domain and student motivation. For this study, motivation
is this internal impetus, and therefore requires an agent. An agent can have motivation, but an
object cannot. These motivations are not directly measureable, but may be measured as latent
constructs. Operationally, agents have motivation if they have a high score on an instrument,
which has some evidence of validity, intended to measure some facet of one of these three
cognitive theories on motivation.

**Motivational Relationships and Structures**

Expectancy-value theory is among the earliest theories on motivation, and although it is
rooted in behaviorism, it has evolved into a theory about expectations of success versus task-
value (Wigfield & Cambria, 2010). Achievement goal structures refer to relationships between
curricular or pedagogical practices that encourage mastery or performance orientations in students. The goals emphasized in educational tasks affect how students approach the situation, and these goal structures affect the quality of students’ engagement with the task (Kaplan, Middleton, Urdan, & Midgley, 2002). In achievement structures, tasks have causal relationships to an agent’s internal motivation (Anderman, Maehr, & Midgley, 1999). The goal structures of a task affect students’ motivations to engage in the task. There is a relationship between an agent’s personal goal orientations and the goal structures inherent in the task. The relationships between an agent and a motivational structure are motivational relationships, and a relationship is motivational if it encourages motivation in an agent. Operationally, a relationship is considered motivational if it has a direct effect on motivation or engagement.

Motivation for Mathematics

If a person tends to engage in mathematics when the opportunity presents itself, then the person is understood to have motivation for mathematics. Operationally, a person has motivation for mathematics if he or she has high scores on an instrument, which has some evidence for validity, intended to measure motivation for mathematics.

Assumptions

While validating the content of the resultant survey from this study, I asked experts on specific theories of motivation to analyze the items incorporated into this instrument. The task for these experts was to give their advice on how well existing items represent the given constructs and how clearly the items discriminate between constructs. This advice was crucial to the validation process, and I assumed that it was given in good faith. Many experts on motivation
have invested much of their own time in research on specific constructs concerning motivation, and therefore, they may believe that the theory they regularly study is of utmost importance. It may be difficult for these experts on particular theories of motivation to get outside of their own bias towards their specific theory and work on a survey that looks across many theories.

Another type of expert employed in this study was instructors with experience in teaching mathematics. Although these educators were not experts on motivation, they had anecdotal evidence of student engagement with mathematics, and I assumed these experiences in the classroom provided insight into the meaning of items as well as possible underrepresentation of motivation for mathematics. These practitioners had their own biases, and it was difficult to separate these biases from their interpretations of student cognitive and affective patterns.

Convergent and discriminant validity were bolstered by appending existing scales to the end of the resultant survey. I assumed that these existing scales performed adequately for the given population. By requiring students to respond to more items than the resultant survey contained, I also assumed that validity based on response processes was not undermined. Ironically, one of the reasons there is a need for an abbreviated instrument is because of a bias associated with longer surveys. Towards the end of longer surveys, participants tend to give more random responses (Berry, Wetter, Baer, Larsen, Clark, & Monroe, 1992). Thus, there was a contradiction in the process, but as with any supplied response survey, there was the assumption that participants responded to all items truthfully.

Limitations

The sourced population was valuable for the external validity of the study but was also an important limitation of the study. Although this study did include many adult learners from
diverse populations and levels of mathematics, it was only focused on college-aged students, all of the participants attended a public university in the southeastern region of the U.S. on the central gulf coast of Florida, and all were enrolled in a developmental algebra course. Therefore, generalizing this study to younger students or students from other geographical regions may not be reasonable. Some of the participants were English second language learners; however, all were enrolled in a college level developmental mathematics course where the only language spoken in the classroom was English. Therefore, I assumed a reasonable command of the English language, and so, this measure may not be reliable for learners with more limited language skills. Also, all participants attended public colleges and universities, and therefore, the findings may not be generalizable to private universities and other institutions with different mandates and different demographic compositions.

Another limitation in the design of this study was the reliance on self-reported achievement and gender data from the participants. The survey was administered anonymously, and therefore, it was not possible to collect achievement and demographic data in an unbiased manner. This choice to have the survey implementation conducted anonymously in a face-to-face manner on paper and pencil was partially made because of assumptions made about the target population, and was partially done to encourage greater participation. Therefore, the reliance on self-reported data may have introduced measurement error into achievement and demographic data.

**Traditional Concerns**

The approach to motivation used here may not be accepted by some. Most research on motivation has focused on one of the traditional frameworks of motivation such as self-
determination, achievement goals, self-efficacy, or expectancy-value. By combining these theories into a single instrument it may be more difficult to measure specific aspects of any one of these theories. However, a bias associated with focusing on a specific framework is that by confining motivation to the framework studied, conclusions only concern that particular framework and may not be valid representations when motivation is viewed as a holistic construct. Although this survey is a response to concerns over underrepresentation, some may see this as problematic.

For this study, qualitative data were collected as part of the process of obtaining evidence on content validity. I then quantified some of these qualitative data and analyzed it using grounded theory with emergent themes categorized using intra-respondent matrices. Gaining evidence through qualitative data adds credibility to the study; however, some may see the quantification of qualitative data as problematic. Although more sources of data may increase the credibility of findings, the use of mixed methods in general and the quantification of qualitative data specifically are not popular with some qualitative researchers.

Summary

Understanding mathematics is important for all people in a healthy democracy, and this exposes the importance of understanding how to motivate students to engage in mathematics. For this study, an instrument to measure motivation across many of the predominant theories on motivation of university level developmental algebra students was developed and initially validated. A call by researchers for more studies looking across these disparate theories revealed a need for this type of abbreviated instrument and validation concerns surfaced when reviewing some of the current research that answered this call. These concerns became apparent as some
recent studies relied on combining many instruments in whole that took a great deal of time to administer, or on the dismantling of published instruments creating shorter surveys with no known structural validity. The instrument developed here started with a large pool of items from many well validated instruments, and through the collection and analyses of both qualitative and quantitative data I answer important questions addressing the validity of the developed instrument. The focus of this study is the items used for the developed instrument, but the population consisting of university level developmental algebra students provided much of the evidence about the validity of the items. This narrow focus may lead to more external validity for the study; however, it also limits the generalizability of the argument to a wider audience.
CHAPTER TWO
LITERATURE REVIEW

There is an enormous amount of research into motivation, with three of the most well-developed motivation frameworks being self-determination theory, achievement goal theory, and self-efficacy. Another construct inversely related to motivation is anxiety. Much of the research into motivation and anxiety examines how classroom relationships and social norms affect student motivation or anxiety as defined by one of these frameworks. By focusing narrowly it may be that researchers are missing the forest for the trees. My attempt is to step back from the forest, and view motivation in an inclusive light. A brief overview of these three motivational frameworks is reviewed, along with several studies. These studies were chosen for their relevance to STEM education; however, most of the participants were not developmental university mathematics students.

There are three goals of this review. The first goal is to improve the consistency of terminology concerning research into motivation by aligning the terms motivation and motivational with the previous definitions. The second goal is to organize theories of motivation and motivational relationships, and to find similarities between current theories. Although research has traditionally focused on one particular framework of motivation or motivational relationships, Hung, Huang, and Hwang (2014) is an example of a recent study that has begun to synthesize several disparate frameworks. The third goal is to approach motivation as a mathematics educator and find how understanding motivation can improve student experiences.
When possible, the empirical research cited is focused specifically on mathematics students; however, some articles cited deal with science or technology as these topics are typically math intensive. It is believed that some of the findings on student engagement from these other subjects may be generalizable to mathematics. Also most of the research is focused on primary and secondary students in the United States; however, Martin, Yu, Papworth, Ginns, and Collie (2014) demonstrated many of these constructs are internationally generalizable.

The end of this chapter outlines the theoretical frameworks associated with motivation used in the development of the Motivation for Mathematics Instrument. This provides a greater focus for the remainder of the study. Finally, a recent study by Usher and Pajares (2009) provides an example of a rigorous development and validation argument.

Motivation

Dörnyei (2001) explains motivation as “why people decide to do something, how hard they are going to pursue it, and how long they are willing to sustain the activity” (p.7). Ryan and Deci (2000) state “motivation concerns energy, direction, persistence, and equifinity –all aspects of activation and intention” (p. 69). For this study, motivation will have a more narrow definition. Motivation is internal to an agent. On the other hand, engagement is the amount of effort spent doing a task over time. How hard someone pursues an activity and how long they are willing to sustain the activity are physically measureable quantities; however, motivation is not directly measureable. It is an attribute of cognition. For example, a cat can be motivated to eat, but the cat food is not motivated to be eaten. Instead, cat food is motivational for cats.

The term motivational is used at least two different ways in research. Pintrich (2003) used the term motivational science as science dedicated to the understanding of motivation, with
science being “reasoned argument from evidence” (p. 668). Although there is a place for philosophical and theological theories of motivation, Pintrich defines motivational science as inquiry into motivation supported by empirical research. I am strongly aligned with Pintrich’s motivational science; however, the term “motivational” in this review will generally refer to a relationship between a structure and an agent. Notice, a structure could be lots of things. Students may become more engaged when they work together, they may become more engaged because of an affection towards a teacher, they may become more engaged when the teacher facilitates discussion, and they may become more engaged when they are able to search for materials on a smart phone. Students, teachers, teaching methods, and types of technology could all be correlated to student engagement, and therefore, these relationships can be motivational. A relationship, which is motivational for a student when interacting with a task, tends to increase the student’s engagement. Motivational relationships are observable and measurable.

There is a great deal of research on motivation, with a fair amount focused on mathematics (Brahier, 2011). As psychology shifted towards an acceptance of cognitive research (Posner, 1989), the science of motivation also moved to investigate the cognitive –not directly measurable-- construct of motivation. Bandura (1997) focused on self-efficacy as a cognitive model with affective and selection components associated with motivation. Ryan and Deci (2000) focused on a social-cognitive model of motivation concerned with autonomy, competence, and self-regulation; and Elliot and Harackiewics (1996) focused on a social-cognitive model of motivation related to achievement goals. These three avenues towards understanding motivation may not be exclusive and probably interact; so following suggestions made by Pintrich (2003), this review approaches motivation as a composite having affective, cognitive, and social components.
Self-Efficacy

Self-efficacy for a given domain is a belief in one’s ability to be successful in that domain (Bandura, 1997; 2012). For instance, students who are self-efficacious in factoring trinomials believe they can factor trinomials. The level of one’s self-efficacy is related to the difficulty of exercises within the domain. A student can be self-efficacious in factoring, but having self-efficacy in factoring trinomials with the coefficient of the second degree term being other than one is a higher level of efficacy than having self-efficacy in factoring a trinomial with the coefficient of the second degree term being one. The generalizability of one’s self-efficacy relates to how well self-efficacy can be transferred across domains. Does a student’s self-efficacy in algebra transfer to statistics? The strength of self-efficacy in a domain relates to how certain self-efficacious people are in their success. Students may feel strongly about their ability to factor the difference of two squares but have weaker self-efficacy for factoring the difference of two cubes. These properties of self-efficacy can be measured through careful attention to difficulties and confidence levels of task specific questions (Zimmerman, 2000).

The four sources of self-efficacy are mastery experiences, vicarious experiences, social persuasions, and emotional states (Bandura, 1997; 2012). The most influential of these are mastery experiences, which are formed when students are successful at completing challenging tasks within a domain. Vicarious experiences are less influential as they depend on self-comparisons between an observer and the person living through the experience, and social persuasions are even less influential as they depend on the perceived credibility of the persuader(s). Positive and negative emotional states have also been shown to be related to self-efficacy with stress, anxiety, and fatigue being inversely related to capability and thus negatively related to self-efficacy of personal control (Bandura, 1988; 2012). Finally, domain specific self-
efficacy has been shown to be directly related to academic motivation through students’ choices and goals, their level of effort, their persistence, and their emotions related to experiences within the given domain (Zimmerman, 2000).

**Self-Determination**

Ryan and Deci (2000) found people have innate psychological needs regarding competence, relatedness, and autonomy that are essential for personal growth and well-being. They also found people have inherent tendencies to challenge themselves, to explore the world, and to search for new knowledge and understanding. When people engage in activities because they find challenge, exploration, or pursuit of knowledge satisfying, then they are intrinsically motivated towards that activity. Social-contextual events that promote competence and relatedness can encourage intrinsic motivation when accompanied by autonomy. Students who receive positive feedback find their learning environment supportive and personable, and students who believe they are in control of their own learning tend to have more intrinsic motivation towards learning. These are a direct relationships. Inverse relationships may also exist as negative feedback, unsupportive environments, and lack of control can also lead to diminished intrinsic motivation (Ryan & Deci, 2000).

Students are extrinsically motivated if they engage in activities for some reason other than personal satisfaction. For Ryan and Deci (2000) this externally controlled motivation is represented as a continuum separated into four main groupings based on the degree of regulation that is external. Integrated regulation has students fully incorporate their engagement in an activity with their values and goals, and they believe the locus of control for engagement is internal. Students who choose to study for math tests because they believe learning mathematics
is personally valuable, and who exhibit goals based on pursuing a career involving mathematics are not studying because they enjoy studying mathematics; therefore, they are not intrinsically motivated. However, they have integrated activity with their self-beliefs, and therefore, see it aligned with their personal values and goals. Activities that are fully incorporated into self-concepts and autonomy are associated with integrated regulation (Ryan & Deci, 2000). When students engage in fully autonomous activities that are seen as valuable but are not fully incorporated into their self-concepts, they are using identified regulation. When students engage in an activity autonomously because of internal rewards or punishments they are using introjected regulation, and when students engage in an action solely because of external rewards or punishments they are externally regulated. Amotivation, which is not considered extrinsic, is when student’s actions are controlled by other people, and usually corresponds feelings of incompetence, demonstrations showing no value for the activity, and exercises showing a complete lack of self-regulation.

After childhood, social pressures force most people to do activities they do not find interesting; thus, most student motivations are extrinsic (Ryan & Deci, 2000). When these uninteresting activities are modeled and valued by role models, students are more likely to engage in the activity, when students receive positive feedback concerning an activity they are more likely to internalize the activity, and when students are given choices in how they engage in these uninteresting activities they are more likely to integrate the activity into their self-concepts. Thus, to move students’ regulation from external or introjected to being identified or integrated the three innate psychological needs become crucial. When student role models discuss the value of mathematics, model mathematical engagement, and encourage students to engage in authentic –self-authored– mathematics; then student motivation for mathematics may move towards the
integrated end of the extrinsic spectrum. However, when role models state mathematics is not needed, they do not personally engage in mathematics, and they control how their students engage in mathematics; then student motivation for mathematics may lend itself towards the externally regulated end of the extrinsic spectrum (Ryan & Deci, 2000).

**Achievement Goal Orientations**

In one of the oldest attempts to frame motivation, McClelland (1951) posited two types of achievement motivation, one associated with avoiding failure, and another associated with attaining success. Dweck (1986) posited that patterns representing motivation can be adaptive or maladaptive, with adaptive patterns encouraging the attainment of goals and maladaptive patterns relating to a failure to set reasonable goals. For Dweck (1986), these patterns come in two classes related to competence; learning goals and performance goals. Learning goals are associated with a desire to understand and master new content, and performance goals are associated with an individual’s desire to be judged favorably or to avoid being judged unfavorably. Students who believe their intelligence in malleable are more likely to develop learning goals as these students are inclined to want to improve their competence. This leads students to set challenging goals for themselves, persist in the attainment of the goals, and hence, to be mastery oriented. This is opposed to students who pursue performance goals and believe their intelligence is fixed. When students have high levels of perceived competence they may be mastery oriented; however, when students have low levels of perceived competence they may exhibit helplessness, avoid challenges, and show little persistence in obtaining their goals (Dweck, 1986).
Elliott and Harackiewics (1996) investigated both approach and avoidance-orientations and developed an achievement goal framework consisting of mastery, performance, and performance-avoidance goal orientations. This framework is a culmination of several earlier frameworks with mastery goals being similar to learning goals and task involvement, and performance goals being similar to ego involvement (Ames and Archer, 1987). Mastery goals are focused on obtaining new skills and knowledge. Students who are mastery oriented choose to engage in a task and learn new material because they want to understand the concepts. This is demonstrated when geometry students want to learn how to prove the Pythagorean Theorem even though they know they will not be tested on knowing the proof. Performance goal orientations, on the other hand, concern comparisons with other students. Students who are performance oriented engage in tasks because they want to demonstrate their abilities. By performing well on assessments they show themselves and others that they are smart. This is demonstrated when students want to know who had the highest grade in the class, and want to display their personal high score for all to see. Much of the achievement literature uses this dichotomous mastery verses performance framework similar to Dweck (1986); however, Elliott and Harackiewics (1996) added a third performance-avoidance-orientation. Performance-avoidance can be seen when students choose not to engage in tasks because they do not want their incompetence made public. This appears in the perceived correlations between the dates and times of final exams and grandmothers’ funerals. When students forget to do their homework or miss tests, it may not be that they are lazy. Consciously or non-consciously they may be avoiding an environment in which they believe they are incompetent. This three factor trichotomous model has some empirical support (Elliott & Church, 1997), and although some
have also posited a 2x2 model with a fourth mastery-avoidance orientation (Elliott, 1999; Pintrick, 2000), there is little empirical evidence for mastery-avoidance.

When achievement goals are framed with the dichotomous framework, mastery-orientations tend to be correlated to increases in intrinsic motivation, and performance-orientations tend to be correlated with decreases in intrinsic motivation (Butler 1987; Deci & Ryan, 1991; Heyman & Dweck, 1992). Students who are mastery oriented choose to engage in new tasks because they find challenging material exciting. If the goal is to become competent at some interesting new task, then it may be reasonable to assume mastery oriented students also tend to believe the locust of causality for the given task is internal. This is opposed to performance oriented students who engage in new tasks because of a desire to demonstrate abilities to others. Because the goal is to impress others, the locust of causality is not completely internal, and so is not completely in the control of the student. Elliot and Harackiewics (1996) found this lack of control can lead to anxiety because poor performance may be a treat to the ego.

When achievement goal orientations are framed as a trichotomous model, Elliott and Harackiewicz (1996) found performance-approach orientations may not be detrimental to intrinsic motivation. Spurred on by the successful feedback they are receiving, performance-oriented students’ intrinsic motivations are not diminished as these students may still be engaged, excited, and generally absorbed in the task. Although performance approach orientations may not reduce students’ intrinsic motivations, this type of orientation may be more aligned with an identified or an internalized type of extrinsic motivation. A performance-oriented student is not performing the task for shear enjoyment of the task. Instead, they have an ulterior motive based in comparisons with other students. Both mastery and performance approach orientations are in
sharp contrast with performance-avoidance, as avoiding a task because of impending failure is antithetical to motivation.

**Similarities between Frameworks**

These three frameworks concerning motivation—self-efficacy, self-determination, and achievement goal orientations—have a great deal of overlap. Perceived competence is a moderating variable for achievement goal frameworks, and for Ryan and Deci’s self-determination framework. Hughes, Gailbreath, and White (2011) also find the cognitive component of perceived competence to be similar to self-efficacy. Removing autonomy and forcing students to perform in a domain in which they are not self-efficacious and do not feel a relationship, may lead to anxiety and distress which is very similar to the impetus needed for students to develop performance-avoidance orientations. Therefore, all three frameworks dealing with motivation have self-efficacy and perceived competence as paramount, and see motivation as a complex construct that is at the heart of all human endeavors. However, unlike Bobis, Anderson, Martin, and Way’s (2011) translation of statements by Pintrick (2003), I do not see the complexity associated with attempting to understand motivation as a limitation of the cognitive construct, but rather, a limitation of research that attempts to define motivation within a narrowly defined framework.

**Attribution Theory**

One theory closely related to achievement motivation is attribution theory. As Dweck and Leggett (1988) explain, how children attribute success and failure influences how much they will persevere when confronted with a challenge. When children believe certain people are inherently
good at math then they will be less likely to persevere when they confront a failure. In this situation failure on a math assignment implies they are just not good at math, and since they are not good at math, they will not be successful at math. On the other hand, children who believe being good at math is something that is acquired through hard work, will persevere when confronted with failure. Mistakes become opportunities for learning instead of signs of inadequacy. Although, attribution theory is not a focus of this study, it is important to mention as a moderating theory on engagement and motivation.

**Motivational Relationships**

The following addresses several theories concerning motivational relationships. Notice, these theories concern relationships between external stimuli and internal cognition. There is a review of theories concerning achievement goal structures and expectancy value. Although they are part of the same theory, achievement structures were separated from achievement orientations as structures are physical and not cognitive, and expectancy-value was included as a theory based in physical relationships between tasks and a person’s belief in successfully completing the task. Keller’s ARCS model was also included as an example of a recent theory that expounds on expectancy-value.

**Achievement Goal Structures**

Aligning with the factors developed as achievement goal orientations but concerning motivational relationships instead of motivation, mastery structures have attributes that encourage mastery orientations, and performance structures have attributes that encourage performance orientations. Cho and Cho (2014) demonstrated that instructors’ supportive
interactions with students and the implementation of mastery structures in on-line instruction led to more mastery orientations in students, and instructors that implemented performance structures tended to have students with higher performance orientations. Some negative consequences of performance structures have also been found. Performance goals embedded in classroom structures that promote selection tend to favor historically privileged groups; whereas, mastery goal structures tend to level the playing field (Smeding, Daron, Souchal, Toczek-Capelle, Butera, 2013; Souchal, Toczek, Daron, Smeding, Butera, & Martinot, 2014). There is also some evidence that mastery-structures tend to reduce the decline in student achievement and intrinsic motivation that typically occurs during middle school (Anderman, Maehr, & Midgley, 1999).

**Expectancy-Value**

Work by Tolman (1932) on rats linked choices associated with human and animal behavior to expectancy, and defined expectancy as an agent’s expectation of success when performing a task with the expectation as the motivating factor. Tolman (1932) also generalizes that rats expecting to be rewarded at the end of a maze have greater motivation to learn the maze because they are incentivized. This is expectancy-value theory. Atkinson (1957) develops a similar model with three factors; motive, expectancy, and incentive. This model related motive to expectancy-value. He had motivation linked to personal aspirations and task difficulty, and fear of failure and inability to control learning linked to anxiety. Values “intrinsic to achievement” were linked to the “subjective probability of success” (Atkinson, 1957, p. 362).

Eccles (1987) compartmentalizes task-value into the four major components of attainment value, interest, utility, and cost. Attainment value deals with how successful
acquisition fits into one’s personal values and goals, interest is similar to intrinsic valuing associated with the pleasure of attainment, utility concerns how necessary attainment is to achieving future success, and cost deals with the consequences of participating in an activity. Jacobs, Lanza, Osgood, Eccles, and Wigfield (2002) reported on a confirmatory factor analysis associated with the administration of a Self- and Task- Perception Questionnaire. In year one of this study 742 students from fifth through twelfth grade and in year two 575 students in similar grades participated. There was an approximately even split between gender. For this confirmatory factor analysis, they found the best fit with a three factor model representing intrinsic interest, attainment value, and extrinsic utility.

More recently, expectancy-value has evolved into a framework based on achievement task-value (Wigfield & Cambria, 2010). Generally, these models link achievement, persistence, and choice to expectations for success and perceived task-value. Wigfield and Eccles (2000) found expectation for success directly related to math achievement and inversely related to math anxiety, and task-value directly related to students’ intentions to engage with mathematics in the future. This achievement-value framework still has the two factor expectancy-value model; however, for Wigfield and Cambria (2010) “both the expectancy and value components are defined in richer ways, and are linked to a broader array of psychological, social, and cultural determinants” (p. 3).

Pintrick (2003) stated the need for more research combining achievement goal orientations with expectancy-values and achievement-values; however, there is a logical difference between these achievement goal orientations and achievement values. Self-determination, and achievement goal orientations are domain dependent but only have a weak connection between the task and an internal cognitive construct. Students who are mastery
oriented have a general disposition towards mastery; however, relationships associated with expectancy and value are motivational (Higgins, 2007). These types of value based motivational relationships have a stronger bond between the student and the task; and the same task, technology, or teacher will not have the same effect on every student. The motivational relationships between the student and the task includes two parties so it would not be consistent to say the use of technology in mathematics is motivational void any mention of the attributes of the students involved. Expectancy-value began in psychological behaviorism, and although achievement task-value does now account for psychological dimensions, its general focus is still on a motivational relationship, and not on a cognitive construct defining motivation internal to an agent. As Wigfield and Cambria (2010) state, “motivation [self-determination] has been characterized as a broader construct” (p. 2) than expectancy values.

**ARCS**

Keller’s (1987, 2009) ARCS model is based on expectancy-value and is aimed at improving the motivational relationships between students and instructional materials. His first model had four factors: expectancy, value represented by interest, value represented by relevance, and outcomes. Interest evolved into attention, relevance stayed unchanged, expectancy became confidence, and outcome became success aligning the four factors to the current acronym.

For Keller, attention is a prerequisite to learning, and the key to instructional design is not just in capturing the student’s attention but in sustaining it. Attention is a physical variable measured in units of time. By using creative unusual examples, encouraging exploration and
autonomy, and using games and simulations, sustained attention may be encouraged (Keller, 1987).

Relevance concerns both what is being taught and how it is being taught. If you cannot explain why students need to learn mathematics, then the relevance of mathematical content has not been adequately explained. Teaching methods can also lead to situated relatedness. Some students desire social interaction, so they find tasks more relevant when they can work on group projects. Other students may be goal oriented, so they desire moderately challenging tasks. By providing opportunities for excellence, letting students take authority and responsibility, explicitly discussing personal motivations for the subject, and modelling enthusiasm; relevance may be improved (Keller, 1987; 2009).

Keller (1987) renamed expectancy to confidence. This may be similar to self-efficacy and perceived competence, and may be related to Dweck’s (1986) framework in that confident people tend to attribute success to ability and not luck (Keller, 1987). Confidence is also moderated by task difficulty and affective constructs, and performance-avoidance oriented students may be driven by a fear of failure caused by low confidence (Keller, 1987; 2009). To instill confidence, Keller (2009) suggests making expectations and instructions as clear as possible, giving students opportunities to succeed at worthwhile challenging tasks, and providing the learner “as much personal control over the actual learning experience as possible” (p. 51).

Three strategies --natural consequences, positive consequences, and equity-- can encourage student satisfaction with a task. According to Keller (2009), if students understand why a task is important and have plenty of opportunities to apply the task, then they will be more intrinsically motivated and have less of a need for extrinsic rewards. Case studies, simulations, and experiential learning can lead to greater task satisfaction as they offer opportunities to
experience natural consequences to learning. Incentives and awards can offer extrinsically motivated students with positive consequences when used appropriately, and to promote fairness, Keller (2009) states rules and incentives need to be enforced equitably.

To Keller (1987, 2008, 2009) these four requirements –attention, relevance, confidence, and success-- are necessary for sustained engagement. Recently, Keller (2008, 2009) included relationships to self-determination and self-efficacy within his model. He suggested that attention is related to autonomy, relevance is related to regulation and selection, confidence is related to perceived competence and self-efficacy, and satisfaction is related to intrinsic and extrinsic motivations. By examining student perceptions of pedagogy and curricula, the ARCS framework provides a template for improving the relationships between students and educational structures imbedded in the academic environment.

Questions for Mathematics Educators

As this is a review of the science of motivation and motivational relationships, the theoretical frameworks discussed must be supported empirically through research focused on improving student engagement in mathematics. A few important questions for mathematics educators are: what motivates mathematics students, what types of curricula are motivational, what types of assessments are motivational, what are the relationships between student motivation and equity in a mathematics classroom, and what professional development is needed to train educators in motivational techniques known to improve student engagement?
What Motivates Mathematics Students?

While looking at motivation from an achievement goal perspective, Meece, Anderman, and Anderman (2006) demonstrated that students’ mastery goals were positively associated with engagement, persistence, and perceptual understanding, but were not generally shown to be strongly related to achievement. On the other hand, they demonstrated how students’ performance goal orientations were shown to be associated with superficial learning, and self-handicapping strategies. Alternatively, while looking at motivation from a self-determination perspective, Lam, Cheng, and Ma (2009) found intrinsic motivation was contagious, as intrinsically motivated teachers either created intrinsically motivated students or were motivated by them. In a more general light, most research demonstrated that students were willing to engage in tasks when they believed they could be successful and they saw value (Higgins, 2007).

One common practice by teachers and parents alike is to offer students external rewards for successful achievement in mathematics, and according to Brophy (2010) this is perhaps the easiest way to improve student engagement. Unfortunately, offering rewards for an action has not been shown to improve student motivation. Instead, a preponderance of evidence has shown that rewards are a form of control (Deci, Koestner, & Ryan, 1999). Although offering students money for A’s in mathematics may increase the time they spend studying, it does not instill in students a desire to do mathematics. The rewards take away students’ opportunities to engage with the mathematical content on their own terms. To improve intrinsic motivation the value of mathematics needs to be associated with benefits gained from understanding mathematics and not in some other external incentive.

There are also issues with motivational relationships in mathematics associated with Keller’s ARCS model. Fifty percent failure rates are typical for many university college algebra
courses, and with 336 community college students in her study, Nguyen (2014) found students in College Algebra had significant differences between their expected grades and their final grades. Students found themselves unprepared for the level of mathematics required, thought the course moved too fast, and covered too much content. These findings suggest motivation in College Algebra is generally low. Using the Course Interest Survey designed by Keller (2009), Nguyen (2014) identified key motivational relationships used by teachers in the classroom relating to attention, relevance, confidence, and satisfaction. All three factors were significantly correlated to satisfaction, with relevance having the highest correlation to satisfaction. She found most of the students enrolled in College Algebra only took the course because it was a general education requirement, and as such did not see the content as relevant. As Keller (2008) states, students who do not believe the course content will be used in their future have issues with relevance.

The three factors --attention, confidence, and satisfaction-- become abundant when children play. For Piaget (1951) play is an innate learning strategy, and for Elkind (2007) all human cognition revolves around three instinctual motives; love, work, and play. Shute, Rieber, and Van Eck (2011) suggest the play phenomenon can occur when students engage in games, and therefore, students become more engaged when learning is goal oriented, active and interactive, and challenging. Students want to overcome difficult obstacles --sometimes alone and sometimes by collaborating with others-- to win the game. When learning mathematics becomes a byproduct of engagement in a game, students become more engaged.

Working in the northeastern United States, Plass, O'Keefe, Homer, Case, Hayward, Stein, and Perlin (2013) used the game Factor Reactor to study how playing it either alone, competitively, or collaboratively affected middle school student achievement and motivation for mathematics. They found competition improved achievement, and both competition and
collaboration improved student interest, enjoyment, and adoption of mastery-orientations. In another study Hung, Huang, and Hwang (2014) found elementary school mathematics students in China, who used digital game based technology to enhance learning, had higher self-efficacy for mathematics than students who only received a more traditional style of instruction. Playing video games and socializing in digital media is widespread among students making this type of environment relevant to students’ lives, and therefore, it may be reasonable to believe game-based digital learning technologies are motivational for most young mathematics students. Remember this may not be true for all students. Students who are not comfortable and self-efficacious using technology may become avoidance-oriented if forced to engage in a digital competitive environment. The effects of motivational relationships may depend on the student.

What Pedagogical Strategies Are Motivational?

Autonomy is one of the three innate psychological needs necessary for intrinsic motivation. Using a correlational analysis, Reeve and Jang (2006) found eight instructional practices significantly correlated to student perceptions of autonomy. They found time spent listening to students and allowing them to work in their own way, allowing students time to talk, offering informational feedback, offering hints and encouragement, being responsive to student generated questions, and allowing students to discuss their perspectives on controlling practices in the classroom were all significantly correlated with student perceptions concerning autonomy. They also found six instructional practices to be negatively correlated with perceived autonomy. Teachers’ practices categorized as monopolizing class time, making statements about how problems should be solved, providing solutions and answers, and giving directives and asking controlling questions significantly decreased perceived autonomy. Ross and Bergin (2011)
presented a simplified actions to do and actions that should not be done. “Offer encouraging, informational feedback, give meaningful rationale for tasks, acknowledge students’ perspectives, give several choices, and listen and respond to students” (p. 61) are instructional practices supportive of autonomy, and “use controlling language, rigid deadlines and rewards, prevent students from handling materials, prematurely give solutions, require students to work at a rigid pace, and accept only certain views” (p. 61) undermine autonomy. Reeve (2009) reviewed 44 studies comparing autonomy supportive relationships verses controlling relationships with virtually every study demonstrating autonomy supportive relationships providing benefits to students and controlling relationships as being unbeneficial.

Competence is an innate psychological need similar to self-efficacy (Hughes et al., 2011). Using Bandura’s (1997) sources of self-efficacy, Usher and Pajares (2009) confirmed that for middle school mathematics students in the southeastern United States all four sources –mastery experiences, vicarious experiences, social persuasions, and affective states– of self-efficacy were correlated to self-efficacy with the most important source for mathematics self-efficacy being mastery experience. This implies mathematics teachers should optimize students’ opportunities to engage in tasks where they will be successful. Rubenstein, Siegle, Reis, McCoach, and Burton, (2012) found teacher feedback reviewing past student accomplishments and posting goals for current assignments encouraged students to reflect on their accomplishments. This self-evaluation by students encouraged the internalization of mastery experiences. They found teacher feedback can function as a verbal persuasion by shedding light on student growth and by being complementary of student successes on specific challenging skills. They found working in groups and having peers model success gave students vicarious experiences because seeing other students being successful implied that they too could succeed. As self-efficacy in a domain is a
strong predictor of achievement, having pedagogical practices aligned with Bandura’s four sources of self-efficacy may be one of the best ways to improve student engagement.

Anderson (2011) described how performance-structures may be positively related to teacher-centered curricula, whereas learning [mastery] structures may be positively related to student-centered instruction. Learning structures were supported by focusing on process and explanation instead of quick responses and single answer questions, allowing creative expression, encouraging students to develop new strategies, and making the mathematics related to experience. Performance goal structures were supported by encouraging students to pursue mathematics so they can have better career choices, rewarding students for completing advanced mathematics, and acknowledging effort and persistence (Anderson, 2011). In Patrick, Kaplan, and Ryan’s (2011) social model; teachers who exhibited emotional and academic support, mutual respect, and task-related interaction were seen as having mastery-structured interactions with students. Although mastery-structures were not generally related to achievement, mastery classroom structures may encourage mastery-orientations in students, thereby moderating some of the negative motivational outcomes and encouraging deep conceptual understandings (Meece, Anderman, & Anderman, 2006). When teachers structure classroom interactions so that understanding is emphasized, and mistakes are seen as opportunities to learn and master content; they are allowing students to control their own learning. This emotional and academic support may instill mastery-orientations making material more related, and therefore, it encourages students to become more intrinsically motivated. Similar to this achievement goal perspective, Ross and Bergin (2011) incorporate a self-determination perspective and conclude, autonomy can be reinforced by offering a few meaningful options, competence can be encouraged by
giving students the opportunity to succeed, and relatedness can be reinforced by creating supportive spaces for learning.

**What Types of Curricula Are Motivational?**

Little research has been conducted tying published curriculum materials used in school systems to theories on motivation (Stein, Remillard, & Smith, 2007). This may be influenced by the difficulty of connecting motivational pedagogical relationships to curricular content, or it may be influenced by a lack of understanding of the importance of motivation for improving achievement. Bergin, Talley, and Hamer (2003) described how to establish motivational relationships in the classroom. He determined it is important to establish learning communities so students feel they can make mistakes in nonthreatening environments, to improve student confidence by allowing students to succeed at challenging tasks, to improve task relevance by clearly establishing why engagement is valuable, and to approach learning with a project-based curriculum. All but one of these suggestions helped to determine if a curriculum was being enacted in a manner that encouraged student motivation, and aside from the suggestion to implement project-based learning, these suggestions should be prevalent regardless of curricula.

Both project-based learning and inquiry-based learning offer more authentic instruction and in turn may positively influence student motivation (Blumenfeld, Soloway, Marx, Krajcik, Guzdial, & Palincsar, 1991; Edelson, Gordin, & Pea, 1999); however, there is not enough empirical research to determine the nature of this relationship. Lam, Cheng, and Ma (2009) found instructional practices aligned with project-based learning to be motivational for secondary school students in Hong Kong by concluding a teachers’ motivation to incorporate a project-based curriculum was related to the students’ motivation for the project-based
curriculum. They found any type of new curriculum may become a mediating variable between teacher motivation for the curriculum and student motivation for the curriculum. Motivation seems to be contagious. If teachers are motivated to teach using a particular curriculum, then their students will be more motivated to learn using the curriculum.

When used as part of a curriculum, virtual worlds have the ability to engage students by establishing a non-threatening environment where socialization, inquiry, and active discovery can occur (Dempsey, Reese, & Weston, 2011). As students exist in the virtual world as avatars, some who do not typically ask questions in a classroom may be more vocal in a virtual world. Virtual worlds typically have no inherent content; however, it is possible to engage students in any type of curriculum used in the physical world. It is up to the curriculum designer to create content, and because of low threat levels associated with experimentation, virtual worlds may be good environments for inquiry-based or project-based instruction. As such, curricula that include engagement in virtual worlds may be motivational for some students.

What Types of Assessments Are Motivational?

As mastery-orientations may be correlated to intrinsic motivation, there is an interest in creating mastery-structured assessments. Blumenfeld (1992) states performance-structured assessments focus on grades and social comparison, whereas mastery-structured assessments are more interested in improvement. Smeding, Darnon, Souchal, Toczek-Capelle, and Butera (2013) imply mastery-structured assessments promote learning whereas performance-structured assessments promote selection. Although many types of assessments could be modified to assess improvement over comparison, performance assessments and portfolios are often represented in literature as examples of mastery-structured assessments.
Performance assessments are designed to promote deep understanding. They consist of group and individual tasks that are difficult and require deep conceptual understandings that students only acquire through spending a significant amount of time engaged (Stefanou & Parkes, 2003; Blumenfeld, 1992; Ames, 1992). Baker, O’Neil, and Linn (1993) found the common attributes of performance-based assessments are they “use open-ended tasks, focus on higher order or complex skills, employ context sensitive strategies, often use complex problems requiring several types of performance and significant student time, consist of either individual or group performance, and may involve a significant degree of student choice” (p. 1211). Notice, performance assessments are not meant to be performance-structured. They are designed to be formative and to promote learning, to be focused on improvement not comparison, and to allow students autonomy. By aligning performance assessments with cognitive theories of motivation it is thought that student motivation will improve; however, there is currently little empirical evidence to support this claim.

Stefanou and Parkes (2003) used three types of assessments; paper and pencil, performance assessments, and labs in middle school science classes. They found students to favor paper and pencil tests as these were the most familiar, and performance assessments tended to mitigate some of the achievement differentials based on social economic status (SES). Generally students did not mind the extra work associated with the performance assessments but were concerned with how unfamiliar types of assessments would affect their grades. It may be that students only believe they are competent for types of assessments where they or someone they know has been successful, or it may be that many students are so performance-oriented that any type of assessment that is not familiar is seen as a threat to their grades. In the late 1990s, Maryland promoted performance-based classroom practices by including performance
assessments as part of its state accountability measures. Lane, Parke, and Stone (2002) found support from teachers and administrators and some positive affects for underprivileged students; however, the program was cancelled before they could publish their research.

There are two problems associated with performance assessments. They have not been shown to significantly increase motivation, and they are not easily scalable. The lack of evidence showing positive affects towards mastery-orientations may be a result of differences in implementation. Students in Stefanou and Parkes’ (2003) study were concerned about their grades, so perhaps the performance assessments used by Stefanou and Parkes were not mastery-oriented. Baker et al. (1993) focused on grading performance assessments, discussed creating detailed scoring rubrics and looked for evidence of generalizability across raters and topics. If comparing student achievement is the goal, then implementation of scoring rubrics and multiple graders will increase the reliability of a performance assessment; however, this type of environment would not be mastery-oriented.

Portfolios are open-ended and authentic, and usually consist of individual work with associated personal reflections. Studying middle school students, Maxwell and Lassak (2008) incorporated student portfolios that contained separate sections for mathematical attitude, problem solving, mathematical growth, mathematical writing, and mathematical connections. They required students to categorize each deliverable and write a reflection on its mathematical content explaining why it fit into the specific category. Students were also required to have parents sign a letter that explained the portfolios and asked parents to read their child’s rendition. They demonstrated that portfolios improved student insights into mathematics, benefited teachers by providing students with opportunities to reflect on problem solving, and helped parents understand their child’s thinking. Several studies have focused on using portfolios in pre-
service teacher courses (Osman, 2011; Imhof & Picard, 2009; Zeichner & Wray, 2001) and have found benefits relating motivation to portfolios were not generalizable across demographics.

Formative is a more general description of assessments that are used to inform students and teachers of what students know. These types of assessments are used to inform instruction. As Clark (2012) explained, formative feedback can be synchronous or internal, but typically formative feedback is external and takes the form of a grade or teacher’s comments. In some cases external feedback can also take the form of tacit knowledge found during discussions of content knowledge between teachers and students. Synchronous feedback has been shown to be highly engaging (Malone & Lepper, 1987) and to increase learning (Dihoff, Brosvic, Epstein, and Cook, 2004), and some research has shown motivational gains from using written detailed feedback instead of numerical grades (Wiliam, 2007).

Self-efficacy is one of the best predictors of achievement (Bandura, 1997; 2012), and mastery experiences may be the best source for self-efficacious beliefs (Usher & Pajares, 2009; Bandura, 1997). This is also true of the inverse. Experiences that do not end successfully may lead to less self-efficacious beliefs, and correlate to negative affect as anxiety can develop when students are forced to perform in a domain in which they believe they are incompetent (Bandura, 1997). Brophy (2013) provided pointers for minimizing anxiety associated with assessments such as letting students know about tests well in advance, avoiding time pressures, discussing outcomes as feedback and not grades, and giving pretests so that students can experience failure in a non-threatening environment. According to Brophy (2013), teachers should also include material on assessments that is beyond students’ current levels and make students aware they will find some problems too advanced.
More research needs to be conducted showing links between student motivation and scores on assessments. Wise and DeMars (2005) found grades on low-stakes assessments were directly related to motivation. Students with low motivation received low scores and students with high motivation received high scores. This implied that motivation had a moderating effect resulting in an inaccurately low measure of ability for students with low motivation. It is suggested that motivational filtering – not using data from students who self-report low motivation – may increase the accuracy of group statistics. In an examination of high stakes assessments, Jürges, Schneider, Senkbeil, & Carstensen (2012) found government mandated end of course exit exams in a mathematics course in German primary and secondary schools improved curricular knowledge, but did not improve mathematical literacy. They found the downside of course exit exams in mathematics was that students in classes where exit exams were mandated found mathematics more difficult and boring, had more anxiety and despair, and were less motivated to learn.

What Are the Relationships Between Student Motivation and Equity in Mathematics Classrooms?

For educators interested in social justice, achievement in science and mathematics is critical for the economic security of all people who want to participate in a modern economy. Unfortunately, math literacy in poor communities and communities of color is lacking, and Moses (2001) views this deficit as excluding historically marginalized students from most of the better paying jobs of the future. This need for mathematical literacy is only going to grow as society becomes more dependent on technology, and therefore, improving motivation to learn mathematics for all students is more important than ever before.
Social economic status (SES) has been a hot topic for researchers interested in differentials in academic achievement since the middle of the 1900’s (White, 1982; Sirin, 2005), and although findings in the research are mixed, White’s and Sirin’s meta-analyses revealed medium effects (.343 for White and .299 for Sirin) of SES on academic achievement, and encouragingly found this differential to be diminishing over time. Some of this can be attributed to reform curricula (Schoenfeld, 2002), but there is still work to do. Smeding, Darnon, Souchal, Toczek-Capelle, and Butera (2013) demonstrated that changing the purpose of assessments in college psychology courses in France from a selection process to becoming an integral part of learning can reduce the SES achievement gap. In this study, they found high SES students generally performed better than low SES students; however, the achievement structure of assessments moderated this effect. Lower SES students performed comparatively better on mastery-structured assessments, higher SES students performed better on performance-structured assessments, and this performance differential was enough to change the passing rate for the low SES students.

Many studies have demonstrated differences in motivation for mathematics based on gender (Butler, 2014; Preckel, Goetz, Pekrun, & Kleine, 2008; Meece, Glienke, & Burg, 2006). Although these differences have become less pronounced over time, they remain persistent. During her review, Butler (2014) states there were no gender differences associated with values students placed on reading or mathematics achievement in early grades, but girls eventually came to place more value on reading than boys. Girls also had lower perceived competence in mathematics than boys; however, their mathematics achievement was higher. This discrepancy may be why boys demonstrated more avoidance-orientations than girls. Social and biological differences also played a part in gender differentials associated with mathematics achievement.
Boys tended to equate being good at mathematics with being smart. This led them to want to pursue careers that proved self-worth and were associated in society with control and power; whereas girls tended to be more altruistic placing more value on literature, arts, and educational careers. This may have led to boys being more motivated to pursue careers requiring mathematics even though girls tended to perform better at mathematics in school (Butler, 2014).

Souchal, Toczek, Darnon, Smeding, Butera, and Martinot (2014) performed a study focusing on the historical performance differential in high school science classes associated with gender. In this controlled experiment, they randomly assigned students to three groups. One group was told they would be tested on the lesson to compare student achievement and determine grades, a second group was told they would be tested on the lesson with the aim of helping them learn the material, and a third group was told they would be asked questions about the lesson but the tests would not be evaluated. Boys performed better in the first situation, boys and girls performed equally in the second situation, and girls performed better in the third situation. Souchal et al. (2014) theorized that mastery-structured assessments may help to remediate achievement differences between historically marginalized groups.

The relationships associated with SES and gender, and between mastery-structures and motivation of historically marginalized students also exists across ethnicity. Gutman (2006) demonstrated mastery-orientations of African American students and their parents may be positively related to student self-efficacy and achievement. Studying 50 low SES African American families with students in high school mathematics, Gutman (2006) found students who self-reported mastery-orientations had inclinations towards higher self-efficacy for mathematics and better grades in mathematics. She found students transitioning to high school mathematics who perceived their mathematics classroom as mastery-structured had higher self-efficacy for
mathematics, and African American adolescents whose parents espoused mastery-orientations had higher grades than similar students of parents who espoused performance-orientations. This indicated mastery-structures in the home and at school may increase student achievement and motivation for African American high school students.

Stevens, Olivárez, Lan, and Tallent-Runnels (2004) found Hispanic students had lower achievement in mathematics than did Caucasian students. Hispanic students also had lower confidence and self-efficacy for mathematics and placed higher value on mathematics than Caucasian students. Hispanic students did not place as much value on evaluating their academic ability as did their Caucasian counterparts; however, because they had fewer mastery experiences than Caucasian students, their self-efficacy was not insulated from poor performance. Stevens et al. (2004) suggested that Caucasian students had more sources of social persuasion than did Hispanic students. Perhaps Caucasian students received more encouragement from outside of school telling them they could be successful in careers that involve mathematics, and this encouragement shielded them from repercussions to self-efficacy caused by poor performance. Stevens, Olivárez, and Hamman (2006) found Hispanic students had greater intrinsic motivation for mathematics than did White students implying Hispanic students had the most to lose from performance-structures. Although performance-structures may increase achievement in older high-ability students, these same structures may decrease intrinsic motivation and deep conceptual understandings in lower-ability younger students. Stevens, Hamman, and Olivárez (2007) also found benefits for historically marginalized students associated with mastery-structures. Here, sixth grade teachers who employed mastery-structures in the classroom improved Hispanic students’ sense of belonging and promoted mastery-
orientations in these same students. Mastery-orientations may be contagious as teachers who promote a mastery-structured environments produce students who are mastery oriented.

**What Professional Development Is Needed to Train Educators in Motivational Structures Known to Improve Student Engagement?**

Gilbert and Musu-Gillette (2007) introduced a rubric with the acronym TARGETTS as a tool to help teachers promote adaptive motivation in mathematics classrooms. There were three important questions for adaptive motivation: can I do this, do I want to, and why do I do it, and students with adaptive motivation had high self-confidence, they valued mathematics, and they were mastery-oriented. Adaptively motivated students have also been shown to perform better at math both in class and on performance assessments, and they have been shown to be more persistent (Wigfield & Eccles, 2000). TARGETTS gives educators a framework for improving motivation in the classroom. The acronym stands for: tasks, autonomy, recognition, grouping, evaluations, time, teachers, and social interactions. Tasks should be chosen so that they enhance self-confidence and mastery-orientations, students should be given the autonomy to approach solutions in their own way, all students should be recognized for their unique contributions, students should be grouped together so that they are able to collaborate constructively, evaluations of student work should emphasize mastery, students need to be given time to work through alternate solutions and incorrect methods, teachers should highlight student effort and strategies, and teachers should focus on social interactions and sharing (Gilbert & Musu-Gillette, 2007). By developing a rubric with an easily remembered acronym, it may be easier to explain how best to incorporate strategies in the classroom that are aligned with theories of motivation.
To remediate problems with student motivation and achievement in science and mathematics in German secondary schools, a professional development program labeled SINUS was developed. Similar to issues in the United States, students in Germany held little regard for mathematics and science, and they attributed success and failure to ability. Likewise, teachers saw themselves as alone in the classroom, they rarely shared their knowledge of teaching with other educators, they had little incentive to engage in professional development, and the professional development they did receive was narrowly focused on specific tasks and not on their true needs (Ostermeier, Prenzel, & Duit, 2010). By not focusing on specific pre-formed teaching units but only supplying general recommendations for overcoming identified shortcomings, by having teachers modify existing approaches and encouraging self-reflection, by highlighting collaboration as a key feature of effective professional development, and by supplying scientific empirically tested methods and examples; teachers were given valuable support for the implementation of reform based curricula (Ostermeier, Prenzel, & Duit, 2010).

SINUS is a modular based program housed in situated learning, with each module rooted in current research on science and mathematics education (Ostermeier, Prenzel, & Duit, 2010). Although there are eleven modules, each participating teacher and school usually chose two or three modules to focus on at any one time. Each module came with written materials, in-service training, and expert consultation to help teachers develop their own lesson plans. These modules also contained a good deal of reform oriented material and best practice examples supplied by university educational departments and teacher training institutes. In this way, teachers were able to immediately implement research based pedagogy in their own classrooms with the support of science and mathematics educators involved in current research.
Ostermeier, Prenzel, and Duit (2010) reported many benefits for students and teachers at schools that took part in the SINUS program. Teachers who took part in this program reported more cooperation between colleagues, and students reported that teachers who took part in this program were more cognitively engaging. Because the modules involved situated learning with specific methodologies for improving instruction, the probability a new approach might fail was reduced, and therefore, it was more likely that new methods might be assimilated into a teacher’s routine. Students in schools that took part in the SINUS program showed improved achievement and engagement when compared to students at schools that did not take part in the study, and this differential in achievement and engagement was also more pronounced for lower tracked students (Ostermeier, Prenzel, & Duit, 2010). As professional development rooted in promoting motivation produces benefits across the spectrum, the current study focuses on several theoretical frameworks to help guide the development of an instrument aimed at measuring motivation.

**Theoretical Framework**

There are many constructs concerning motivation, and many theories of how relationships between agents and structures can be motivational. To develop a survey measuring motivation for mathematics by including items representing several predominant theories and to uncover relationships between theories, this study combines several traditional theoretical frameworks into one instrument aimed at measuring motivation for mathematics. This approach is a pragmatic response to a narrower single framework viewpoint. The three traditional theories for motivation to be incorporated are self-efficacy (Bandura, 1997), self-determination theory (Ryan & Deci, 2000), and achievement goal orientations (Nichols, 1984; Dweck, 1986; Elliot &
Harackiewicz, 1996; Elliot & Church, 1997), and these are considered to be narrowly defined as they individually focus on self-beliefs, personal agency, or educational goals. The two motivational frameworks incorporated are achievement goal structures (Elliot & Harackiewicz, 1996; Elliot & Church, 1997) and expectancy-value (Wigfield & Cambria, 2010). These are also considered to have a narrow scope as they individually focus on socially imposed relationships and behavioral outcomes. These five theoretical foundations are the basis for the instrument developed. By combining several of the predominant theories into one instrument in this validity argument, it may be possible to look across these disparate theories and find new insights into relationships between theories.

Bandura’s self-efficacy (1986) is included as the most predictive indicator of achievement of all the included theories on motivation. Self-efficacy deals with a person’s belief that he or she will be successful when they engage in a specific domain, and for Bandura the sources of self-efficacy are mastery experiences, vicarious experiences, social persuasions, and affective states. Of these sources, mastery experiences have been shown to have the greatest impact on a student’s self-efficacy. In this context, self-efficacy is associated with students’ beliefs that they can be successful when engaged with mathematics. One construct that has had some popularity recently is perceived-competence. Although on its face this seems to be very similar to self-efficacy, this relationship is not explored.

Ryan and Deci (2000) developed self-determination as a continuum of motivation from intrinsic motivation, where engagement is completely autonomous and self-regulated, through several types of extrinsic motivation, where autonomy and self-regulation become compromised, to amotivation, where engagement is forced and regulation is by others. According to self-determination, motivation can become more intrinsic by encouraging autonomy, making the
content related, or enhancing the perception of competence. Notice self-determination is a broad construct applicable to all human endeavors.

Achievement goal theory is for the most part focused on academic outcomes. Elliot and Church (1997) refined this achievement goal theory into a trichotomous model with learners approaching a subject through personal mastery and performance orientations, and avoiding a subject through performance-avoidance orientations. A mastery-approach orientation is characterized by a learner's desire to understand the content and showing less concern for grades or comparisons to others. A performance-approach orientation is characterized by a learner's desire to do well on assessments and to be compared favorably with others. A performance-avoidance orientation is characterized by learners avoiding situations where they feel incompetent because of a desire not to be compared unfavorably with others. Another facet of achievement goal theory deals with motivational relationships.

Achievement structures are social and physical characteristics in an academic setting that are perceived by learners to promote mastery orientations or performance orientations. Mastery-approach structures are people, situations, or objects that promote understanding as the primary impetus. Deep conceptual knowledge is valued over comparisons to others. Performance-approach structures are people, situations, or objects that promote performing well on assessments as the primary impetus. Favorable comparisons with peers drive engagement. Performance-avoidance structures are people, situations, or objects that discourage engagement because of a desire not to be unfavorably compared with peers. These structures cause learners to avoid situations where they do not feel competent.

Expectancy value is one of the oldest of the motivational theories and is rooted in behaviorism. As developed by Atkinson (1957), agents are more inclined to complete a task if
they expect a positive outcome. This ties the expectation of success directly to the value placed on the given task. Eccles (1987) expressed four factors involved with judging the value of a task --attainment value, interest, utility, and cost. Here, attainment value concerns how being successfully engaging in the task will fit into one’s personal values and goals, interest is associated with how enjoyable one finds the task, utility concerns how successful acquisition will benefit one’s future success, and cost deals with the consequences of participating in the task. Of all the motivational theories explored, expectancy value has the strongest link between expectations of successfully engaging in a task, and the values placed on successful engagement in that task.

**Usher and Pajares (2009): A Validation Study for Motivation Related Instrument**

Usher and Pajares’ (2009) approach to the development and validation of the Sources of Self-efficacy Scales (SSES) is an example of a rigorous development and validation study. Their study contained three phases. During the first phase they used a focus group consisting of students, parents, teachers, and administrators and tasked these focus groups with taking the preliminary survey and commenting on unclear or unfamiliar wording. Then they revised and administered the 84 survey items to 1,111 six, seventh and eighth grade students. To provide evidence of construct validity, they also administered four other instruments (mathematics grade self-efficacy, mathematics courses self-efficacy, mathematics skills self-efficacy, and self-efficacy for self-regulated learning (Bandura, 2006; Hacket & Betz, 1989; National Council for Teachers of Mathematics, 2000; Bandura, 2006; Usher & Pajares, 2008)) measuring mathematics self-efficacy. Based on recommendations from Singer and Willett (2003), they examined descriptive statistics and bivariate correlations between each subscale total and the four previously published
measures of self-efficacy. Then they used Cronbach’s alpha to examine internal consistency for each subscale; and based on poor item to total correlations, item to outcome correlations, high skewness or high kurtosis, they deleted or revised items with two or more unfavorable conditions.

During the second phase of development, they administered the survey to 824 students from grades six through eight. The revised survey included 86 items, and they performed an internal consistency analysis by finding Cronbach’s alpha for each of the four subscales. Using similar criteria as phase one, and cutoffs for skewness and kurtosis recommended by Kline (2005), they removed inadequately performing items. Then using Promax rotation, they conducted an exploratory factor analysis, and after examining seven, six, and five factor structures, they kept a four factor structure and removed items that loaded on more than one factor. They then reported between-factor correlations.

During the third phase of development, they submitted items to experts on social cognitive theory to gain evidence of content validity. They reworded items and added additional items based on this feedback. To examine convergent and discriminant validity, they administered items from several instruments that measured constructs known to be related to self-efficacy. They used four items from Miller, Greene, Montalvo, Ravindran, and Nochols (1996) instrument, six items from Marsh’s (1996) mathematics self-concept, 10 items from Usher and Pajares’ (2006) inviting/disinviting index, and scales associated with achievement goal orientations and self-handicapping strategies from the PALS (Midgley et al., 2000) to measure engagement and other theoretical constructs associated with motivation. They utilized 10 items concerning optimism from a survey by Scheier and Carver (1985), and collected teacher ratings to represent academic achievement. Then they flagged items based on Kline’s (2005)
recommendations, as well as any items with a correlation below |.30|. When they found items to be similarly worded the best performing item was retained. They conducted a confirmatory factor analysis and reported appropriate fit indices. They also examined measurement invariance based on gender, ethnicity, and ability level. Finally, they conducted a multiple regression analysis examining the independent contributions each of the four sources of self-efficacy had in predicting other self-efficacy measures.

This study may be used as a model of how a rigorous development and validation process may be accomplished for an instrument meant to measure a construct related to motivation.

Summary

This chapter reviewed several of the most predominant theories on motivation. I began by reviewing theories on motivation such as self-efficacy, self-determination, and achievement orientations. I then review theories on motivational frameworks such as achievement structures and expectancy-value. Although achievement orientations and structures are generally part of the same tradition, these were separated because orientations are a cognitive construct with the locus of causality internal and structures are associated with an external locus of causality.

Next, important questions for educators are discussed. As there may be a consensus across frameworks that a construct similar to self-efficacy is the most influential factor in predicting student success in academic settings in general and in mathematics achievement in particular, it may be reasonable to believe that educators may promote curricula and pedagogical styles that encourage students to believe they can be successful in mathematics. Educators are generally adept at creating an atmosphere that is fun in elementary grades, but as the material gets more rigorous in middle school and later, many educators may prefer to get down to
business. They believe that to learn abstract mathematics, students must roll up their sleeves and get to work. Teachers may see this type of serious hard work as required because students must pass high stakes tests to move to the next grade level, and teachers must focus students on passing these test as if their jobs depend on it, because in many cases, they do.

The research is clear. The best way to improve student confidence is through mastery experiences. Kids, who have experienced success, believe they can be successful. Therefore, educators and administrators need to reflect on why society has decided to use testing for purposes other than helping students succeed. There is a need for summative and formative assessments to provide information about student achievement and to guide future learning, and many politicians and professional pundits state they are reforming education with the children’s best interest at heart. However, there is an abundance of empirical evidence demonstrating that putting children through experiences where they will not be successful is detrimental to their motivation. Everything done in an educational setting should have the goal of improving student engagement and achievement. With this in mind, all pedagogy, curricula, and assessments should promote these goals. In a society focused on competition, the question for educators should be how to incorporate mastery-structures, and promote the intrinsic valuing of mathematics in the classroom.

Autonomy and choice are crucial for student motivation, and even as the benefits of student autonomy are well supported empirically, parents often see teachers who let students have agency over their own learning as not being in control of the classroom (Reeve, 2009). Letting students have freedom to solve problems in their own way can be daunting for teachers, as this requires a higher level of content knowledge for the teacher to be able to recognize correct solution strategies. Encouraging deeper mathematical understandings of teachers, pedagogical
practices that give students control of their learning, and methodologies based in research on the science of motivation may be the best pathway for promoting student achievement. After all, professional development for in-service teachers that promotes change based in a strong relationship between classroom instruction, university researchers, and empirically supported methodologies may be the best way to answer the question, “What can society do to improve student motivation for and engagement with mathematics, and thereby, improve mathematics learning?” However, it is critical that this professional development has credible research as its foundation, and this research is both internally and externally valid. Therefore, just as a carpenter needs an accurate ruler, educational researchers need a tool to accurately measure motivation.

This review concluded with a discussion of the theoretical frameworks employed in the development of the instrument that is the focus of this study, and then detailed the development and validation of the Sources of Self-Efficacy Scale by Usher and Pajares (2009). This study by Usher and Pajares is important as it is a rigorous example of a development and validation process similar to what is completed here.
CHAPTER THREE

METHOD

This study aims at developing and initially validating an abbreviated instrument based on some of the predominant theories on motivation that may be able to measure motivation for mathematics of university level developmental algebra students. In this chapter, the development and validation process is outlined. The preliminary sections describe the five sources of validity evidence and how the three phase process described here addresses these various sources. I begin by describing the expert review of items that led to the selection of the most representative items from a large pool of items for the included theories, then cognitive interviews of students and instructors provide insight into the cognitive processes involved in responding to the items that survived the earlier expert review, and finally, I describe the quantitative analyses used to build a structural equation model that regressed achievement upon the latent motivation variables represented by the items that survived from phase two. In this way, a rigorous three phase development and validation argument is revealed.

Sources of Validity Evidence

My goal was to create a survey that brought predominant theories together in a way that made it possible to measure motivation across constructs in a short amount of time with some confidence in the measure’s validity. To develop a validity argument, this study relies on the Standards for Educational and Psychological Testing (American Educational Research
Association, 2014) as the primary resource for issues concerning validity, and Usher and Pajares’ (2009) validity study provides an example of a rigorous validation argument. Both qualitative and quantitative analyses were used, and at several instances qualitative data were quantified to aid in organization and comparisons and to provide evidence of the alignment between an item and theory. Much of the qualitative analyses relied on grounded theory as described by Straus and Corbin (1990), and much of the qualitative data was quantified as described by Onwuegbuzie (2003).

The Standards for Educational and Psychological Testing (American Educational Research Association, 2014) states validity is a unitary concept and an ongoing process, and the separate sources of validity should not be considered separate types of validity. Instead, each source adds to the overall argument, and evidence that accumulates over time should be judged by the users of an instrument as to whether the instrument is being used appropriately. Five sources of validity evidence are addressed in this study.

This study addressed content validity—the relationships between participants’ understandings of the meanings of items and the theoretical constructs these same items are intended to measure—in several ways. The items included in the developed instrument originated from previously published instruments intended to measure similar theoretical constructs, and the items went through a review process by experts in the field. Hence, the items should have initially had some level of content validity, and an expert review bolstered their content validity. Cognitive interviews to examine respondents’ interpretations of items also added evidence for content validity. These cognitive interviews followed a framework developed by Tourangeau (1984), and the analysis of the qualitative data from the expert review and the cognitive interviews follow a grounded theory approach (Straus & Corbin, 1990) aided by intra-respondent
matrices (Onwuegbuzie, 2003). Quantitative correlational analysis between the theoretical factors contained in the instrument being developed and previously published subscales also demonstrated content validity. By relying on several sources of qualitative and quantitative data, a stronger validity argument may have been accomplished.

Although evidence of validity based on response processes was not provided, an effort to improve validity based on response processes guided decisions on several of the techniques used during administration. Padilla and Benítez (2014) discuss three types of validity based on response processes.

1) The performance of the “test takers” or “examinees” in the test or questionnaire items reflects the psychological processes and/or cognitive operations delineated in the test specifications.

2) The processes of judges or observers when evaluating the performance or products of the different test takers are consistent with the intended interpretation of the scores.

3) Groups of test takers defined by demographics, linguistic or other conditions associated with the intended use of the test, did not differ in the nature of their performance or in the responses because of sources of “construct-irrelevant variance” (Padilla & Benítez, 2014, p. 138).

Part of the impetus of this study was to reduce construct irrelevant variance, and by doing so, to increase validity based on response processes. Berry, Wetter, Baer, Larsen, Clark, and Monroe (1992) demonstrated that items towards the end of long surveys tend to be less reliable. Thus by making the MMAI administrable in less than 15 minutes, it may have been possible to reduce some of the construct irrelevant variance associated with longer surveys. By developing an
abbreviated instrument validity based on response processes was indirectly addressed. Also, the phase-three instrument was administered in a face-to-face environment on paper and pencil, and all responses were anonymous so that neither the instructor nor I had knowledge of who participated. These methods may have encouraged honest responses, produced a better representation of all the students in the classroom, and therefore, may have reduced construct irrelevant variance.

An exploratory factor analysis, a reliability analysis, and a confirmatory factor analysis provided evidence of validity based on the internal structure of the survey. For the exploratory analysis I assumed separate factors to be correlated, and therefore used an oblique rotation to determine factor structure. Pattern and structure matrices were reported. Cronbach’s alpha provided a measurement of the internal consistency of the instrument, and this was reported for each factor. Finally, a measurement model was developed based on the findings from the exploratory factor analysis and on theoretical grounds. All relevant fit indices were reported. I examined modification indices to determine if some of the items may have meanings that were too similar and reported any correlated errors with chi-square greater than 10. I related the theories on motivation to the final factor structure of the survey and used these factors in all other analyses. The strength of the relationships revealed by these analyses provided evidence of validity based on the internal structure of the instrument.

Correlations between the latent factors associated with this survey and subscales from previously published surveys, and a structural equation model with achievement on the latent factors associated with this survey provided evidence of validity based on relationships between variables. Gender was explored as a moderating variable on this relationship. Two types of evidence were collected for this purpose. First, I administered subscales from previously
published surveys at the same time as the phase-three instrument. For this, subscales from the PALS relating to the achievement goal orientations of mastery and performance, and a subscale from the Intrinsic Motivation Inventory (IMI) (http://www.selfdeterminationtheory.org) relating to intrinsic motivation were used. These scales were randomly assigned to participants so that an approximately equal percentage of participants took one of these subscales while they completed the phase-three instrument. Bivariate correlations of these previously published subscales with the factors in the phase-three instrument intended to measure the same construct were reported. Self-reported achievement and gender data were collected as the last two items on the phase-three instrument, and these became dependent and moderating variables in the structural equation model.

I addressed validity based on consequences by ensuring students understood that their responses were anonymous, participation would in no way affect their grade, and the instructor would not know who participated. Some research has shown that validity based on consequences is an issue for low stakes assessments (Wise & DeMars, 2005), and as this survey was not a graded assessment, there may have been some issues associated with consequences because of the low stakes nature of the administered instrument.

Three Phase Systematic Approach

The current study was conducted in three phases. The first phase began with the selection of items from existing instruments that were currently being used in educational research to measure self-efficacy, self-determination theory, achievement goal theory, or expectancy-value. The first phase of development of the Motivation for Mathematics Abbreviated Instrument (MMAI) relied on qualitative analysis of expert commentary and on quantitative data associated
with expert selection of items. The qualitative data consisted of comments made by theoretical experts on motivation. These comments were solicited through email’s petitioning participation, or through text boxes located below each section of a survey asking experts to select the best items from a list. As this was voluntary response sampling, opportunities for selective sampling were few, and this lack of interaction with the data limited a true grounded theory approach. A fellow researcher and I analyzed these qualitative data utilizing an intra-respondent matrix (Onwuegbuzie, 2003) and constant-comparison methodology (Straus & Corbin, 1990).

Quantitative data were collected through expert selection of items, and the most popular items became the phase two instrument.

Phase two consisted of cognitive interviews with four developmental algebra students and two developmental algebra instructors. The first two student participants were selected based on gender and their answer to the question “Do you like math?” The desire was to represent both genders and different levels of liking math. The third student participant was selected because he answered indifferently to liking math. The fourth student participant was selected because she liked mathematics and balanced the genders. Two instructor participants were selected based on a desire for diversity in experience both culturally and academically. A fellow researcher and I utilized a constant comparison grounded theory approach (Straus & Corbin, 1990) and intra-respondent matrices (Onwuegbuzie, 2003) to analyze the data from these interviews.

Phase three consisted of administration of an instrument consisting of items that survived the phase two analysis along with subscales from other previously published surveys intended to measure mastery orientations, performance orientations, and intrinsic motivation. Self-reported achievement and gender items were also included in the phase-three instrument. I conducted an exploratory factor analyses and a confirmatory factor analysis, and constructed a structural
equation model consisting of the dependent variable achievement regressed on the latent factors representing motivation. Gender was included as a moderating variable on the relationships between achievement and these same latent factors. Finally, correlations between the latent factors measuring motivation and the previously published subscales were reported. See Table 1 for a summary of each phase of this study including participants, the source of data, and the unit of measure.

Table 1. Summary of Research by Phase.

<table>
<thead>
<tr>
<th>phase</th>
<th>instrument</th>
<th>no. items</th>
<th>data</th>
<th>participants</th>
<th>unit of measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>email responses</td>
<td>122</td>
<td>expert commentary</td>
<td>8 Experts</td>
<td>phrases (N=8)</td>
</tr>
<tr>
<td></td>
<td>three on-line surveys</td>
<td>122</td>
<td>expert commentary and selection of items</td>
<td>123 Experts*</td>
<td>concept phrases (N=489)</td>
</tr>
<tr>
<td>2</td>
<td>cognitive interviews</td>
<td>53</td>
<td>interview transcripts</td>
<td>4 students 2 instructors</td>
<td>concept phrases (N=2764)</td>
</tr>
<tr>
<td>3</td>
<td>preliminary instrument administration</td>
<td>34</td>
<td>student responses</td>
<td>186 students</td>
<td>student responses (N=186)</td>
</tr>
</tbody>
</table>

The focus of each phase was the validation of the items reviewed for that phase; therefore, the number of items (no. items) in each phase of the study shows the progression associated with the selection and removal of items.

*Actual number of participants may be lower as some may have answered more than one survey.

Phase 1 in Detail

For phase one, a large pool of items ensured adequate representation of the included constructs. All data collected from participants was to aid in the validation of the items, and therefore the data were not about the participants. The goal was to end up with an instrument that could measure self-efficacy, self-determination, achievement goals, and expectancy-value, that
also had the ability to discriminate between these constructs. To represent self-efficacy, all items from Usher and Pajares’ (2009) *Sources of Self-Efficacy Scales* were included. To represent self-determination, all items from Pintrich et al.’s (1991) *Motivated Strategies for Learning Questionnaire* representing intrinsic and extrinsic motivation, all items from Pelletier, et al.’s (1995) *Sport Motivation Survey* representing intrinsic and extrinsic motivation, and all items representing intrinsic motivation from the *Intrinsic Motivation Inventory* reviewed by McAuley, Duncan, and Tammen (1987) were included. To represent achievement goal theory, all items from Midgley, et al.’s (2000) *Patterns of Adaptive Learning Scale* representing mastery orientations, performance orientations, mastery structures, and performance structures were included. To represent expectancy, all items from Pintrich et al.’s (1992) *Motivated Strategies for Learning Questionnaire* representing expectancy were included, and to represent task-value all items from Miller, et als. (1999) *Perceived Instrumentality Scale* and all items from Pintrich et al.’s (1992) *Motivated Strategies for Learning Questionnaire* representing task-value were included. This resulted in 122 items with 11 representing mastery orientations, 10 representing performance orientations, 12 representing mastery structures, 8 representing performance structures, 19 representing intrinsic motivation, 15 representing extrinsic motivation, 24 representing self-efficacy, 12 representing expectancy, and 11 representing task-value. From these items I constructed three on-line surveys, one representing intrinsic motivation and mastery goals, one representing extrinsic motivation and performance goals, and one representing self-efficacy and expectancy-value. See Appendix A for these surveys.

The *Sources of Self efficacy Scale* (Usher & Pajares, 2009) was originally validated for sixth through eighth grade students. The *Motivated Strategies for Learning Questionnaire* (Pintrich et al.’s 1992) was originally developed for undergraduate students at University of
Michigan. The Sport Motivation Survey (Pelletier, et al., 1995) was originally developed for university athletes. The Intrinsic Motivation Inventory reviewed by McAuley, Duncan, and Tammen, (1987) was originally developed for all levels of amateur athletes from high school through university and beyond. The Patterns of Adaptive Learning Scale (Midgley, et al., 2000) was validated for students from elementary through high school. The Perceived Instrumentality Scale (Miller, et al., 1999) was originally validated with university students. Therefore, the items used in this study originated from instruments designed for students from a wide range of ages with most being university students; however, in some cases items have been taken from surveys used in elementary, middle, and high schools. The current study focuses on students at university, with most of these students in their freshman year, and all of these students taking a developmental algebra course. See Appendix B for a list of the items used, the source of the items, and the participants in the original development and validation process for these surveys.

**Participants and Data Collection for Phase 1**

I administered the three online surveys using SurveyMonkey.com. One survey included items representing intrinsic motivation and mastery goals, one survey included items representing extrinsic motivation and performance goals, and one survey included items representing self-efficacy and expectancy-value. These surveys directed experts in motivation to select the items that would best represent the intended construct but may also discriminate between constructs. Through a series of three emails, I petitioned all 511 members of the Motivation in Education Special Interest Group (SIG) of the American Education Research Association (AERA) using email addresses published on the AERA SIG website. Fifty-seven experts responded to the intrinsic motivation and mastery goals survey, 25 experts responded to
the extrinsic motivation and performance orientations survey, and 41 experts responded to the self-efficacy and expectancy-value survey. The first email petitioning experts to take one of these surveys introduced the research and explained the nature of the study, the second email was a reminder for participants who may have overlooked the first email, and the third email thanked the people who had already participated and set a date for the close of the surveys. The expert participants were informed that an abbreviated instrument designed to measure motivation for mathematics of general education southeastern United States college students was being developed, and this instrument would be intended to measure several of the predominant theories on motivation including achievement goal theory, self-determination, self-efficacy, and expectancy-value. The experts were informed that their participation was anonymous and voluntary, and an informed consent statement was attached to the emails. I asked all participants to reply to the emails with any comments they may have about the overall nature of the study. Eight experts left comments to the email petitions.

The expert participants were asked to respond to any of the surveys in which they were qualified to answer based on their individual research agendas, and for each factor represented, expert commentary was encouraged. The intrinsic motivation and mastery goals survey directed respondents to select the five best items for each of the three included factors that represented intrinsic motivation, mastery orientations, and mastery structures. The extrinsic motivation and performance goals survey directed respondents to select the five best items for each of the three included factors that represented extrinsic motivation, performance orientations, and performance structures. The self-efficacy and expectancy-value survey directed respondents to select two items from each of the four sources of self-efficacy, and to select the five best items to represent expectancy and the five best items to represent task-value. The results of these surveys
were collected through the online software for review, and experts contributed 489 phrases as comments to the survey items. All responses were compiled and a fellow researcher and I used an intra-respondent matrix to organize and code the concept phrase commentary. With the goal of having adequate representation of each construct, the most popular items as selected by the experts were used to construct a preliminary instrument for the next phase of the study.

**Data Analysis for Phase 1**

There were two types of commentary. First, expert comments were collected as replies to the emails. These comments were to address the overall nature of the study, and although participation in the surveys was anonymous, several respondents identified themselves. Experts entered the second type of comments into textboxes on the surveys located at the end of each section representing a unique factor on motivation. These comment boxes were not labeled as only pertaining to the previous construct, but this may have been implied by location. As there were only a few email replies and there were many survey comments, these two types of commentary were handled differently. Emergent themes were developed and reported in the form of codes for both, and although I did not need it for the email comments, an intra-respondent matrix was used to aid in the organization and coding of the survey comments. A fellow researcher and I coded all of the data. First the data was separated into concept phrases. Each comment was discussed, and when a comment was made up of individual phrases that could stand alone as separate ideas, then the commentary was separated. Through discussion, we came to consensus on the separation of all data into individual concept phrases, and the selection of codes that were represented by each concept phrase. The other researcher and I each have at least fifteen years of experience teaching developmental algebra at the university level, and both
have extensive knowledge of research methodology at the graduate level. The other researcher has a PhD in Leadership in Higher Education and works as a mathematics instructor at a state college, and I am currently working towards my PhD in Mathematics Education with this study as my final dissertation.

In analyzing the survey comments, we separated the data into concepts, and we entered these concepts as the rows of an intra-respondent matrix. Then theories on motivation and emergent themes from the data were included as the columns of the matrix. When a concept phrase was considered an example of a code we coded it with a one, and when it was not an example of the code we coded it with a zero. During this coding process, as themes emerged from the data, we added them as columns in the matrix, and we removed columns representing codes when they were no longer useful. Once all the coding was completed, we computed effect sizes for each column by dividing the total from each column by the number of concept rows. Examples of the email comments and the survey comments, and an analysis of the intra-respondent matrix and effect sizes per code were used to better understand how well the items represented their intended theoretical constructs. As the expert commentary was a voluntary response sample, it may have been biased towards negative responses, and therefore, the effect sizes may have indicated problematic theoretical concerns.

Finally, the quantitative data obtained from the expert selection of best items was the justification for the items to be selected for phase two. By using the best items as chosen by experts and through analyzing the expert commentary, the data from phase one provided evidence to help answer the first research question, “To what extent do the items in the Motivation for Mathematics Abbreviated Instrument represent their intended constructs?”
Phase 2 in Detail

As with phase one, the focus of phase two was about the initial validation and selection of the best items and not about the participants that provided this validation and selection evidence. The phase two instrument consisted of six intrinsic motivation items, seven mastery orientation items, seven mastery structure items, five extrinsic motivation items, six performance orientation items, seven performance structure items, six self-efficacy items, six task-value items, and five expectancy items for a total of 53 items. Audio recorded cognitive interviews with four students and two instructors provided data for transcriptions. Two researchers coded these transcripts, and these data provided evidence for or against the inclusion of items for the next phase of this study.

Participants and Data Collection for Phase 2

For the second phase of this study, I selected participants from a public university in the southeastern United States for cognitive interviews. First, all students in one Intermediate Algebra section filled out a notecard with their names, student email address, and an answer on a scale of one to 10 to a question about how much they liked mathematics. I initially selected one female student who self-reported a dislike of mathematics and one male student who liked mathematics. This resulted in a female student who was originally from Columbia but had lived in the southeastern United States most of her life, and a male student who had spent most of his life in Miami, FL. Then after some analysis of the data from these interviews, I selected a third student who was indifferent to mathematics. This male student was from a military family, and went to high school in a large mid-western city. Later, I determined that it would be beneficial to
have a female who liked mathematics, so I selected a female student from New York, NY. This resulted in two male and two female student participants.

I also interviewed two instructors who had several years’ experience teaching developmental and undergraduate mathematics courses. One instructor was a White female from the northeastern United States who was teaching as an adjunct professor for the mathematics department, and one was a Black female from a Caribbean island who was a lecturer and a graduate student in engineering. Generally, the adjunct professor was mastery oriented and the graduate student was performance oriented.

I interviewed each participant individually in-person and audio recorded the interviews to be transcribed later. Before each interview, each participant was informed about the voluntary nature of their participation, the purpose of the study, and the possible one hour duration of the interview. I also gave them a copy of the phase two items and the cognitive questionnaire. After the interview, all participants were asked if they would be available for follow-up questions. At the time of the interviews participants were informed their participation was voluntary, and they could choose not to participate at any time.

Student cognitive interviews were based on recommendations made by Tourangeau (1984) about cognitive processes used when answering survey items. During the interviews, I reworded or modified questions when necessary to elicit responses, and follow-up questions were asked to aid in clarity. Audio recordings of these interviews were later transcribed. I also conducted cognitive interviews with the two instructors. These interviews were based on the framework by Tourangeau (1984) in a process that was similar to the student interview process. After the audio recordings of all the interviews were transcribed, a fellow researcher and I analyzed the data in a process similar to Straus and Corbin’s (1990) constant-comparison
grounded theory approach, and we employed intra-respondent matrices to organize the data and find effect sizes per item for each code (Onwuegbuzie, 2003). The final intra-respondent matrix contained 2764 concept phrases.

The student interviews began with selectively sampling one student who stated she did not like mathematics, and one student who stated he liked mathematics. Then I selected a third student based on theoretical and demographic concerns to help define some of the themes that arose during the first two interviews. During an initial data analysis the student who stated he liked mathematics was generally found to be mastery oriented and this seemed to be unique. In an effort to understand this difference, I chose the fourth student to be a female who liked mathematics. This fourth interview helped define some of the emergent theories from the first three interviews, led to better saturation of the data, and although liking math did not completely explain any student’s motivation for mathematics, a relationship did emerge between liking mathematics, and in a general sense, being more motivated for mathematics. As being motivated for mathematics should be related to liking mathematics and as gender has been shown to be a moderating variable on the relationship between motivation for mathematics and achievement, this selective sampling relied on theoretical foundations to help achieve diversity in response patterns.

**Data Analysis for Phase 2**

I compiled and printed all items in the phase two instrument so all participants could read the items as they were being discussed. Questions relating to Tourangeau’s (1984) cognitive interview framework were also printed and placed before the participants. I conducted each individual interview face-to-face in a quiet setting and began the interviews by explaining the
consent document, the purpose of the interview, and by discussing the cognitive interview questionnaires. I loosely referred to the following questions when discussing each item during the student cognitive interview:

1. What was the meaning of (insert item)?
2. What information did you need to answer (insert item)?
3. What judgements did you make when answering (insert item)?
4. What was your answer to (insert item)?

I loosely referred to the following questions when discussing each item during the instructor cognitive interview:

1. What was the meaning of (insert item)?
2. What information would a student need to answer (insert item)?
3. What judgments would a student make when answering (insert item)?
4. What was your answer to (insert item)?

Each interview was audio recorded. During the interviews I read each item aloud and discussed the cognitive interview questions as they pertained to the item. When necessary, follow-up questions were asked to clarify and unpack cognitive processes that emerged through the interview process. After each interview, a fellow researcher and I analyzed the recordings and used emergent themes to formulate questions for future interviews. In this way, current data guided future data collection.
The coding process. At the beginning of the analysis, a fellow researcher and I used codes representing the sub factors associated with the relevant motivation theories along with concerns over wording of items to analyze the interview data. These same codes became the basis for the initial coding process. We placed the data in an intra-respondent matrix with the rows of the matrix being individual concept phrases from the data, and the columns of the matrix being the codes that emerged from the data. We separated the data into concept phrases based on individual ideas that flowed from the participants’ dialogue and not based on grammar or length. Therefore some concept phrases only contained one word and others contained several sentences. We worked in concert on this separation of dialogue into concepts and worked towards consensus for the separation of each phrase. The bias in this process was towards shorter concept phrases.

Once we separated the interview data into concept phrases, the coding process began with codes representing the sub factors of the theories on motivation that were relevant to the items used in this study. In the initial analysis we also included codes associated with the psychological needs articulated by Ryan and Deci (2000) and the sources of self-efficacy articulated by Bandura (1986). The initial codes were intrinsic motivation, extrinsic motivation, mastery orientations, performance orientations, expectancy, task-value, self-efficacy, competency, autonomy, relatedness, mastery experiences, vicarious experiences, social persuasions, and affective responses. Along with these codes based in theory, codes emerged during analysis associated with relevance of mathematics, engagement in mathematics, the social dynamics associated with learning mathematics, metacognitive processes associated with learning mathematics, the levels of difficulty of mathematical content, curricular and pedagogical concerns, issues relating to the wording of items, and issues relating to the multilevel aspects of
the data. Some of these codes were resilient and others faded away quickly. Through a process of attrition and conglomeration over a period of several months with codes being added, similar codes being merged, and codes found to be unrelated to the concerns of this study being removed; 10 core codes emerged. These codes represented intrinsic motivation, mastery orientations, performance orientations, self-efficacy, engagement, affective reactions, relevance, relatedness, multilevel aspects, and concerns over wording.

The intra-respondent matrix of cognitive interview data ended up having 2764 rows with each row representing one concept phrase. This matrix was used to organize and partition the data per survey item. See Table 2 for the 10 codes and the roots of keywords, which emerged from the data, used to help define the code and to search for examples of the code within the data. Compet is an example of a root keyword used to search for the words compete, competition and competing. Depending on the context of the phrase any of these three words may have pointed towards an example of a given code. Also, we listed several words such as understand and teacher as representative of more than one code. Out of context, none of the keywords may be seen as examples of a code, and some words --depending on context-- could be viable search terms for several codes. See Appendix E for the summarized intra-respondent matrix along with effect sizes of each code per phase two item.
Table 2. Codes Used in Analysis.

<table>
<thead>
<tr>
<th>codes</th>
<th>Keywords</th>
</tr>
</thead>
<tbody>
<tr>
<td>fun</td>
<td>Fun, enjoy, like, excite, want to</td>
</tr>
<tr>
<td>mastery</td>
<td>grasp, learn, understand (working towards understanding), complex, master, getting it, mistake</td>
</tr>
<tr>
<td>performance</td>
<td>grade right test compet exam pass GPA best prove well percentage compare average points benchmark measure competition result</td>
</tr>
<tr>
<td>relevance</td>
<td>appl life everyday world career future major goal employer relate value occupation important reward goal benchmark win lose award recognition gratification</td>
</tr>
<tr>
<td>efficacy</td>
<td>Mistake, difficult, get it, ability, smart, confiden, understand (to possess understanding), grasp, hard, comfort, know, retain, no clue, literate</td>
</tr>
<tr>
<td>engage</td>
<td>speak up contribute immersed challenge tried push hours engrossed interesting effort practic work giving up passion repeat struggle, over and over, do your best involved hard</td>
</tr>
<tr>
<td>affect</td>
<td>hate feel humble happy bad relax stress passion discourag stupid care embarras pressure confused risk jumbled scare</td>
</tr>
<tr>
<td>relatedness</td>
<td>friend people we interact them conversation they others teacher supportive judge family advertis impress scene parents 'look smart' individual peers expectations encouragement confidential 'hold your hand' resources tutor ask aid google help</td>
</tr>
<tr>
<td>multilevel</td>
<td>class teacher high school college experience current syllabus type algebra geometry major stem</td>
</tr>
<tr>
<td>wording</td>
<td>define mean clear same depends differen interpret synonym similar</td>
</tr>
</tbody>
</table>

Selection of items. In an effort to reduce the number of items per factor, questionable items were removed. Items were considered questionable if evidence suggested they were confusing for students, or they did not represent the intended construct. In this way, the phase two instrument was tailored for phase three so that intrinsic motivation became represented by
four items, mastery orientations by four items, mastery structures by four items, extrinsic motivation by three items, performance orientations by four items, performance structures by four items, self-efficacy by four items, task-value by three items, and expectancy by four items. The data from this phase of this study also provided evidence for the first research question, “To what extent do the items in the Motivation for Mathematics Abbreviated Instrument represent their intended constructs?”

**Phase 3 in Detail**

I collected data for the third phase of this study through the administration of the phase-three instrument to 186 developmental algebra students at the University of South Florida. I conducted exploratory and confirmatory factor analyses of these data and used the measurement model that arose from these analyses in a structural equation model to reveal relationships between self-reported achievement and the latent factors concerning motivation. Gender was added as a moderating variable on this relationship, and then after grouping the data by gender, specific differences in relationships between achievement and motivation were explored. Finally, I examined bivariate correlations between previously published subscales and latent factors intended to measure these same constructs.

**Participants and Data Collection for Phase 3**

A Monte Carlo simulation in Mplus version 7.4 on a 16 item four factor model with factor loadings between .5 and .8, and correlations between factors between .3 and .5 demonstrated a need for at least 85 participants to have a power of .90 for all of the loadings in
the measurement model used in the phase 3 analysis. This was the minimum sample size for this study.

The third phase of the development and validation process consisted of administering the phase three instrument to all students enrolled in developmental or intermediate algebra courses at the University of South Florida in the fall of 2015 and the spring of 2016. These gateway courses were designed to improve students’ algebra skills in preparation for college level mathematics. There were six sections of these courses offered in the fall of 2015 and six offered in the spring of 2016. The instructors of the classes that took part in this study allowed the administration of the survey during the first fifteen minutes of one class session. To begin the administration, I handed out paper surveys along with a consent statement. Students were informed of the anonymous nature of the survey, that their participation was voluntary, and that the results were to be used for research regarding motivation of mathematics. See Appendix C for the consent statement. Almost all of the students attending class on the day of the survey participated with a final total of 186 responses. The majority of participants were female (84 male, 2 unreported). Eighty-one participants self-reported having an A in the class, 75 having a B, 17 having a C, eight having a D, and three having an F. Two did not report a grade. Many of the students taking these courses were international, many were English second language learners, and many were out of state students. Therefore, this population was a diverse segment of the overall student body.

I administered the phase three instrument along with either the mastery orientation or performance orientation previously published subscale (PPSS) from the PALS (Midgley, et al. 2000), or the intrinsic motivation PPSS from the Intrinsic Motivation Inventory (selfdeterminationtheory.org). The resultant survey contained four items representing intrinsic
motivation, four items representing mastery orientations, four items representing mastery structures, three items representing extrinsic motivation, four items representing performance orientations, four items representing performance structures, four items representing self-efficacy, three items representing task-value, and four items representing expectancy for a total of 34 items. The intrinsic PPSS contained five items, the mastery orientation PPSS contained six items, and the performance orientation PPSS contained five items. One of these three PPSS was randomly attached to the phase-three instrument, so one third of the participants each completed one of these previously published subscales. Finally, the last two questions on each phase-three instrument asked participants to include their gender and their current course grade as self-reported demographic and achievement measures.

**Data Analysis for Phase 3**

Utilizing SPSS version 22, I reviewed descriptive statistics including skewness and kurtosis for all items contained in the phase three resultant instrument, and reported the internal consistency for each factor in the final measurement model using Cronbach’s alpha. Utilizing Mplus version 7.4, I conducted an exploratory factor analysis using oblique Geomin rotation. An oblique rotation was deemed appropriate as the included factors were theoretically correlated because they all measured different frameworks describing motivation.

Utilizing Mplus version 7.4, I conducted a confirmatory factor analysis and reported Chi-square goodness of fit, confirmatory fit index (CFI), root mean square error of approximation (RMSEA), and standardized root mean square residual (SRMR). I employed a diagram to detail the final measurement model and examined all parameters and modification indices to better understand correlated errors between items that may have represented similar concepts.
Utilizing Mplus 7.4, I built a structural equation model with the dependent variable achievement regressed upon the four latent motivation factors from the measurement model used in the confirmatory factor analysis. To examine the moderation of gender on the relationships between the four motivation factors and achievement, I created interaction variables between gender and these four motivation factors and included these along with gender in the regression. Then to better interpret this moderating effect, a regression of achievement on the four motivation factors with gender as a grouping variable was performed. As achievement was skewed, and therefore not normally distributed, I used Maximum Likelihood Robust (MLR) as an estimator and reported all significant relationships.

I also conducted a final correlational analysis with the data separated by the three included previously published subscales and reported correlations between these subscales and the four factors from the structural equation model representing motivation. The data obtained from phase three provided evidence to answer the three research questions,

2. To what extent can a latent factor measurement model that represents the included constructs in the Motivation for Mathematics Abbreviated Instrument be found to fit response data from developmental algebra college students?

3. What relationships exist between the factors representing the included constructs from the Motivation for Mathematics Abbreviated Instrument and previously published subscales representing intrinsic motivation, mastery goals, and performance goals?
4. What relationships exist between the included factors in the Motivation for Mathematics Abbreviated Instrument, gender and self-reported student achievement, and how are these relationships similar to previously reported relationships in educational research?

Summary

Validity is an ongoing process, where instruments gain validity as evidence mounts, and the AERA (2014) discusses five sources of validity evidence. For the current study, content validity was addressed by beginning with items from previously published surveys intended to measure a specific construct. Theoretical experts assessed these items, and selected the items that they believed best represented the specific construct. Next, cognitive interviews were conducted to better understand the cognitive processes of students and instructors as they reviewed and responded to the items selected by experts. Then, the most representative items were administered to many students and a correlational study compared the responses to these items with previously published subscales intended to measure similar constructs. Exploratory and confirmatory factor analyses provided evidence of validity based on the internal structure of the administered instrument. Finally, achievement was regressed upon the four factors measuring motivation while viewing gender as a moderating variable. This provided validity evidence based on relationships with other variables, and the cognitive interviews provided insights into validity concerns based on response processes. The administered instrument was kept reasonably short, and the instrument was administered in a face-to-face setting on paper and pencil. These methods may have helped to mitigate construct irrelevant variance and possibly dissuaded validity concerns surrounding response processes. To mitigate validity issues based on
consequences associated with participation and to minimize quid pro quo bias, I explained to the participants that their participation was voluntary and anonymous. By not collecting identifying information, the instructors of the course and the researchers were blind to who participated. In this way, the methods used in this study provided evidence for an initial validity argument.
CHAPTER FOUR

RESULTS

This study was conducted in three phases. The first phase consisted of an expert review of items through the use of on-line surveys. The data collected for this phase consisted of expert commentary, and the percentage endorsement of each item. The commentary was reviewed using a constant comparison grounded theory approach and the qualitative data was quantified using intra-respondent matrices. The original data from the expert commentary gave insights into theoretical concerns associated with how well the items represented their intended constructs, and the data from the expert selection of items led to the selection of items for the second phase. The second phase consisted of cognitive interviews with students and instructors. Audio recordings of these interviews became the basis of interview transcripts. A fellow researcher and I then separated these transcripts into concept phrases and entered them into an intra-respondent matrix. Using a constant comparison grounded theory approach we then coded these concept phrases by appealing to emergent themes. The original data from the second phase interviews gave insight into the cognitive processes employed by participants when responding to the items. This gave insight into how well the items represented their intended construct, and these data were used to select the most representative items for phase three. The third phase consisted of administering the items surviving from the phase one and phase two analyses to students taking developmental algebra courses at the University of South Florida. The data from this administration became the basis for exploratory and confirmatory factor analyses, bivariate
correlational analyses, and a structural equation model regressing achievement on the latent factors representing motivation. A final four factor model provided evidence supporting the content validity of the items in the final Motivation for Mathematics Abbreviated Instrument (MMAI), this instrument demonstrated good internal structural validity, and revealed relationships between variables --both internal and external to the instrument-- similar to what has previously been seen in the literature.

This chapter began by exploring the data obtained through expert commentary. Experts then select items to proceed to phase two. In phase two, I discuss the selection of participants for the cognitive interview process and then report on informative phrases that led to concerns about social aspects of the items, poor wording of items, and the multilevel nature of some responses. In phase three, exploratory and confirmatory factor analyses are conducted, a structural equation model is constructed to look at relationships between the latent motivation factors from the phase three instrument and achievement, relationships associated with gender as a moderator are revealed, and the bivariate correlations between subscales from previously published instruments and the factors from the phase three instrument representing similar constructs are reported.

Phase 1

The first phase answered the first research question; “To what extent do the items in the Motivation for Mathematics Abbreviated Instrument represent their intended constructs?” To add evidence for content validity, two types of data are collected through three on-line surveys with the purpose of better understanding how well the items represent the theoretical construct they were intended to represent. The first type of data was commentary, and it consisted of replies by experts to the petition emails or comments by experts in text boxes located within the online
surveys. The unit of measure used for analysis was the concepts contained in the individual phrases that made up the commentary. This analysis consisted coding these data by examining emergent themes and describing these themes using examples from the original data.

The second type of data in phase one was the result of the selection of items by the experts. Each section of the three surveys asked experts to pick the items that best represented the intended construct. This gave the items a ranking based on popularity and was related to the proportion from this sample of experts in motivation that endorsed the item.

**Expert Replies to Emails**

The first type of comments from phase one were overall statements about the nature of the research. Experts sent these as replies to one of the three petition emails. Of these replies, several did not directly concern the surveys but were encouragement about the research. These generally acknowledged that this type of research was needed. These replies had wording similar to “I did something very similar for a project in my PhD” and “good luck with your research.” Although this was not directly helpful, this type of response was valuable in that it showed an appreciation of the importance of the research. These replies were also valuable in that they were not anonymous, and so it was possible to see that international researchers of motivation from Japan and Germany as well as the United States were interested in this topic. One informative researcher also commented that the scale to be used in the final survey would affect the items chosen.

Several of the replies were more substantive and dealt with the constructs themselves. Two replies concerned the underrepresentation of specific theories on motivation. One researcher suggested that based on her research attachment theory might need to be included as a significant
source of motivation. For this researcher, early life experiences are conditioned by the way “secure attachment affords the confidence to engage difficult tasks,” and because mathematics is often seen as difficult, this may be a strong factor in student motivation for mathematics.

Another expert was concerned with the absence of both mastery and performance avoidance items. She stated, “I was amazed with [sic] Performance Avoidance and Performance Approach were distinguished from one another. Same with Mastery Approach and Avoidance.” Although it was impossible to include all frameworks concerning motivation, having experts on research in motivation chime in on constructs they believed to be missing in this current study was valuable.

Other comments dealt with the issue of misrepresentation. The items used to represent self-efficacy were sourced from a survey by Usher and Pajares (2009) measuring sources of self-efficacy. I chose these items because of a strong validation argument by the developers of the survey. The content validity of this argument was bolstered by comments from A. Bandura and as such I considered it to be theoretically sound. However, as stated by one of the replies to the petition emails, these items may not measure self-efficacy in itself, instead they may be measuring the source of an individual’s self-efficacy. As he stated, “the items seem to represent how much the sources (e.g., vicarious experiences) shape one's self-efficacy.” Thus, the items may have assumed a survey respondent was self-efficacious in mathematics and were meant to measure where this self-efficacy originated.

Other comments concerning misrepresentation dealt with task-value and extrinsic motivation. One comment concerned task-value. As Eccles and Wigfield (1995) found task-value may have three distinct facets; utility, attainment-value, and liking, and as these three facets of task-value were not discussed in the directions, respondents to this survey may not have uniformly responded with items measuring the intended construct. As one expert responded,
“you included items that represented three components of task-value … so you may have some trouble interpreting your results.”

Another comment concerning extrinsic motivation may allude to a more critical limitation for developing an abbreviated measure. Because extrinsic motivation covers such a wide spectrum, one respondent commented that it may not be possible to create an abbreviated instrument that can adequately measure extrinsic motivation. As she stated, motivation is “a continuum from intrinsic to internalized to introjected to extrinsic, and in the items you've selected I see a range of those motivational levels,” therefore, “if you're only measuring intrinsic and extrinsic motivation, you might miss the complete picture.”

**Expert Comments to Survey Sections**

Of the 511 members of the AERA SIG for motivation in education, a total of 57 experts responded to one or more of the included factors in the survey dealing with intrinsic motivation and mastery goals, 25 experts responded to one or more of the included factors in the survey dealing with extrinsic motivation and performance goals, and 41 experts responded to one or more of the factors included in the survey dealing with self-efficacy and expectancy-value. The largest percentage of comments were for the extrinsic motivation factor with 52% of respondents to this factor commenting, and the second largest was for the self-efficacy factor dealing with mastery experiences with 39% commenting. Performance structured items collected the least percentage of comments with 24% commenting.

In the intra-respondent matrix employed in this phase, we found that 21% of phrases dealt with self-efficacy, 26% of phrases dealt with theoretical concerns, and 42% of phrases dealt with survey critiques. Here, the percent of phrases containing a code is equal to 100 times the
effect size for that code. See Appendix D for a summary of effect sizes per code. Because of the reliance on voluntary response, high effect sizes may indicate problematic theoretical concerns.

Only about eleven percent of the petitioned experts responded to the survey, and less than half of these respondents commented to the emails or to the survey sections. Because of this low percentage of participation and the voluntary nature of the sample, the comments may be biased; however, several trends were found. The self-efficacy items were not measuring self-efficacy, the task-value items could be improved, and extrinsic motivation may be too broad of a construct for this application. These conclusions were in contrast to the items for other factors. Although there was some concern about intersections between factored sets of items and the theories they represent, there was little concern that these items did not represent their intended constructs.

The majority of self-efficacy comments alluded to the self-efficacy items not representing self-efficacy. These items were sourced from Usher and Pajares’ (2009) Sources of Middle School Mathematics Self-efficacy Scale (SSES), and in concert with the intent of this instrument, several experts commented that the items represented the sources of one’s efficacy but did not represent self-efficacy. As one expert stated, “These seem to represent how much vicarious experiences shape one’s self-efficacy,” but “they do not seem to measure self-efficacy that resulted from vicarious experiences.”

Two other similar themes haunted the self-efficacy items. First, several comments revealed a temporal aspect to self-efficacy. As one expert explained, “self-efficacy items should be focused on present and future performances, not just past mastery experiences.” Another expert stated “efficacy is a future oriented judgment. These are more reflective of self-concept.” This belief about present and future events may be alluding to a relationship between self-efficacy and expectancy. As one expert stated, “I expect self-efficacy items to have an element of
expectations of future tasks.” This may be the problem with using the SSES to measure someone’s efficacy. Nine of the scales original items speak to past events with wording similar to, “I have always been successful with math,” or “I have been praised for my ability in math” (Usher and Pajares, 2009, p. 98). Notice these imply a past event as the source of some assumed self-efficacy that is presently in existence.

Another issue present in the comments concerned the width of the domain where self-efficacy resides. Several experts believed self-efficacy must be focused on a specific task as revealed in statements such as, “self-efficacy involves confidence for completing specific tasks,” and “math as a field would be too broad under this view.” To say one is self-efficacious in math may reveal a misunderstanding of theory as one cannot be self-efficacious in such a broad domain. Perhaps it would be more in line with self-efficacy frameworks to say one is self-efficacious at creating geometric constructions using compass and straightedge. Self-efficacy is one of the strongest predictors of performance (Bandura, 1986), and the more specific the event is, the better its predictive power may be. As one has to be self-efficacious in many domains to be self-efficacious in math, math may be too broad of a domain to be aligned with Bandura’s (1997) theoretical framework as it is understood by some experts.

Another issue discussed in the self-efficacy comments concerned negatively worded items. As one expert stated, “I’m generally against negatively worded items because they tend to exhibit poor psychometric properties.” As the principal researcher, I made a decision early in this study not to include items representing amotivation or avoidance as these represented the opposite of motivation; thus, all potential items in the first phase were positively worded except the self-efficacy items as sourced from affect. All items in the SSES dealing with affect were negatively worded, but mathematical self-efficacy sourced from affect does not have to be
negative. As one expert noted, “some people get great emotions from math,” and as another expert remarked, “these items seem to measure math anxiety, which could then predict self-efficacy, but they don't represent self-efficacy sourced from affect.” Negative affect associated with math may be a construct that is inversely related to self-efficacy, but may not be self-efficacy in itself. There is also a more basic measurement issue associated with including negative items. The inclusion of negatively worded items may lead to more misrepresentation of the construct, and when negative wording is associated with answers concluded through agreement or disagreement, respondents may be put in the awkward position of disagreeing with a statement that is aligned with their beliefs (Galhbach, 2015).

Evidence also existed revealing problems with items representing two of the other included theories. Task-value, and extrinsic motivation may have been misrepresented. As task-value can be separated into the four factors; utility, attainment, liking, and cost (Eccles, 1987), or into the three factors; intrinsic interest, attainment value, and extrinsic utility (Eccles & Wigfield, 1995), it may not be possible to represent task-value with one factor. As one expert noted, “all items are value, some are attainment, some are liking/interest, and none are cost,” and another stated the items should represent “all four dimensions (including cost).” This perceived lack of coverage for the complete task-value framework led several experts to offer alternative wordings and sources of items. One expert stated that I should remove the “I do mathematics because” language, and another stated the need for intrinsic interest items such as “I do mathematics because it exercises my mind in ways” or “I do mathematics because it relaxes me and it takes my mind off other things.” One expert suggested to use items similar to ones found in Eccles’ research.
Many experts stated extrinsic motivation concerned more than one level of control and wanted to separate extrinsic motivation into Ryan and Deci’s (2000) four levels; external, introjected, identified, and integrated. As one expert stated, “a lot of the items seem to be toeing the line or falling far on the identified/integrated regulation side,” also stating that “‘feeling bad if I was not taking the time to do it’ is definitely in the introjected regulation category,” finally concluding the need for externally regulated items. This same expert stated that “an item or two focused more explicitly on rewards and/or punishment would round this out a bit better.”

Several comments were also concerned with discrimination between extrinsic motivation and performance goals. As one expert stated, “there are many items that overlap with performance goals,” and another stated, “mastery and performance goals are largely hypothesized to be orthogonal.” This discussion about achievement goals, while reviewing extrinsic items, may reveal the items are not distinguishing between the included frameworks. This may be symptomatic of the breadth of the extrinsic motivation framework. As an expert stated, “extrinsic motivation is a very broad construct, almost of the point of being meaningless,” and therefore, “I would not attempt to measure it using an abbreviated measure.”

Other survey critiques concerned factors that were missing or interrelated. Several experts noted the lack of avoidance orientations for both mastery and performance, and several discussed how interrelated intrinsic motivation was with mastery and performance. The lack of avoidance and amotivation were by design, and many experts saw the distinguishing factor separating intrinsic motivation from achievement orientations was enjoyment. As one expert stated, “The intrinsic motivation measures that are best are those that focus simply on enjoyment and other positive emotional experiences students have while doing math.” Others pointed out that “pleasure in new knowledge seems too close to mastery goals,” and that “enjoyment could
be for a variety of extrinsic, performance, or mastery oriented reasons.” For one expert, the focus for mastery orientations “should be about the task-based standards of mastery and understanding, less so on the self-improvement standard,” and it may “not be about the pleasure of engagement, which should be measured as intrinsic motivation.” Whether critical or just discussion of the theory, many of the comments about intrinsic motivation were concerned with positive affect, and this may be what distinguishes intrinsic motivation from mastery.

Relationships between intrinsic motivation and mastery also appeared in comments on mastery structures. As one expert stated, “mastery structures per se can be either autonomy supportive or controlling,” and this may be related to a distinction made “between perceived teacher instruction/goal emphases, and classroom goal structure.” Notice, control has moved outside of the student. The teacher or the classroom is influencing student action, and therefore the student is no longer performing for pure joy. This control may be key for distinguishing intrinsic motivation from any achievement goal structure, and although control from an achievement structured environment may be shared by the teacher or imposed by a social construct associated with classroom norms, the fact that autonomy is missing is enough to distinguish intrinsic motivations from mastery structures. As a motivational theory, achievement goal structures are different than the other frameworks because the items concern states that are “imposed on the students.”

One framework associated with motivation that was not included in the initial frameworks in the surveys was attribution theory, and some of the data suggested this framework was represented by items intended to represent expectancy. As one expert stated, “some of the items on this list confound expectancy with other attribution-related elements,” and another stated, “many of these are not expectancy items, they are ability self-concept items and causal
attribution items.” This also led to a warning to “consider the overlap between expectancy and efficacy in your research” as many of the items may “cross load with the SE items.” As an expert noted, expectancy “is actually the same thing as self-efficacy,” because “ability self-concepts are a different but highly related construct.” One suggestion about wording was not to use the term “confident” in items meant to measure expectancy as this term beckoned self-efficacy. This type of implied self-efficacy of the items led one expert to state, “many of these items are either focused on general self-efficacy or competence expectancy and not necessarily expectancy as laid out in expectancy-value theory.” For this respondent, expectancy was epitomized by the statement, “if I perform this behavior, then I will attain this outcome.” Although much of the critique of the expectancy items dealt with concerns of cross loading with other constructs, some of the experts thought the included items were adequate representations of expectancy. As one expert stated, “all items represent expectancy equally well.”

This alludes to an issue with all of the comments offered during phase one of this study. These comments were collected as voluntary response samples. Less than 24% of the petitioned experts responded to the survey, and the majority of experts who did respond did not leave any comments. Thus, the comments may have an associated bias. As the comments may not be indicative of the beliefs of all expert respondents, they were not used as a deciding factor for items in phase two; however, the concepts contained in the comments provided insight into how well the items represented the intended constructs. Through inspection of the comments, it became apparent that some experts believed the self-efficacy items misrepresented self-efficacy because of a focus on past experiences, not having a specific domain in which to be efficacious, and through using negatively worded items representing anxiety instead of efficacy. Some experts believed the task-value items were not rich enough to measure all included sub factors.
for task-value. Some of these sub factors for task-value might be utility, attainment, liking, and cost; or they might be intrinsic interest, attainment value, and extrinsic utility. Some experts believed it was not possible to represent extrinsic motivation with an abbreviated instrument because it applied to such a broad array of actions. For these experts extrinsic motivation is a spectrum of control ranging from the forced actions associated with amotivation to the complete autonomy associated with engagement just for the pure intrinsic enjoyment. Therefore, the extent of the domain including all levels of control is too broad to represent with just a few items on an abbreviated instrument. The other six included factors; intrinsic motivation, mastery orientations, mastery structures, performance orientations, performance structures, and expectancy did not suffer from concerns associated with misrepresentation. Although some experts expressed doubts concerning convergent and discriminant validity within and between the remaining six constructs, there was little evidence in the comments that the items representing these six factors were not reasonably representative of their intent.

**Popularity of Items by Factor**

The task associated with phase one was for experts to choose the items that best represented the intended factor. The items were sourced from many previously published surveys, and all had some evidence for validity (McAuley, Duncan, & Tammen, 1987; Midgley, et al., 2000; Miller, et al., 1999; Pelletier, et al., 1995; Pintrich et al., 1992; Usher & Pajares, 2009). For the items representing each of the individual factors --intrinsic motivation, extrinsic motivation, achievement goal orientations, achievement goal structures, expectancy, and task-value-- experts were asked to pick the five items that best represented the factor while discriminating it from associated factors. For self-efficacy, the experts were asked to pick a total
of eight items—two from each of Bandura’s four sources—that best represented the given construct. This selection process led to rankings based on the proportion of experts that endorsed the item. By selecting items based on a cut score of endorsement of at least 40%, and on recommendations from the email and survey commentary, the original 122 items were narrowed down to six intrinsic motivation items, five extrinsic motivation items, seven mastery orientation items, seven mastery structure items, six performance orientation items, five performance structure items, six self-efficacy items, six task-value items, and five expectancy items for a total of 53 items. See Appendix F for the items selected for the second phase of this study along with the percent of the respondents who endorsed each item.

**Phase 2**

Cognitive interviews of students were the source of data for the second phase of this study. These interviews helped answer the first research question, “To what extent do the items in the Motivation for Mathematics Abbreviated Instrument represent their intended constructs?” As the instrument developed here is designed to measure motivation of university students in developmental algebra, the focus of phase two was not on theory but instead on how participants experienced each item. As a starting point, the cognitive questions—based on work by Tourangeau (1984)—provided evidence of four types of information; comprehension, recall, judgement, and response; and led to better understandings of the cognitive processes involved in a person’s response to a survey item. Therefore, the cognitive student and instructor questionnaires contained four lines of questioning for each item. Answers to these questions were the basis for the phase two data.
Phase 2 participants

The initial instructor interview was with a young White female from the Northeastern United States with a masters in mathematics who was teaching as an adjunct. She had several years of experience working with students in Intermediate Algebra and during her interview evidence emerged that revealed mastery-oriented beliefs about instruction. To take advantage of existing cultural and academic diversity, a young Black woman from the Caribbean who was a graduate student working towards a terminal degree in engineering was selected for the second instructor interview. Her interview revealed many performance-oriented beliefs about her students. To have a mastery oriented and a performance oriented instructor was considered beneficial, and both instructors offered insights into how students might read an item, leading to some concerns regarding word choice.

The mastery oriented instructor tended to look for the meaning of the items and how they would be interpreted by students. She saw her students as wanting to learn mathematics and interpreted the items by how well a mastery oriented student might answer. Although she tended to see her students as having a desire for knowledge, she did believe students might misinterpret some of the items because of poor wording. An example of this thinking was revealed when she was questioned about the item “I do mathematics for the prestige of being mathematically literate.” Here she was concerned with the word “prestige” because she believed it may be interpreted differently for different students. As she stated, “I would think they know what literate means. But prestige, maybe, maybe not. Because I know sometimes at least with students who are from a foreign country, if maybe they were given this sort of statement that could throw them off, because they may not know what prestige means.” This questioning of student interpretations of items was also evident when students were asked about an item referencing the
importance of understanding mathematics and not just memorizing. The mastery oriented instructor was concerned that students would misunderstand this statement. She stated, “I think this could be misleading as well for students because they think memorizing is a form of understanding.”

The performance oriented instructor also took issue with the wording of this same item. “I don’t know exactly what you mean by memorize. You’ve got to know the [multiplication] tables so that means you have to know --memorize. So I guess, so I'm not sure what like an example of something that’s memorized I don’t understand.” For her, much of mathematics was memorization, so to separate memorization from understanding was not conceivable. She tended to see her students as only wanting a grade, and tended to see mathematics as requiring a good deal of memorized background knowledge. “If you want to solve a quadratic, I have to know a quadratic formula.” According to her, they were generally not interested in learning mathematics, and she found many items to be irrelevant as students would not possibly see mathematics as enjoyable or relevant. According to her, “They don’t really see the importance or usefulness, they are like, I’m not going to use this again.”

**Emergent Categories**

During the interviews, data arose regarding the constructs of interest for this study, and I often unpacked students’ statements by asking probing questions about the constructs. Review of the audio recordings after each interview also helped to formulate new probing questions for future interviews. The codes utilized at the beginning of this process concerned the relevant theories on motivation; self-determination, achievement goals, self-efficacy, and expectancy-value. I also separated these theories into their sub-factors and used intrinsic motivation,
extrinsic motivation, amotivation, mastery orientations, performance orientations, avoidance orientations, mastery structures, performance structures, self-efficacy, expectancy, and task-value as initial codes. I supplemented these with codes representing Ryan and Deci’s (2000) psychological needs associated with autonomy, competence, and relatedness; codes representing Bandura’s (1986) four sources of self-efficacy –mastery experiences, vicarious experiences, social persuasions, and affective experiences; and codes representing types of task-value –utility, attainment, liking, and cost.

As the goal of this study was to represent these sub-factors concerning motivation with the items being reviewed, this choice of codes was prudent and expedient for these interviews. After collecting all of the interview data, a fellow researcher and I used these same codes as the basis for the initial review.

The separation of the transcripts into concepts was not based on a predefined length of a phrase or on grammar. The shortest concept was “Yes” when this was an affirmative response to a question, and the longest concepts contained several sentences where each sentence had the same meaning. The longest concept from the transcripts was, “Well it depends on the class, what’s basic. You know it depends on the, I mean what’s basic. I mean basic could be one plus one or basic could be solving an equation. It just depends on what basic is. It depends on what is basic.” In this case the concept was the term basic depends on the material being taught in the classroom, and we felt that this was one concept and not many repetitions of the same concept. This type of ambiguity associated with informal speech patterns made the separation of the transcripts a matter of judgment, with the researchers’ bias towards smaller units.

As we separated the transcripts by concept, we coded the concepts. This process started by utilizing the 22 codes stated earlier; however, as the coding progressed and evidence seemed
to suggest new codes, we added new codes. As participants discussed their classroom experiences, we added codes for achievement, curriculum, and pedagogy, and as participants discussed the type of mathematics, we added a code for difficulty. As participants discussed their thought processes, we added codes for memory and metacognition, and as participants discussed social dynamics, we added a social interaction code. As participants discussed future plans, we added a temporal code, and as participants discussed how hard they worked both in and out of the classroom we added an engagement code. At one point or another in this process, we considered 41 separate codes.

It soon became apparent that several codes were redundant because it was impossible to distinguish between them, several appeared so infrequently that they could not be considered to be an emergent theme, and several led to dead ends as they did not help answer the original research questions. As a result of this difficult and lengthy process, we found 10 codes to be useful in categorizing the themes that emerged from the data.

Intrinsic motivation consisted of concepts associated with pure enjoyment. We placed participants’ statements into this category if they wanted to do mathematics, they were excited about mathematics, or they liked to engage with the content. As one student with low motivation for mathematics stated, “I like to actually do math because I like the whole hands-on kind of portion of it,” and another, “[math] is something that I’ve enjoyed doing.” Along with affirmative responses, this category contained negative responses such as, “[I] don’t want to do it because I don’t know how to do it.” Often the same student would state a positive and a negative response in close temporal proximity. As one highly motivated and mastery oriented student stated, “I like math because there is a lot to it and its complex,” but “I really don’t like working through 12 steps in order to get one answer.” Some answers in this category concerned the
beliefs of others. As one performance oriented moderately motivated student stated, “What I like might be different from what someone else likes.” For this phase of this study it was important to know if the items were invoking cognitive processes associated with their associated constructs, and not necessarily whether the participant would endorse the item; therefore, we considered all evidence linking the participants’ cognitive processes to codes to be valuable regardless of whether that evidence was positively or negatively related.

We created two codes representing achievement goals, one for mastery and one for performance. When asked questions about a mastery item, a mastery oriented student with low motivation stated, “I want to improve my math skills.” She went on to say she thought the class was easy, and saw differences in the terms skills and concepts. Wanting to improve math skills was a five for her, but wanting to learn new concepts carried more risk so she gave that a three. Although she stated she wanted to improve her math skills and she stated she wanted to learn new concepts, and we coded both statements as mastery, the differences in how she would rate the items reveals some of the complexity apparent from the cognitive interviews. Word choice led to real differences in student responses to items. To complicate matters further, after some probing, the same student went farther stating, “I don’t want to overload myself, and bring down my GPA because I didn’t understand something.” This statement contained three concepts, overload myself revealed some affective domain traits, bring down my GPA revealed some performance traits, and I didn’t understand something revealed some self-efficacy concerns.

Also, the subject of this statement was the course in which she chose to enroll, and a common theme throughout much of the data had this type of multilevel dynamic. As the mastery oriented instructor stated, “It’s important to learn the math concepts.” It’s important to learn revealed a mastery approach, and by specifying the math concepts is seemed as though she was speaking of
the current course she was instructing. Thus, we used codes for concerns over wording of items, affective domain constructs, self-efficacy, and issues relating to the multilevel nature of the data in the final analysis. We also found evidence for codes representing engagement, relevance, and relatedness.

As we coded the concepts that revealed evidence of self-efficacy, it became apparent that the word understanding was being used in two different ways. When understanding is something that one is striving for, then it shows evidence of mastery orientations; however, when understanding is something that one possesses, then it shows evidence of self-efficacy. As the performance oriented instructor stated, “Depends on their level of understanding and how confident they are in their own abilities.” Here understanding was something the students possessed, and therefore, we coded this as self-efficacy. Students’ who believe they understand the material are self-efficacious. This is opposed to another statement by the same instructor stating, “I don’t think it’s about understanding [and] learning.” Here, understanding equated to learning and so was not seen as something the student already possessed. Instead it was something the student was --or in this case was not-- working towards. In another instance a student stated, “You have to understand it first and then you can go on to master it.” This was interesting as she was describing the strong relationship between efficacy and mastery. Other words such as get it and grasp had similar classification problems associated with differentiating between mastery orientations and self-efficacy, and one technique that we found to be valuable was to replace a word with mastery or efficacy and see if the meaning of the phrase changed.

We also found it difficult to distinguish between affective domain constructs and intrinsic motivation. If someone engages in an activity because they enjoy it, then often they may say it makes them happy; however, if they are engaging in mathematics because it makes them happy,
then they are not necessarily intrinsically motivated. They may be engaged because of an affective personal reward. What was the end—math or emotion? Therefore, when a phrase concerned positive affective concepts, we coded it based on whether the focus was the engagement with math, or the individual’s affective response. An example of data pointing to intrinsic motivation of the student was, “I like the complexity behind solving the problems.” Here this student enjoyed the challenge of working with complex problems, the end was working with complex problems, and so they were intrinsically motivated to doing mathematics. However, when the same student also stated, “When I get to the final answer and it’s the right one, then I’m happy.” Here the end is about being happy, not doing mathematics, so this was considered an affective state.

We originally included expectations and task-value as codes; however, these had less utility than relatedness and relevance. There were rare instances of students expressing how they expected to do well in the course, but most often when participants discussed expectations they were speaking of the expectations of others. Students would discuss how their parents expected them to do well, or the instructors would discuss their expectations for their students. As a mastery oriented student stated, my parents “just like, expect me to go to college,” or when discussing one of the mastery items the master oriented instructor stated, students’ responses to the item “would be based on maybe the concepts that they’re expected to learn that semester.” We coded these types of statements as relatedness, and this code also included discussions of other types of relationships. When a student discussed how he enjoyed working on homework with his friends, or when a student stated, “all my math teachers have been really supportive,” these statements were also coded as relatedness.
Codes associated task-value were initially included; however, we found task-value to be more useful when framed as relevance. Therefore, when students discussed how the mathematics they were learning was relevant to them, we coded these concepts as relevance. When a student stated, “If I don’t have any worldly application to it, it will just fly through one ear and out the other.” She was expressing how she was more motivated to master mathematics that was relevant to her life. As items did not focus on specific tasks, most concept phrases coded as relevance focused on the overall utility of mathematics. As one student who was moderately motivated towards mathematics stated, “I was never really a huge math guy, but I know that it is important.” As this discussed the overall utility of mathematics, we coded this type of vague statement as relevance. The performance oriented teacher stated, “their connections to the real world is really word problems,” and an unmotivated student stated, “I don’t really care for slope intercepts [because they] don’t have any worldly application.” Notice again, both positive and negative statements were given the same code as they both revealed evidence of the cognitive construct associated with motivation, and both shed light on relationships between mathematics and the importance placed on mathematics by the participants. As the mastery oriented instructor stated when discussing an intrinsic motivation item, “[Mathematics] is fun when you can apply it.”

Codes for two constructs strongly related to motivation were engagement and affective domain constructs. Engagement dealt with statements made by students about doing mathematics. As a student with low motivation stated, “To me that means that I practice it a lot,” and as this same student stated later, “once I am involved in an activity I do like to do it for a while.” Although this student did not like mathematics she did see the importance of spending time engaged with mathematics. To her, engagement was associated with a negative affective
response. She stated, “I thoroughly enjoyed the subject, and that’s not really how I feel about it.” She also stated, “If I find something else or something more appealing I will drop it [mathematics] in an instant.” Another well-motivated student stated, “I like the challenge of starting off with a word problem and I got with like 12 different steps. I mean it’s challenging sometimes and it gets annoying and tedious [other times].”

We included two codes in the final analysis that were not concerned with the cognitive constructs associated with motivation, but instead, were concerned with the nature of the instrument itself. When refining the wording of the items used in phase one and two, the desire was to avoid necessitating a multilevel approach to modeling the structure of the instrument. The cognitive interview transcripts quickly revealed this was not possible. Regardless of the general wording of the items, students and instructors related their cognitive processes back to specific classroom experiences. As the master oriented instructor stated, “maybe when they [students] had math classes from previous semesters or prior education maybe wasn’t as good of an experience. And maybe currently in the semester that they are in, the term that they are in. Maybe they have a different experience. So yes I think experience weighs heavily for sure in what they would feel about a subject matter.” Here, she is explaining how the students responses to the items would change based on the course they are currently taking. This appeal to a multilevel data structure was also prevalent in student responses. As one well motivated student stated, “Yes I would like to learn a lot of math concepts this year because I’m in intermediate algebra and I should be in pre-cal or calculus.” Because the class he was taking was understood to be developmental, he was very focused on learning as much as possible so he could proceed to the higher courses.
Finally, wording of items was a predominant code. This was to be expected as the nature of inquiry was to determine which items were best suited for an abbreviated measure, and which items could be better worded. Although the students did comment on wording occasionally, the two instructors saw this as their mission. Interestingly, the instructors often thought words would be problematic that were not. It was also interesting how students would change their responses to items drastically over slight changes in wording. Some words that caused concerns were mistakes, memorize, smart, and dreams. As one student stated, “There is a difference between dreams and goals.” Although math played an important part in achieving her goals, it played no part in attaining her dreams as her goal was to get a college degree, but her dream was to be a singer.

Selection of Items

Three common themes led to issues with student interpretations of items. First, words that quantified a cognitive construct gave students’ pause. Words such as a lot and very much tended to confuse. “Making a lot of mistakes” led students and instructors to ponder what a lot of mistakes might imply. After all, at some point a lot of mistakes becomes counterproductive and could not be considered to be motivating. As the performance oriented instructor stated, “from the student point of view making a lot of mistakes doesn’t make it fun,” and she expounds on this by explaining that after making several mistakes students might say, “I can't figure it out, okay I quit I don't know how to this.” As a student with low motivation stated, “If I just keep going and I’m erring every time, I’m just going to get frustrated.” As the performance oriented instructor stated, making a lot of “mistakes might to them mean they’ll never like” mathematics. For similar reasons, we preferred “I think mathematics is enjoyable” over “I enjoy doing
mathematics very much.” As a moderately motivated student stated, “I enjoy doing math, [but] not very much.” For him enjoying something very much would never apply to mathematics.

There were also social aspects to students’ interpretations of items. Phrases such as well-regarded and look smart tended to make students think about issues unrelated to the construct at hand. When asked a question about being well regarded, a student who did not like math stated, “I don’t agree with that. I know that people don’t really talk to me because I’m good at math, they talk to me because I have other personality traits that intrigue them more than the subject,” or when I asked another student who liked math a question about looking smart, she stated, “I do math because I enjoy it, not because I want to say oh look, I got a 92 on that. You are making the grade for yourself.” She went on to explain this item implied she might do math because she wanted to show off, and she was not a show off.

Many items caused students to reflect on their current course, and these reflections concerned both content and pedagogy. When asked if mathematics was interesting, one student explained, “So, what I’m thinking about right now is I really like algebra myself, but I really hate geometry.” Another student when asked the same question explained, “Depending what that means. To me mathematics is a very broad term and we have to think about all the other branches in mathematics because some of it is pretty interesting but other criteria is not.” Therefore, answers to items may be dependent on course content. Likewise, several items caused students to reflect upon their current classroom. As one student explained when asked generically about her past math teachers, she responded, “most definitely, my teacher always says it is ok to make mistakes just ask questions and fix the problem.” When I asked another student a question about math teachers recognizing improvement he stated, “yes, from my experience at USF so far since most of our stuff is online, it’s more between you and the teacher.
She will recognize us for improvements but for homework, tests and quizzes, it’s just a grade.”

See Table 3 for the items removed, the reason for removal, and evidence supporting removal.

As well as helping to organize evidence against items, the intra-respondent matrix also helped to demonstrated evidence for items to be included in the Phase three instrument. All intrinsic motivation items destined for Phase three had effect sizes above .13 for the intrinsic motivation code. This implied at least 13% of the concept phrases uttered by the participants when discussing each of these particular intrinsic motivation items showed evidence of the code the item was meant to represent. All surviving mastery orientation items had effect sizes above .19 for the code representing mastery. All performance orientation items had effect sizes above .31 for the code representing performance. There was no code for expectancy; however, all but one of the expectancy items did have effect sizes above .15 for the code representing self-efficacy, and as we saw earlier from the expert commentary, self-efficacy has a strong relationship with expectancy. An interesting side note was that two of the expectancy items had effect sizes above .32 for mastery, and the other two had effect sizes above .45 for performance. Although the lack of evidence for a code representing expectancy in the transcripts was not helpful for establishing content validity of the expectancy items, the effects for the codes associated with the other items may imply there was some evidence for the content validity of these items.
Table 3. Items Removed From Phase Two Resultant Instrument.

<table>
<thead>
<tr>
<th>Item removed</th>
<th>Removal reason</th>
<th>Supporting data</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>intrinsic motivation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I do mathematics because I like the feeling of being totally immersed in the activity.</td>
<td>feeling immersed is confusing and linked to mastery</td>
<td>T2.-“If it’s something that they understand, they will feel good, but if it’s something that they think they don’t understand and that they should be understanding then they just become totally... like don’t want to do it because I don’t know how to do it.”</td>
</tr>
<tr>
<td>I enjoy doing mathematics very much.</td>
<td>very much is subjective and too extreme</td>
<td>S1.-“I enjoy doing math, [but] not very much.”</td>
</tr>
<tr>
<td><strong>Mastery orientations</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I like mathematics that I’ve learned from even if I make a lot of mistakes.</td>
<td>a lot of mistakes may be counterproductive</td>
<td>T2.-“From the student point of view making a lot of mistakes doesn’t make it fun,” “if I just keep going and I’m erring every time I’m just going to get frustrated.”</td>
</tr>
<tr>
<td>It’s important to me that I improve my math skills this year.</td>
<td>improvement implied performance</td>
<td>S2.-“my teachers didn’t care as much to recognize effort, they were just hoping for the students to pass. &quot;My teacher will recognize but for homework, quizzes, tests, etcetera.”</td>
</tr>
<tr>
<td>An important reason why I do mathematics is because I want to get better at it.</td>
<td>getting better implied performance</td>
<td>S4.-“I really really want to get a good grade.” “So that when it comes time for the test I don’t feel like I have to cram or sweat.”</td>
</tr>
<tr>
<td><strong>Mastery structures</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In my math courses it has been important to understand mathematics, not just memorize it.</td>
<td>Memorize was confusing</td>
<td>T1.-“But I think this could be misleading as well for students because they think memorizing is a form of understanding.” T2.-“I don’t know exactly what you mean by memorize.” “It has been important to understand it but part of math is memorization.”</td>
</tr>
<tr>
<td>In my math courses, how much I improve has been really important.”</td>
<td>“How much I improve” implied performance</td>
<td>S4.-“I want the A grade the A plus grade whatever the grading system is so, very true.” “I want an A in my math class so you got to do your stuff.”</td>
</tr>
<tr>
<td>My math teachers have emphasized really understanding math not memorizing it.</td>
<td>Memorizing was confusing</td>
<td>T1.-“But I think this could be misleading as well for students because they think memorizing is a form of understanding.” T2.-“I don’t know exactly what you mean by memorize.” “It has been important to understand it but part of math is memorization.”</td>
</tr>
<tr>
<td><strong>Extrinsic Motivation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I do mathematics because it allows me to be well regarded by people that I know”</td>
<td>Well regarded was poor wording</td>
<td>T1.-“The word regarded may be a term that could stump a student.” S2.-“I know that people don’t really talk to me because I’m good at math, they talk to me because I have other personality traits that intrigue them.”</td>
</tr>
<tr>
<td>Getting a good grade in math courses has been the most satisfying thing for me”</td>
<td>Getting a good grade showed strong interaction with performance.</td>
<td>S1.-“I love getting a good grade knowing that I did well, get the reward for it.” S3.-“Showing you’re getting the results of the effort you put in and in this case you’re getting a good grade in your math course.”</td>
</tr>
</tbody>
</table>
Table 3 (Continued)

<table>
<thead>
<tr>
<th>Item removed</th>
<th>Removal reason</th>
<th>Supporting data</th>
</tr>
</thead>
</table>
| I do mathematics because people around me think it’s important to be intelligent. | Students defined intelligence broadly. So deleted to be intelligent.          | T1: “Is that intelligent in a well rounded sense? Or is that intelligent just in the math subject alone?”  
S3: “Not everyone around me judges solely off of mathematics.”  
S2: “I have met many bright people who aren’t the greatest at math.” |
| Performance Orientations                                                     |                                                                              |                                                                                  |
| In my math courses one of my goals has been to look smart in comparison to other students. | Look smart had a negative social connotation. | S1: “I don’t like to look smart.”  
S2: “I don’t really care what people think of me.”  
S4: “[I’m] not a show off” |
| Performance Structures                                                       |                                                                              |                                                                                  |
| My math teachers have pointed out who gets good grades as an example to others. | pointed out was problematic.                                                   | S2: “This question makes it seem like they purposely, put it in your face.”  
T2: “No, can’t do that. The student who would get the highest could tell people but you can’t do that as a teacher.” |
| Self-efficacy                                                                |                                                                              |                                                                                  |
| I do well on even the most difficult math assignments.                        | Even the most difficult implied help strategies.                             | T2: “you could Google it”  
S3: “there is a lot of resources here now we got the smart lab”  
T2: “once they have aid, it wouldn’t be difficult if you got something to look at follow.” |
| When I see how another student solves a math problem, I could see myself solving the problem in the same way. | Students do not trust other students’ solution strategies.                    | S1: “[When] a student [solves a problem] I don’t know if they are right.”  
S4: “People always do some crazy going around in a circle craziness to solve a math problem.”  
S4: “They do unnecessary steps that you don’t have to do.” |
| Task-value                                                                   |                                                                              |                                                                                  |
| I do mathematics because learning math is important for attaining my dreams.  | Dreams were different than goals                                              | S4: “there is a difference between dreams and goals. I would say this is true for my goals but not for my dreams. I want to be a singer.” |
| I do mathematics because understanding math is important for becoming the person I want to be. | The person you want to be is all encompassing.                                | S2: “There are other things in my life that define who I am, and I don’t think passing a math class or failing one is going to define me.”  
S4: “I don’t think math has anything to do with self-confidence or self-esteem or which lipstick color you want to buy.” |
| I think mathematics is useful for me to learn                                | Mathematics is useful is vague. I will use math demonstrates action.          | T1: “I think to use the mathematics I learn I can see that as, more of an actually action, where you see yourself as actually using the math versus the saying I think mathematics is useful.” |
| Expectancy                                                                   |                                                                              |                                                                                  |
| I’m certain I can understand the most difficult material presented in a math class. | Depends on how students define difficult.                                     | T2: “They might be fractions is difficult and I’m like, ‘No, it’s not.’”  
S4: “I don’t know it is only difficult if you don’t understand it. If other people find it difficult then you think it is not difficult then you can’t really call it difficult.” |

To label the source of the data the four students are labeled S1, S2, S3, and S4, and the two instructors are labeled T1 and T2.
**Phase 3**

The administration of an instrument containing the items surviving from phase two, items from a previously published subscale (PPSS), and items asking about gender and course grade was the source of data for phase three. These data were examined through an exploratory factor analysis, and a confirmatory factor analysis where a measurement model was constructed. I then built a structural equation model with achievement regressed upon the latent variables from the measurement model. I added gender to this model as a moderating variable and then grouped the model by gender to report differences in male and female participants. Finally, bivariate correlations between the PPSS and the latent variable from the measurement model intended to measure the same construct were reported. These analyses provided evidence for internal structural validity and validity based on relationships between variables.

**Descriptive Statistics**

Three surveys were developed for phase three. All three surveys contained the items surviving from the phase two analysis, and each had one of three complete subscales from PPSS attached to the instrument after the surviving phase two items. Thus an intrinsic survey had the items representing intrinsic motivation from the *Intrinsic Motivation Inventory* (selfdeterminationtheory.org), a performance survey had the items representing performance goal orientations from the *PALS* (Midgley, et al. 2000) attached, and a mastery survey had the items representing mastery goal orientations from the *PALS* (Midgley, et al. 2000) attached. All surveys had two final items asking for the participant’s gender and current course letter grade. See Table 4 for descriptive statistics of all items except the ones from the PPSS.
Table 4. Descriptive Statistics for Phase-Three Instruments (n=186).

<table>
<thead>
<tr>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
</tr>
<tr>
<td>im17</td>
</tr>
<tr>
<td>im4</td>
</tr>
<tr>
<td>im18</td>
</tr>
<tr>
<td>im16</td>
</tr>
<tr>
<td>mo7</td>
</tr>
<tr>
<td>mo9</td>
</tr>
<tr>
<td>mo10</td>
</tr>
<tr>
<td>mo8</td>
</tr>
<tr>
<td>ms8</td>
</tr>
<tr>
<td>ms11</td>
</tr>
<tr>
<td>ms6</td>
</tr>
<tr>
<td>ms3</td>
</tr>
<tr>
<td>em4</td>
</tr>
<tr>
<td>em6</td>
</tr>
<tr>
<td>em15</td>
</tr>
<tr>
<td>po4</td>
</tr>
<tr>
<td>po3</td>
</tr>
<tr>
<td>po2</td>
</tr>
<tr>
<td>po5</td>
</tr>
<tr>
<td>ps1</td>
</tr>
<tr>
<td>ps4</td>
</tr>
<tr>
<td>ps6</td>
</tr>
<tr>
<td>ps8</td>
</tr>
<tr>
<td>se5</td>
</tr>
<tr>
<td>se8</td>
</tr>
<tr>
<td>se13</td>
</tr>
<tr>
<td>se17</td>
</tr>
<tr>
<td>tv4</td>
</tr>
<tr>
<td>tv6</td>
</tr>
<tr>
<td>tv1</td>
</tr>
<tr>
<td>ex7</td>
</tr>
<tr>
<td>ex5</td>
</tr>
<tr>
<td>ex11</td>
</tr>
<tr>
<td>ex10</td>
</tr>
<tr>
<td>gender</td>
</tr>
</tbody>
</table>

I used the following abbreviations, intrinsic motivation (im), mastery orientation (mo), extrinsic motivation (em), performance orientation (po), self-efficacy (se), expectancy (ex), task-value (tv). See Appendix A for the original items.
In the expert commentary from phase one, concerns were voiced about the factors representing extrinsic motivation, self-efficacy, and task-value. These experts communicated that extrinsic motivation was too broad of a construct for an abbreviated instrument, self-efficacy was not represented in this instrument because the domain needed to be defined more narrowly, and the task-value items did not adequately represent task-value. Because of these theoretical concerns over the extrinsic motivation, self-efficacy, and task-value subscales, I excluded items meant to represent these constructs from the remainder of analyses, and as the instructor and student cognitive interviews made the classroom dependency of responses to the mastery and performance structure subscales apparent, these items were not included in the remainder of analyses. Cronbach’s alpha was computed separately for each of the remaining four subscales. After separating the responses into three groups based on the three previously published subscales (PPSS), Cronbach’s alpha was computed for each of the factors for each of the instruments. See Tables 5 thru 8 for reliability estimates of the analyzed instruments.

Table 5. Internal Consistency for Four Factor Instrument

<table>
<thead>
<tr>
<th></th>
<th># items</th>
<th>Cronbach's alpha</th>
<th>Lower Bound</th>
<th>Upper Bound</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combined instrument</td>
<td>16</td>
<td>.87</td>
<td>.85</td>
<td>.90</td>
</tr>
<tr>
<td>Intrinsic motivation</td>
<td>4</td>
<td>.90</td>
<td>.88</td>
<td>.92</td>
</tr>
<tr>
<td>mastery orientations</td>
<td>4</td>
<td>.88</td>
<td>.85</td>
<td>.91</td>
</tr>
<tr>
<td>performance orientations</td>
<td>4</td>
<td>.85</td>
<td>.81</td>
<td>.88</td>
</tr>
<tr>
<td>Expectancy</td>
<td>4</td>
<td>.89</td>
<td>.86</td>
<td>.91</td>
</tr>
</tbody>
</table>

This only includes the four remaining factors associated with the Motivation for Mathematics Abbreviated Instrument (n=183).
Table 6. Internal Consistency for Phase 3 Intrinsic Motivation Instrument.

<table>
<thead>
<tr>
<th># items</th>
<th>Cronbach's alpha</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combined instrument</td>
<td>21</td>
<td>.92</td>
</tr>
<tr>
<td>Intrinsic motivation</td>
<td>4</td>
<td>.90</td>
</tr>
<tr>
<td>mastery orientations</td>
<td>4</td>
<td>.86</td>
</tr>
<tr>
<td>performance orientations</td>
<td>4</td>
<td>.89</td>
</tr>
<tr>
<td>Expectancy</td>
<td>4</td>
<td>.91</td>
</tr>
<tr>
<td>PPSS intrinsic</td>
<td>5</td>
<td>.92</td>
</tr>
</tbody>
</table>

This includes five items from a previously published subscale (PPSS) associated with intrinsic motivation (n=60).

Table 7. Internal Consistency for Phase 3 Mastery Orientation Instrument.

<table>
<thead>
<tr>
<th># items</th>
<th>Cronbach's alpha</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combined instrument</td>
<td>22</td>
<td>.93</td>
</tr>
<tr>
<td>Intrinsic motivation</td>
<td>4</td>
<td>.88</td>
</tr>
<tr>
<td>mastery orientations</td>
<td>4</td>
<td>.92</td>
</tr>
<tr>
<td>performance orientations</td>
<td>4</td>
<td>.86</td>
</tr>
<tr>
<td>Expectancy</td>
<td>4</td>
<td>.91</td>
</tr>
<tr>
<td>PPSS mastery</td>
<td>6</td>
<td>.93</td>
</tr>
</tbody>
</table>

This includes six items from a previously published subscale (PPSS) associated with mastery orientations (n=64).

Table 8. Internal Consistency for Phase 3 Performance Orientation Instrument.

<table>
<thead>
<tr>
<th># items</th>
<th>Cronbach's alpha</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combined instrument</td>
<td>21</td>
<td>.86</td>
</tr>
<tr>
<td>Intrinsic motivation</td>
<td>4</td>
<td>.91</td>
</tr>
<tr>
<td>mastery orientations</td>
<td>4</td>
<td>.85</td>
</tr>
<tr>
<td>performance orientations</td>
<td>4</td>
<td>.77</td>
</tr>
<tr>
<td>Expectancy</td>
<td>4</td>
<td>.85</td>
</tr>
<tr>
<td>PPSS performance</td>
<td>5</td>
<td>.86</td>
</tr>
</tbody>
</table>

This includes five items from a previously published subscale (PPSS) associated with performance orientations (n=61).
Exploratory Factor Analysis

To provide evidence of validity based on the internal structure of the administered survey and utilizing Mplus version 7.4, an exploratory factor analysis was conducted on the 16 items that represented intrinsic motivation, mastery orientations, performance orientations, and expectancy. Unlike the items that represented the other constructs these four constructs were not plagued with theoretical or dependency issues as evident from the expert comments, and the cognitive student and instructor interviews. As all four factors represented motivation and hence were correlated, an oblique Geomin rotation was used. I selected four factors in this analysis because the first four factors had eigenvalues greater than one with the eigenvalue for the fifth factor less than one, a scree plot revealed a noticeable steepening in slope after the fourth factor, and parallel analysis also determined a four factor solution was appropriate. See Figure 1 for the scree plot and Figure 2 for the parallel analysis plot. The four extracted factors loaded along theoretical lines as may be seen on the pattern matrix in Table 9 and the structure matrix in Table 10. These four factors were considered reliable as they each contained four items with all of their loadings above .600 (Stevens, 2009). All but one item had loadings above .729.
Figure 1. Scree plot displaying the result of an exploratory analysis of items from the phase three administration of the Motivation for Mathematics Abbreviated Instrument (MMAI).*

*Notice the marked change in slope after the fourth factor. This analysis resulted in four factors with an Eigenvalue greater than one, and these four factors explained 71.6% of the variance in the model.

Figure 2. Parallel analysis plot demonstrating the four factor structure of the 16 relevant items from the phase three administration of the MMAI.*

*Notice the first four items are clearly above the parallel analysis eigenvalues.
### Table 9. Pattern Matrix from Exploratory Factor Analysis.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>im17</td>
<td>.773*</td>
<td>.057</td>
<td>-.050</td>
<td>.108</td>
</tr>
<tr>
<td>im4</td>
<td>.703*</td>
<td>.081</td>
<td>.026</td>
<td>-.085</td>
</tr>
<tr>
<td>im18</td>
<td>.854*</td>
<td>.016</td>
<td>-.014</td>
<td>.069</td>
</tr>
<tr>
<td>im16</td>
<td>.929*</td>
<td>-.037</td>
<td>.043</td>
<td>.001</td>
</tr>
<tr>
<td>mo7</td>
<td>.078</td>
<td>.744*</td>
<td>-.041</td>
<td>-.017</td>
</tr>
<tr>
<td>mo9</td>
<td>-.071</td>
<td>.923*</td>
<td>-.017</td>
<td>-.014</td>
</tr>
<tr>
<td>mo10</td>
<td>.060</td>
<td>.742*</td>
<td>.020</td>
<td>.035</td>
</tr>
<tr>
<td>mo8</td>
<td>.039</td>
<td>.741*</td>
<td>-.031</td>
<td>.041</td>
</tr>
<tr>
<td>po4</td>
<td>.054</td>
<td>-.024</td>
<td>.621*</td>
<td>.052</td>
</tr>
<tr>
<td>po3</td>
<td>-.135</td>
<td>.035</td>
<td>.794*</td>
<td>.104</td>
</tr>
<tr>
<td>po2</td>
<td>-.027</td>
<td>.119</td>
<td>.794*</td>
<td>.010</td>
</tr>
<tr>
<td>po5</td>
<td>.176*</td>
<td>-.061</td>
<td>.816*</td>
<td>-.107</td>
</tr>
<tr>
<td>ex7</td>
<td>-.028</td>
<td>.041</td>
<td>.012</td>
<td>.748*</td>
</tr>
<tr>
<td>ex5</td>
<td>.052</td>
<td>-.037</td>
<td>-.007</td>
<td>.869*</td>
</tr>
<tr>
<td>ex11</td>
<td>-.006</td>
<td>.122</td>
<td>.094</td>
<td>.723*</td>
</tr>
<tr>
<td>ex10</td>
<td>.032</td>
<td>-.029</td>
<td>-.025</td>
<td>.860*</td>
</tr>
</tbody>
</table>

Pattern matrix resulting from principle axis factoring using Geomin rotation for a four factor exploratory model that included items representing the four constructs intrinsic motivation (im), mastery orientations (mo), performance orientations (po), and expectancy (ex). *p<.05

### Table 10. Structure Matrix from Exploratory Factor Analysis.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>im17</td>
<td>.833</td>
<td>.437</td>
<td>.065</td>
<td>.407</td>
</tr>
<tr>
<td>im4</td>
<td>.710</td>
<td>.362</td>
<td>.090</td>
<td>.216</td>
</tr>
<tr>
<td>im18</td>
<td>.885</td>
<td>.422</td>
<td>.094</td>
<td>.390</td>
</tr>
<tr>
<td>im16</td>
<td>.917</td>
<td>.382</td>
<td>.133</td>
<td>.341</td>
</tr>
<tr>
<td>mo7</td>
<td>.406</td>
<td>.778</td>
<td>.164</td>
<td>.331</td>
</tr>
<tr>
<td>mo9</td>
<td>.332</td>
<td>.883</td>
<td>.119</td>
<td>.339</td>
</tr>
<tr>
<td>mo10</td>
<td>.404</td>
<td>.786</td>
<td>.153</td>
<td>.370</td>
</tr>
<tr>
<td>mo8</td>
<td>.380</td>
<td>.771</td>
<td>.101</td>
<td>.356</td>
</tr>
<tr>
<td>po4</td>
<td>.127</td>
<td>.121</td>
<td>.635</td>
<td>.213</td>
</tr>
<tr>
<td>po3</td>
<td>.001</td>
<td>.145</td>
<td>.811</td>
<td>.262</td>
</tr>
<tr>
<td>po2</td>
<td>.112</td>
<td>.238</td>
<td>.812</td>
<td>.243</td>
</tr>
<tr>
<td>po5</td>
<td>.193</td>
<td>.102</td>
<td>.798</td>
<td>.132</td>
</tr>
<tr>
<td>ex7</td>
<td>.269</td>
<td>.341</td>
<td>.198</td>
<td>.757</td>
</tr>
<tr>
<td>ex5</td>
<td>.358</td>
<td>.346</td>
<td>.204</td>
<td>.871</td>
</tr>
<tr>
<td>ex11</td>
<td>.327</td>
<td>.435</td>
<td>.289</td>
<td>.794</td>
</tr>
<tr>
<td>ex10</td>
<td>.336</td>
<td>.339</td>
<td>.183</td>
<td>.854</td>
</tr>
</tbody>
</table>

Structure matrix resulting from principle axis factoring using Geomin rotation for a four factor exploratory model that included items representing the four constructs intrinsic motivation (im), mastery orientations (mo), performance orientations (po), and expectancy (ex).
Confirmatory Factor Analysis

Following the structure revealed in the four factor exploratory analysis that included the items representing the four remaining constructs and utilizing Mplus version 7.4, a confirmatory factor analysis was conducted. The factors representing intrinsic motivation, performance orientations, mastery orientations, and expectancy were linked to the four surviving items from phase two that represented these respective constructs. Maximum Likelihood Robust (MLR) was used as an estimator. Although this model did contain significant misfit, $X^2(98, N = 186) = 148.48, p = .0008$, based on its fit indices, $RMSEA = .053 90\% CI [.034, .069], CFI = .964, SRMR = .045$ it was a reasonably good fit for the data. Modification indices revealed two performance items –po3 and po5– to have correlated error $X^2(1, N = 186) = 10.014$, and two expectancy items –ex5 and ex10– to have correlated error $X^2(1, N = 186) = 12.379$. These were significant enough that a modification to the model would improve the overall fit. After allowing these pairs of items to correlate, the fit of the model improved with $X^2(96, N = 186) = 126.57, p = .0200, RMSEA = .041 90\% CI [.017, .060], CFI = .978, SRMR = .042$. However, for the remainder of the analyses errors of these items were not allowed to correlate. See Figure 3 for the final model with four latent factors and no correlated errors.
Relationships between Motivation, Gender, and Achievement

To provide evidence of validity based on relationships to other variables, a structural equation model was built to determine relationships between achievement and the latent constructs associated with motivation. I ran the model in Mplus 7.4 and used MLR as the estimator. This was appropriate because achievement had significant deviations from normality as shown by its skewness (-1.34) and kurtosis (1.90), and MLR may be a robust estimator to
deviations from normality (Powell, 2013). Figure 4 is the structural equation model showing the relationships between the four factors in the measurement model and achievement. The analysis indicated this model was a reasonably good fit for the data $X^2(110, N = 186) = 162.985 p = .0008$, $RMSEA = .051$ 90% C.I. (.033, .067), $CFI = .965$, $SRMR = .045$, and 36% of the variance in achievement was explained by this model. The only latent factor representing motivation that was a significant predictor of achievement was expectancy.

Figure 4. Structural equation model showing relationship between latent factors measuring motivation and achievement.*

*I used maximum likelihood robust as an estimator. Expectancy was the only factor that was a significant indicator of achievement.

*p < .001
I also conducted analyses to determine if gender had a moderating effect on the relationships between the latent factors measuring motivation and achievement. First, measurement invariance based on gender was examined. As chi-square could not be compared in the regular way because of the use of MLR in estimation, Mplus 7.4 was relied on for chi-square differences between configural, scalar, and metric invariance. Configural invariance assumed that the configuration of the measurement model was the same for both genders, but the intercepts, slopes, and error terms were allowed to vary between groups. Metric invariance assumed configural invariance, but forced the factor loadings to be the same for both genders. Scalar invariance assumed metric invariance but added a further restraint forcing the intercepts to be the same for both genders. As the fit of the model did not get significantly worse with each level of added restraint, invariance testing revealed that metric invariance held across gender. See Table 11 for chi-square and degrees of freedom differences as well as fit indices for each level of invariance.

**Table 11. Summary table for Measurement Invariance.**

<table>
<thead>
<tr>
<th></th>
<th>$\chi^2$</th>
<th>d. f.</th>
<th>$\Delta \chi^2$</th>
<th>$\Delta$ d. f.</th>
<th>CFI</th>
<th>RMSEA</th>
<th>SRMR</th>
</tr>
</thead>
<tbody>
<tr>
<td>configural model</td>
<td>262.937</td>
<td>196</td>
<td></td>
<td></td>
<td>0.954</td>
<td>0.061</td>
<td>0.061</td>
</tr>
<tr>
<td>metric invariance</td>
<td>273.648</td>
<td>208</td>
<td>10.27</td>
<td>12</td>
<td>0.955</td>
<td>0.059</td>
<td>0.067</td>
</tr>
<tr>
<td>scalar invariance</td>
<td>290.742</td>
<td>220</td>
<td>17.196</td>
<td>12</td>
<td>0.952</td>
<td>0.059</td>
<td>0.07</td>
</tr>
</tbody>
</table>

*Summary table of likelihood ratio test for differential item functioning across gender using Mplus version 7.4 and MLR estimator.*

To determine if gender had a moderating effect on the relationships between the four latent factors associated with motivation and achievement, I created interaction variables to represent each latent variable’s interaction with gender. Then achievement was regressed on the
four latent variables along with gender and its four interaction variables. See Table 12 for the parameter estimates of this model. This model revealed the interaction between gender and expectancy was significant ($p = .001$), the interaction between gender and performance was significant ($p = .049$), and the interaction between gender and mastery was almost significant ($p = .058$).

Table 12. Regression of Achievement on Latent Variables Moderated by Gender.

<table>
<thead>
<tr>
<th>Achievement on</th>
<th>parameter</th>
<th>S.E.</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>intercept</td>
<td>3.138</td>
<td>0.095</td>
<td>.000</td>
</tr>
<tr>
<td>intrinsic</td>
<td>0.167</td>
<td>0.115</td>
<td>.147</td>
</tr>
<tr>
<td>mastery</td>
<td>-0.228</td>
<td>0.150</td>
<td>.129</td>
</tr>
<tr>
<td>performance</td>
<td>-0.098</td>
<td>0.124</td>
<td>.429</td>
</tr>
<tr>
<td>expectancy</td>
<td>0.932</td>
<td>0.161</td>
<td>.000</td>
</tr>
<tr>
<td>female</td>
<td>0.156</td>
<td>0.106</td>
<td>.141</td>
</tr>
<tr>
<td>female * intrinsic</td>
<td>-0.067</td>
<td>0.142</td>
<td>.639</td>
</tr>
<tr>
<td>female * mastery</td>
<td>0.289</td>
<td>0.152</td>
<td>.058</td>
</tr>
<tr>
<td>female * performance</td>
<td>0.306</td>
<td>0.156</td>
<td>.049</td>
</tr>
<tr>
<td>female * expectancy</td>
<td>-0.574</td>
<td>0.175</td>
<td>.001</td>
</tr>
</tbody>
</table>

*Parameters from structural equation model demonstrating relationship between the dependent achievement variable and latent motivation variables being moderated by gender. MLR used as estimator.*

As this demonstrated the relationships between expectancy and achievement, and performance and achievement were significantly moderated by gender, I conducted a structural equation model analysis with observations grouped by gender to better interpret these differences. In this analysis, performance orientations had a significant ($p = .031$) direct relationship with achievement in females but not in males, and expectancy had a significant direct relationship to achievement for both males ($p < .001$) and females ($p = .003$). Although gender was not shown to be a significant moderator on the relationship between intrinsic
motivation and achievement, or between mastery orientations and achievement; intrinsic motivation did show a nonsignificant \( p = .087 \) direct relationship with achievement for males, and mastery orientations were inversely related to achievement for males but not for females. See Figure 5 for regression equations.

\[
\text{Achievement for males}^* \\
A = 3.103 + 0.227 \text{im} - 0.221 \text{mo} - 0.087 \text{po} + 0.831 \text{ex}
\]

\[
\text{Achievement for females}^* \\
A = 3.264 + 0.082 \text{im} + 0.054 \text{mo} + 0.191 \text{po} + 0.362 \text{ex}
\]

**Figure 5.** Regression equations for achievement (A) on intrinsic motivation (im), mastery orientations (mo), performance orientations (po), and expectancy (ex). Observations were grouped by gender.

*The only slope parameter that was significantly different than zero for males was expectancy \( p < .001 \); however, performance \( p = .031 \) and expectancy \( p = .003 \) were significant for females.*

Finally, bivariate correlations were examined between the previously published subscales (PPSS) and the factors from the Motivation for Mathematics Abbreviated Instrument (MMAI) that were intended to represent the same construct. Of the 186 participants who took the survey, 64 took the survey with the intrinsic motivation PPSS attached, 61 took the survey with the mastery orientation PPSS attached, and 61 took the survey with the performance orientation PPSS attached. An analysis of internal consistency using Cronbach’s alpha revealed the instrument with intrinsic motivation PPSS attached had a reliability estimate of .943 for the PPSS and .899 for the intrinsic motivation factor from the MMAI. The instrument with the mastery orientation PPSS attached had a reliability estimate of .901 for the PPSS and .916 for the
Mastery orientation factor from the MMAI, and the instrument with the performance orientation PPSS attached had a reliability estimate of .882 for the PPSS and .767 for the Performance orientation factor from the MMAI. The instrument with the intrinsic motivation PPSS attached demonstrated a correlation between the latent intrinsic motivation factor from the MMAI and the latent intrinsic motivation PPSS to be .981. The instrument with the mastery orientation PPSS attached demonstrated a correlation between the latent mastery orientation factor of the MMAI and the latent mastery orientation PPSS to be .558. The instrument with the performance orientation PPSS attached demonstrated a correlation between the latent performance orientation factor of the MMAI and the latent performance orientation PPSS to be .823. All of these correlations were significantly different than 0 (p <.001).
CHAPTER FIVE
DISCUSSION

Beginning with items intended to measure factors associated with self-determination, self-efficacy, achievement goal theory, and expectancy-value, I undertook a quest for a combined instrument. I never found this grand all-encompassing abbreviated instrument. Factors fell away as evidence suggested the related construct was not well represented, I removed items as evidence suggested they were not the best representatives of their construct, and in the end an abridged instrument emerged. This abbreviated instrument had reasonably good measurement properties, and may be able to measure some of the important factors from some of the most influential theories on motivation.

Experts voiced strong arguments against some of the original premises of this study. In an attempt to measure extrinsic motivation, an argument was made that this effort was futile. Extrinsic motivation was not defined narrowly enough for an abbreviated measure. Ryan and Deci (2000) explained motivation as a continuum from intrinsic motivation to amotivation with four main types of extrinsic motivation between. It became apparent that trying to represent this broad structure with relatively few items would be close to impossible. Other experts held the view that all items in any instrument measuring motivation except for items that measure intrinsic motivation and perhaps items that represent the opposite of motivation could be thought of as measuring some form of extrinsic motivation. Although this seemed to be an extreme
position, the broadly defined continuous nature of the extrinsic motivation construct meant extrinsic motivation was out.

Experts also voiced concerns over self-efficacy as it was being represented. This argument; however, went in the opposite direction. Instead of attempting to represent a broad construct narrowly, I was representing a narrow construct broadly. Self-efficacy—as defined by Bandura (1986)—is always in reference to a specific domain, and the experts did not see asking students about their self-efficacy for mathematics as an appropriate line of questioning. Certainly asking students if they are self-efficacious in calculus is a different question than asking students if they are self-efficacious in algebra. To ask students if they are self-efficacious in mathematics was meaningless, and therefore, self-efficacy was out.

When judging the task-value items, experts voiced similar concerns about whether the original pool of items represented the multifaceted nature of the construct, and whether the general domain of mathematics was specific enough for students to be able to respond to the items. Several studies have looked into the multifaceted nature of task-value with Eccles (1987) separating task-value into utility, attainment, liking, and cost, or a few years later with Eccles and Wigfield (1995) separating task-value into three factors representing intrinsic interest, attainment value, and extrinsic utility. This multifaceted nature of task-value led to concerns that the construct may not have been adequately represented. The other concern was over the vagueness of questions such as “I will be able to use the mathematics I learn?” These questions seemed to force students into having to read content into the question. Students had questions similar to, “what mathematics are you talking about,” and made statements similar to, “certainly there is some mathematics that might be useful, but the mathematics I learned today may not be as useful as the mathematics I will learn tomorrow.” This led to the opinion that task-value was
being underrepresented and was too domain specific to be included in this generalized type of instrument. Thus, task-value was out.

Now comes the question, what is left? Experts had general agreement on the intrinsic motivation items and the expectancy items. They also generally agreed on the mastery orientation and performance orientation items. Although there was some concerns over the wording of the mastery and performance structure items these also gained some endorsement; however, these concerns were born out during the student cognitive interview process. There was an inherent dependency implied by the structure items. Although I made some effort to word these items in a general manner, the cognitive interviews made it clear this could not be done. When students were asked about working towards understanding mathematical content or about the importance of taking math tests, they inevitably reflected on the course in which they were currently enrolled. Although these factors may have been adequately represented by their respective items, the dependency associated with students being clustered into classrooms led these factors to be excluded from the final model. Therefore, the final Motivation for Mathematics Abbreviated Instrument (MMAI) consisted of four factors representing intrinsic motivation, mastery orientations, performance orientations, and expectancy.

In this chapter I discuss how data from this study supplied evidence for three sources of validity by examining content validity, validity based on relationships between variables, and validity based on the internal structure of the instrument. The validity evidence is then related back to this studies original research questions. Through a discussion about the limitations of this study and the implications that the development of an abbreviated measure might have on future research. I conclude by discussing the study’s findings and how practitioners and researchers alike my find the developed instrument useful.
Validity Evidence

As validity is an ongoing process with evidence for validity found through various sources, it is not possible to state an instrument is valid. Instead, evidence for validity may be presented from the various sources of validity and in this way a validity argument is established. The focus of this study was to develop and validate an instrument intended to measure motivation in mathematics for university undergraduate students in developmental algebra courses. To bolster this argument, three of the five sources of validity as defined by the Standards for Educational and Psychological Testing (American Educational Research Association, 2014) were addressed through the collection and examination of qualitative and quantitative data. I addressed a fourth source – validity based on response processes – to some extent by an original impetus for the study. Not only was the MMAI intended to measure motivation for mathematics, but an important focus of the study was to make this instrument abbreviated so that in the future it could be implemented in a reasonably short amount to time. The final resultant instrument was sixteen items long with four items for each of four factors. See Appendix G for a copy of the final MMAI.

Evidence Based on Content

The first and third research questions concerned evidence to bolster content validity. The first question was;

1. To what extent do the items in the Motivation for Mathematics Abbreviated Instrument (MMAI) represent their intended constructs?
I answered this question through an online survey of experts and through cognitive interviews with instructors and students. Expert commentary to the online survey revealed that several of the intended constructs could not to be represented by an abbreviated instrument measuring mathematics in a generalized domain. Because of this, extrinsic motivation, self-efficacy, and task-value items were removed from the final version of the MMAI. The remaining items were all chosen by the majority of experts as being reasonable representations of their intended constructs; however, the final items included in the MMAI were not necessarily the most popular with experts.

I revealed issues during the cognitive interviews that were not exposed through the expert selections and commentary. Phrases such as very much and a lot forced students to quantify cognitive processes and tended to confuse and obfuscate responses. Also phrases such as well-regarded and look smart tended to have unintended social consequences. Students believed they had more important qualities than being good at math, so being well-regarded had little to do with math. Students also did not do math to look smart as that might imply they were trying to show off. As a result of these types of issues, several items were removed.

Other researchers developed all of the surviving items to represent their intended constructs, and all surviving items came from previously published surveys that had some level of validation in the literature. They were each chosen by a majority of the respondents from the AERA SIG for motivation as being good representations of their intended construct, and were not removed from contention because of issues arising from cognitive interviews with subjects from their intended audience. Effect sizes computed from the cognitive interview data revealed the items may have encouraged cognitive processes aligned with their respective constructs. All
of this may add to the content validity argument as does evidence used to answer the third research question.

The third research question was;

3. What relationships exist between the factors representing the included constructs from the Motivation for Mathematics Abbreviated Instrument (MMAI) and previously published subscales representing intrinsic motivation, mastery goals, and performance goals?

To answer this question, a four factor measurement model was generated, and correlations between the factors from the previously published subscales (PPSS) and the latent factors from the MMAI intended to represent similar constructs were analyzed. In every case, the PPSS were significantly correlated to the similar factors. Thus the intrinsic motivation subscale from the Intrinsic Motivation Inventory (selfdeterminationtheory.org) was directly correlated to the intrinsic motivation subscale of the MMAI, the mastery orientation subscale from the PALS (Midgley, et al. 2000) was directly correlated to the mastery orientation subscale of the MMAI, and the performance orientation subscale from the PALS (Midgley, et al. 2000) was directly correlated to the performance orientation subscale of the MMAI. The intrinsic motivation relationship was very strong and the factors from the PPSS and from the MMAI both had good reliability. Therefore this demonstrated good external convergent validity. The performance orientation relationship was strong; however, both factors had weak reliability. This may be indicative of issues with student interpretations of items, or it may indicate there was some dependence between items associated with clustering of data around classrooms or content. The
mastery orientation relationship was not particularly strong, but the small number of items showed reasonably good reliability. This may be indicative of some issues associated with the items from the mastery orientation PPSS concerning poor wording as demonstrated in the student cognitive interviews concerning the MMAI items. Although further work with the PPSS could clarify some of these issues, all three of these relationships lend further evidence for the content validity of the MMAI.

**Evidence Based on Relationships to Other Variables**

To build a case for validity with evidence from relationships to other variables, factors from the MMAI structural equation model were included in a linear regression with the dependent variable achievement. To examine whether gender was a moderating variable on this relationship, gender and interaction terms between gender and the four latent variables representing the factors from the MMAI in a second analysis were included in the regression. The research question explored was;

4. What relationships exist between the included factors in the Motivation for Mathematics Abbreviated Instrument, gender, and self-reported student achievement, and how are these relationships similar to previously reported relationships in educational research?

The first regression revealed expectancy was the only significant predictor of achievement. As achievement in this study was self-reported by having students answer the question “My current
grade in the class is A B C D F.” Having expectancy highly correlated to achievement seemed reasonable. Students who self-reported a high grade expected to make high grades.

The second regression demonstrated gender was a significant moderator of the relationship between the factors on motivation and achievement, and this is aligned with earlier research by Butler (2014). Similar to Butler’s findings, females had higher achievement than males and intrinsic motivation was a stronger predictor of achievement for males than for females. This second regression also revealed a significant relationship between performance orientation and achievement for females, and a non-significant inverse relationship between mastery orientation and achievement for males. These are also somewhat aligned with findings by Meece, Anderman, and Anderman (2006). As these relationships between motivation and achievement with gender as a moderating variable are similar to earlier findings, they lend evidence to the validity argument.

**Evidence Based on Internal Structure**

With the purpose of providing validity evidence based on the internal structure of the MMAI, the second research question was;

2. To what extent can a latent factor measurement model that represents the included constructs in the Motivation for Mathematics Abbreviated Instrument be found to fit response data from developmental algebra college students?

To begin the process of conducting an exploratory factor analysis, descriptive statistics and internal consistency estimates were reported. The descriptive statistics revealed some deviations
from normality of several items included in the final model; however, none of these items to be included in the exploratory factor analysis had skewness or Kurtosis values with magnitudes greater than 1. Cronbach’s alpha was utilized as a measure of the internal consistency. The four factors in the final model each contained four items with Cronbach’s alpha for the intrinsic motivation factor being .901, the mastery orientation factor being .879, the performance orientation factor being .846, and the expectancy factor being .891. Although reliability estimates using Cronbach’s alpha are expected to be low when using such a small number of items, these reliability estimates may indicate this instrument had some issues with internal inconsistency. As the final model was only 16 of the 43 items included in the survey, some noise may have been created by the inclusion of items not associated with the final MMAI, and some dependency of responses based on clustering of students within classes may have led to weaker reliability estimates.

I conducted an exploratory factor analysis with these same sixteen items and revealed a four factor solution was desirable by parallel analysis, eigenvalue greater than one, and a scree plot. As theory indicated a four factor solution, this result was as a strong indication of the instrument aligning with theory. The pattern matrix resulting from an oblique rotation revealed all loadings within factors to be greater than .729 except one item that loaded on the performance orientation factor at .637. All loadings outside of factors were less than .157. This provided evidence of good internal convergence within factors and good internal discrimination between factors.

A confirmatory factor analysis using a measurement model linking these sixteen items to their respective four latent factors also revealed strong discrimination between factors and convergence within factors, and with reasonably good fit indices (RMSEA=.062 90% C.I.(.046,
the model demonstrated a good fit for the data. Modification indices associated with this model revealed significantly correlated errors between two pairs of items. Although these correlated errors did imply that these paired items may be too similar in meaning, the exploratory factor analysis and the good fit of the confirmatory factor analysis did provide evidence of validity based on the internal structure of the MMAI.

Limitations

A limitation of this study that affected the analysis was the limited amount of data collected. Much of the qualitative interview data revealed a dependency in the data based on clusters of students with classrooms, and although 186 participant responses were collected during phase three of this study, these responses came from only twelve classrooms taught by only five instructors. Because of this clustering of the data and the small number of clusters, it was not possible to explore the multilevel nature of the observations. Therefore, concerns over violating the assumption that observations must be independent may be well founded.

Another limitation was that the study focused on students in developmental algebra courses at a public university. This focus provided better external validity with the chosen population; however, it also limited the generalizability of the instrument to other audiences. Even though some of the items originated from surveys used to measure motivation in elementary through high school students, none of the evidence used in this validity study came from this population. This makes it difficult to construct an argument that this instrument is a valid measure of motivation for mathematics students not enrolled in developmental algebra courses.
Another limitation was the source of the items. All items were sourced from previously published surveys, and although this did add evidence for content validity, no mechanism existed to fabricate new items when a construct was believed to be misrepresented. Analysis of the qualitative data revealed problematic wording in several of the items, and in several situations this caused the item to be removed. This was a byproduct of a one-way dialogue with experts. Therefore, bilateral communication between experts and researchers would have been beneficial and may have allowed for more modifications of existing items and the possibility of writing new items when necessary.

Implications of the Results for Practice

The purpose of this study was to provide researchers a tool that could be used to measure motivation across frameworks, and an abbreviated instrument with an initial validity argument has been produced. This instrument has evidence for content validity, it has been shown to reveal relationships between the included constructs and other variables in a manner similar to what is provided in current research, and it has good internal consistency. Therefore, future researchers should be able to take advantage of this work and use this instrument in future studies that need to measure motivation in mathematics. As well as research, practitioners and grant writers may also find benefits in using this instrument. Classroom instructors who do not want to spend excessive instructional time administering a lengthy survey may see a benefit in an abbreviated measure, and grant writers may see a benefit in measuring changes in motivation over time to document the success of a new grant funded intervention. Therefore the three possible ways this instrument may be used in the future are

- in research by university professors,
• in practice by teachers, and
• to verify progress for grant writers.

Although this survey was designed to measure motivation across constructs, the strong discrimination between factors may indicate that subscales from this instrument could be administered separately.

One impetus of this study was to provide researchers a means to look across constructs on motivation. The MMAI provides a means of looking across constructs concerning intrinsic motivation, achievement goals, and expectancy. This can be done quickly, and therefore, many situations, where teachers and other stakeholders are concerned about classroom disruption, may now be more accessible. Giving a researcher fifteen minutes of class time may be more manageable than longer periods of time. This abbreviated nature of the instrument may also open up different measurement possibilities. Single case studies using motivation as the measured variable, and determining the effects of different classroom interventions may now be possible. Certainly the abbreviated nature of the instrument would make multiple measurements over time possible, and if researchers are only interested in a specific factor this same type of study could be accomplished by utilizing just one of the subscales.

Some of the qualitative data derived from instructor interviews was inconsistent with the student interview data. The instructor with mastery orientations tended to see her students as mastery oriented, and the performance oriented instructor tended to see her students as performance oriented. I attribute some of this to experience; however, it may be a case of seeing what is expected. One valuable use of the MMAI may be to give instructors a means of assessing student beliefs. This instrument gives teachers a quick way to assess student orientations, and the results may be educational for teachers who have performance based deficit views of their
students. If –through the implementation of the MMAI– teachers find their students are mastery oriented, they may change how they approach the subject matter, and if teachers find their students are performance oriented they may rethink course objectives.

As researchers and educators see the need to assess student achievement, many grant writers may also see the importance of measuring motivation of the participants that are the focus of their grant. Often grants have many instruments used for assessing progress, and although the writers of the grants see the importance of understanding some of the cognitive constructs associated with learning and disposition, they may see this as less important than assessing achievement or other grant related foci. The MMAI –as an abbreviated measure– gives grant writers a means of assessing student motivation that is not as intrusive as a longer survey, and therefore, it gives the writers of grants a means of assessing cognitive effects on motivation associated with their intervention. Although achievement scores are important, it is also important that students are motivated to continue learning mathematics throughout their lives regardless of their scores on achievement tests.

**Recommendations for Further Research**

There are at least three overall themes deemed important for future research. These themes can be summarized by

- inclusion of more constructs,
- conducting multi-level analyses, and
- generalizing findings to a larger audience.

By focusing on these three concepts it may be possible to add to the validity evidence and broaden the applicability of this instrument to more constructs and a wider audience.
The work on developing an abbreviated instrument that looks across the original constructs associated with this study is not complete. Self-efficacy and task-value were removed because experts suggested the generalized nature of the items in the MMAI was not appropriate for these two domain specific constructs; however, I do believe self-efficacy items could be coupled with the MMAI if the domain was narrowed. Therefore, a study where the items from the MMAI are altered to focus on a specific domain in mathematics, and these items are included with items meant to measure self-efficacy in the same specific domain may be advantageous. Similarly a study with altered domain specific items from the MMAI coupled with items representing task-value may also be advantageous. These task-value items would also need to be representative of the various facets of task-value per one of the current predominant frameworks on task-value.

Another important thread for future research ties in with the multi-level nature of students’ perceptions of mathematics within classrooms. This data dependency related to differences in classroom norms and instructional pedagogies makes a larger study with many independent classrooms an important future step. In this scenario, the two factors representing mastery and performance structures could be included with the four factors of the current MMAI, and an analysis could be implemented to develop initial validity evidence for a multi-level six factor version. With this tool, it may then be possible to measure differences in motivation between classrooms as well as within classrooms. This type of multilevel analysis has the latent factors on motivation as repeated measures within students, and students within classrooms. This type of study may also benefit by the implementation of a yet to be developed instructor MMAI that has the items reworded so they reflect instructors views of their pedagogical strategies.
Finally, during the current study students in developmental algebra courses were the focus of inquiry. This narrow focus makes it difficult to generalize this instrument to a broader audience. Therefore, future research needs to be conducted with audiences that are increasingly farther removed from the population of this study. A study with high school students in courses with similar content would be valuable to help generalize the use of this instrument to high school students. A study with university students in undergraduate mathematics courses that are not considered developmental would also give valuable generalizability evidence. By slowly increasing the scope of participants, and employing random selection, it may be possible to increase the population that can be measured with this instrument. These types of studies may also give valuable insight as to differences between these disparate populations. These generalization studies may need to be bolstered with qualitative cognitive interview data to understand what processes a participant from a new population is relying upon to respond to the items within the MMAI.

Conclusions

A four factor instrument designed to measure intrinsic motivation as defined in self-determination (Ryan & Deci, 2000), mastery and performance orientations as defined in achievement goal theory (Elliott & Church, 1997), and expectancy as defined in expectancy value (Eccles, 1987) was developed. Some evidence of content validity, validity based on relationships to other variables, and validity based on the internal structure of the instrument was also provided in this initial validation study. Expert selection of items from published surveys measuring similar constructs, expert commentary, cognitive interviews with students and instructors, and correlations between the four factors in the resultant instrument and previously
published surveys provided evidence for content validity of the items in the instrument developed for this study. An exploratory factorial analysis revealed a four factor model with strong discrimination between factors and strong convergence within factors suggesting good internal structure of the developed instrument, and exploratory and confirmatory factor analyses revealed a measurement model based on theoretical considerations fit the data fairly well. These analyses provided evidence of validity based on the internal structure of the instrument. Finally, a structural equation model with achievement regressed on the latent factors from this measurement model with gender as a moderating variable showed expectancy to be a significant predictor of achievement for both males and females, and performance orientations to be a significant predictor of achievement for females. Nonsignificant results suggested that females had higher achievement than males, intrinsic motivation may be more influential for male achievement than for female achievement, and mastery orientations may be inversely related to achievement in males. These relationships were similar to findings from previously published studies on motivation so they provided evidence of validity based on relationships to other variables. Therefore, the final developed Motivation for Mathematics Abbreviated Instrument has some evidence supporting an initial validation argument and may be considered an appropriate tool to use by researchers, practitioners, and grant writers when they are interested in measuring the motivation for mathematics of university level developmental algebra students.
REFERENCES


Reeve, J. (2009). Why teachers adopt a controlling motivating style toward students and how they can become more autonomy supportive. *Educational Psychologist, 44*, 159-175.


APPENDICES
Appendix A: Online Expert Surveys.

**Self-efficacy and Expectancy-value.**

Self-efficacy
To develop an abbreviated measure you are being asked to select the best of many good items sourced from previously validated instruments (see below).

1. Choose two items that best represent self-efficacy sourced from mastery experiences.
   (se1) I make excellent grades on math tests.
   (se2) I have always been successful with math.
   (se3) *Even when I study very hard, I do poorly in math.
   (se4) I got good grades in math on my last report card.
   (se5) I do well on math assignments.
   (se6) I do well on even the most difficult math assignments.
   Comments:

2. Choose two items that best represent self-efficacy sourced from vicarious experiences.
   (se7) Seeing adults do well in math pushes me to do better.
   (se8) When I see how my math teacher solves a problem, I can picture myself solving the problem in the same way.
   (se9) Seeing kids do better than me in math pushes me to do better.
   (se10) When I see how another student solves a math problem, I can see myself solving the problem in the same way.
   (se11) I imagine myself working through challenging math problems successfully.
   (se12) I compete with myself in math.
   Comments

3. Choose two items that best represent self-efficacy sourced from social persuasions.
   (se13) My math teachers have told me that I am good at learning math.
   (se14) People have told me that I have a talent for math.
   (se15) Adults in my family have told me what a good math student I am.
   (se16) I have been praised for my ability in math.
   (se17) Other students have told me that I’m good at learning math.
   (se18) My classmates like to work with me in math because they think I’m good at it.
   Comments

4. Choose two items that best represent self-efficacy sourced from affect.
   (se19) *Just being in math class makes feel stressed and nervous.
   (se20) *Doing math work takes all of my energy.
   (se21) *I start to feel stressed-out as soon as I begin my math work.
   (se22) *My mind goes blank and I am unable to think clearly when doing math work.
   (se23) *I get depressed when I think about learning math.
   (se24) *My whole body becomes tense when I have to do math.
   Comments:
   * items are negatively worded.
Expectancy-value.
To develop an abbreviated measure you are being asked to select the best of many good items sourced from previously validated instruments (see below).

5. Choose five items that best represent utility.
(tv1) I do mathematics because learning math plays a role in reaching my future goals.
(tv2) I do mathematics because learning math is important for attaining my dreams.
(tv3) I do mathematics because my achievement is important for attaining my dreams.
(tv4) I do mathematics because my achievement plays a role in reaching my future goals.
(tv5) I do mathematics because understanding math is important for becoming the person I want to be.
(tv6) I think I will be able to use the mathematics I learn.
(tv7) It is important for me to learn mathematics.
(tv8) I am very interested in mathematics.
(tv9) I think mathematics is useful for me to learn.
(tv10) I like mathematics.
(tv11) Understanding mathematics is very important to me.

Comments:

6. Choose five items that best represent expectancy.
(ex1) If I study in appropriate ways, then I will be able to learn the mathematics for this course.
(ex2) It is my own fault when I don’t learn mathematics.
(ex3) When I try hard enough, then I understand mathematics.
(ex4) When I don’t understand mathematics, it is because I didn’t try hard enough.
(ex5) I believe I will receive excellent grades in a math class.
(ex6) I’m certain I can understand the most difficult material presented in a math class.
(ex7) I’m confident I can understand the basic concepts taught in a math class.
(ex8) I’m confident I can understand the most complex material presented by the instructor in a math class.
(ex9) I’m confident I can do an excellent job on the assignments and tests in a math class.
(ex10) I expect to do well in a math class.
(ex11) I’m certain I can master the skills being taught in a math class.
(ex12) Considering the difficulty of mathematics and my skills, I think I will do well a math class.

Comments:

References:
Extrinsic Motivation and Performance Goals.

To develop an abbreviated measure you are being asked to select the best of many good items sourced from previously validated instruments (see below).

Choose items that best represent extrinsic motivation and at the same time may discriminate extrinsic motivation from performance orientations and also may discriminate intrinsic motivation from performance structures.

1. Choose five items to represent extrinsic motivation
   
   \textit{(em1)} Getting a good grade in my math courses has been the most satisfying thing for me.
   \textit{(em2)} The most important thing for me right now is improving my overall grade point average, so my main concern in my math courses has been getting a good grade.
   \textit{(em3)} If I can, I want to get better grades in my math courses than most of the other students.
   \textit{(em4)} I want to do well in my math courses because it is important to show my ability to my family, friends, employer, or others.
   \textit{(em5)} I do mathematics because I must do it to feel good about myself.
   \textit{(em6)} I do mathematics because people around me think it is important to be intelligent.
   \textit{(em7)} I do mathematics to show others how good I am at it.
   \textit{(em8)} I do mathematics because it helps me maintain good relationships with my peers.
   \textit{(em9)} I do mathematics because it allows me to be well regarded by people that I know.
   \textit{(em10)} I do mathematics because, in my opinion, it is a good way to meet people.
   \textit{(em11)} I do mathematics because I would feel bad if I was not taking time to do it.
   \textit{(em12)} I do mathematics because it is one of the best ways to develop other aspects of myself.
   \textit{(em13)} I do mathematics because it is a good way to learn lots of things which could be useful to me in other areas of my life.
   \textit{(em14)} I do mathematics because it is absolutely necessary to do mathematics if one wants to understand the world.
   \textit{(em15)} I do mathematics for the prestige of being mathematically literate.

   Comments:

2. Choose five items to represent performance orientations
   
   \textit{(po1)} I would feel good if I was the only one who could answer the teacher’s questions.
   \textit{(po2)} In math courses, I have wanted to do better than other students.
   \textit{(po3)} I have felt successful in my math courses when I did better than the other students.
   \textit{(po4)} I have liked showing math teachers that I’m smarter than the other students.
   \textit{(po5)} Doing better than other students in my math courses has been important to me.
   \textit{(po6)} In math courses, it has been important to me that other students think I am good at mathematics.
   \textit{(po7)} One of my goals is to show others that I’m good at mathematics.
   \textit{(po8)} One of my goals is to show others that mathematics is easy for me.
   \textit{(po9)} In my math courses, one of my goals has been to look smart in comparison to the other students.
   \textit{(po10)} In my math courses, it has been important that I look smart compared to others.

   Comments:
3. Choose five items to represent performance structures

(ps1) In my math courses, getting good grades has been the main goal.
(ps2) In my math courses, getting correct answers has been very important.
(ps3) In my math courses, it has been important to get high scores on tests.
(ps4) My math teachers have made it easy to tell which students get the highest grades and which students get the lowest grades.
(ps5) My math teachers have pointed out who gets good grades as an example to others.
(ps6) My math teachers have talked a lot about the importance of getting high test scores.
(ps7) My math teachers have talked a lot about the importance of making the honor roll or being recognized at honor assemblies.
(ps8) My math teachers have encouraged students to compete with each other academically.

Comments:

References:
www.selfdeterminationtheory.org

Intrinsic Motivation and Mastery Goals.

To develop an abbreviated measure you are being asked to select the best of many good items sourced from previously validated instruments (see below).

Choose items that best represent intrinsic motivation and at the same time may discriminate intrinsic motivation from mastery orientations and also may discriminate intrinsic motivation from mastery structures.

1. Choose five items to represent intrinsic motivation.

(im1) I do mathematics for the pleasure that I feel while engaging in difficult tasks.
(im2) I do mathematics for the pleasure that I feel while learning techniques that I have never tried before.
(im3) I do mathematics because I feel a lot of personal satisfaction while mastering certain difficult concepts.
(im4) I do mathematics for the excitement I feel when I am really involved in the activity.
(im5) I do mathematics for the intense emotions that I feel while I am doing activities that I like.
(im6) I do mathematics because I like the feeling of being totally immersed in the activity.
(im7) I do mathematics for the pleasure I feel in discovering new knowledge.
I do mathematics for the pleasure it gives me to know more about the concepts I am studying.
I do mathematics for the pleasure of discovering new strategies to be successful on tests.
I do mathematics for the pleasure of discovering new solution strategies.
In my math courses, I have preferred assignments that really challenge me so I can learn new things.
In my math courses, I have preferred assignments that arouse my curiosity, even if they are difficult to learn.
The most satisfying thing for me in my math courses has been trying to understand the content as thoroughly as possible.
In my math courses, when I have had the opportunity I choose assignments that I can learn from even if they don't guarantee a good grade.
I enjoy doing mathematics very much.
Mathematics is fun to do.
I would describe mathematics as very interesting.
I think mathematics is enjoyable.
While doing mathematics, I think about how much I enjoy it.

Comments:

2. Choose five items to represent mastery orientations.
I like mathematics that I'll learn from even if I make a lot of mistakes.
An important reason why I do mathematics is because I like to learn new things.
I like mathematics best when it really makes me think.
An important reason why I do mathematics is because I want to get better at it.
An important reason I do mathematics is because I enjoy it.
I do mathematics because I'm interested in it.
It’s important to me that I learn a lot of new math concepts this year.
One of my goals in my math courses has been to learn as much as I can.
One of my goals is to master a lot of new mathematics this year.
It’s important to me that I thoroughly understand mathematics.
It’s important to me that I improve my math skills this year

Comments:

3. Choose five items to represent mastery structures.
In my math courses, trying hard has been very important.
In my math courses, how much I improve has been really important.
In my math courses, really understanding the mathematics has been the main goal.
In my math courses, it has been important to understand mathematics, not just memorize it.
In my math courses, learning new ideas and concepts has been very important.
In my math courses, it has been OK to make mistakes as long as I am learning
My math teachers have stressed the importance of trying hard.
My math teachers have thought making mistakes was OK as long as I was learning and improving.
My math teachers have thought that learning should be fun.
My math teachers have emphasized really understanding math, not just memorizing it.
My math teachers have made real efforts to recognize students for effort and improvement.

My math teachers have made real efforts to show students how the mathematics they do in school is related to their lives outside of school.

Comments:

References:
www.selfdeterminationtheory.org
Appendix B: Sources of Items and Original Participants.

Table B1. Sources of items and participants used for original validation study.

<table>
<thead>
<tr>
<th>Construct</th>
<th>Potential Items</th>
<th>Source</th>
<th>Participants</th>
</tr>
</thead>
</table>
| Mastery orientation | I like mathematics that I'll learn from even if I make a lot of mistakes.  
An important reason why I do mathematics is because I like to learn new things.  
I like mathematics best when it really makes me think.  
An important reason why I do mathematics is because I want to get better at it.  
An important reason I do mathematics is because I enjoy it.  
I do mathematics because I'm interested in it.  
It's important to me that I learn a lot of new math concepts this year.  
*One of my goals in my math courses has been to learn as much as I can.  
*One of my goals is to master a lot of new mathematics this year.  
*It’s important to me that I thoroughly understand mathematics.  
*It’s important to me that I improve my math skills this year. | Midgley, et al., 2000 | elementary through high school |
| Performance orientation | I would feel good if I was the only one who could answer the teacher’s questions.  
*In math courses, I have wanted to do better than other students.  
*I have felt successful in my math courses when I did better than the other students.  
*I have liked showing math teachers that I’m smarter than the other students.  
*Doing better than other students in my math courses has been important to me.  
In math courses, it has been important to me that other students think I am good at mathematics.  
One of my goals is to show others that I’m good at mathematics.  
One of my goals is to show others that mathematics is easy for me.  
In my math courses, one of my goals has been to look smart in comparison to the other students.  
In my math courses, it has been important that I look smart compared to others. | Midgley, et al., 2000 | elementary through high school |
| Mastery structures | In my math courses, trying hard has been very important.  
In my math courses, how much I improve has been really important.                                                                                                                                               | Midgley, et al., 2000 | elementary through high school |
Table B1 (Continued)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>In my math courses, really understanding the mathematics has been the main goal.</td>
<td></td>
<td>In my math courses, getting good grades has been the main goal.</td>
<td></td>
<td>I do mathematics for the pleasure that I feel while engaging in difficult tasks.</td>
<td>university athletes</td>
</tr>
<tr>
<td>In my math courses, it has been important to understand mathematics, not just memorize it.</td>
<td></td>
<td>In my math courses, getting correct answers has been very important.</td>
<td></td>
<td>I do mathematics for the pleasure that I feel while learning techniques that I have never tried before.</td>
<td></td>
</tr>
<tr>
<td>In my math courses, learning new ideas and concepts has been very important.</td>
<td></td>
<td>In my math courses, it has been important to get high scores on tests.</td>
<td></td>
<td>I do mathematics because I feel a lot of personal satisfaction while mastering certain difficult concepts.</td>
<td></td>
</tr>
<tr>
<td>In my math courses, it has been OK to make mistakes as long as I am learning</td>
<td></td>
<td>My math teachers have made it easy to tell which students get the highest grades and which students get the lowest grades.</td>
<td></td>
<td>*I do mathematics for the excitement I feel when I am really involved in the activity.</td>
<td></td>
</tr>
<tr>
<td>My math teachers have stressed the importance of trying hard.</td>
<td></td>
<td>My math teachers have pointed out who gets good grades as an example to others.</td>
<td></td>
<td>I do mathematics for the intense emotions that I feel while I am doing activities that I like.</td>
<td></td>
</tr>
<tr>
<td>My math teachers have thought making mistakes was OK as long as I was learning and improving.</td>
<td></td>
<td>My math teachers have talked a lot about the importance of getting high test scores.</td>
<td></td>
<td>I do mathematics because I like the feeling of being totally immersed in the activity.</td>
<td></td>
</tr>
<tr>
<td>My math teachers have thought that learning should be fun.</td>
<td></td>
<td>My math teachers have talked a lot about the importance of making the honor roll or being recognized at honor assemblies.</td>
<td></td>
<td>I do mathematics for the pleasure I feel in discovering new knowledge.</td>
<td></td>
</tr>
<tr>
<td>My math teachers have emphasized really understanding math, not just memorizing it.</td>
<td></td>
<td>My math teachers have encouraged students to compete with each other academically.</td>
<td></td>
<td>I do mathematics for the pleasure it gives me to know more about the concepts I am studying.</td>
<td></td>
</tr>
<tr>
<td>My math teachers have made real efforts to recognize students for effort and improvement.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My math teachers have made real efforts to show students how the mathematics they do in school is related to their lives outside of school.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table B1 (Continued)

<table>
<thead>
<tr>
<th>Intrinsic motivation</th>
<th>Pelletier, et al., 1995</th>
<th>university athletes</th>
</tr>
</thead>
<tbody>
<tr>
<td>I do mathematics for the pleasure of discovering new strategies to be successful on tests.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I do mathematics for the pleasure of discovering new solution strategies.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>In my math courses, I have preferred assignments that really challenge me so I can learn new things.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>In my math courses, I have preferred assignments that arouse my curiosity, even if they are difficult to learn.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The most satisfying thing for me in my math courses has been trying to understand the content as thoroughly as possible.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>In my math courses, when I have had the opportunity I choose assignments that I can learn from even if they don’t guarantee a good grade.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I enjoy doing mathematics very much.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Mathematics is fun to do.</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>I would describe mathematics as very interesting.</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>I think mathematics is enjoyable.</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>While doing mathematics, I think about how much I enjoy it.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Getting a good grade in my math courses has been the most satisfying thing for me.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The most important thing for me right now is improving my overall grade point average, so my main concern in my math courses has been getting a good grade.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If I can, I want to get better grades in my math courses than most of the other students.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I want to do well in my math courses because it is important to show my ability to my family, friends, employer, or others.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Extrinsic motivation</th>
<th>McAuley, Duncan, &amp; Tammen, 1987</th>
<th>all levels of athletes</th>
</tr>
</thead>
<tbody>
<tr>
<td>I do mathematics because I must do it to feel good about myself.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I do mathematics because people around me think it is important to be intelligent.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I do mathematics to show others how good I am at it.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I do mathematics because it helps me maintain good relationships with my peers.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I do mathematics because it allows me to be well regarded by people that I know.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I do mathematics because, in my opinion, it is a good way to meet people.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I do mathematics because I would feel bad if I was not taking time to do it.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I do mathematics because it is one of the best ways to develop other aspects of myself.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I do mathematics because it is a good way to learn lots of things which could be useful to me in other areas of my life.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pelletier, et al., 1995</th>
<th>university athletes</th>
</tr>
</thead>
<tbody>
<tr>
<td>I do mathematics because I must do it to feel good about myself.</td>
<td></td>
</tr>
<tr>
<td>I do mathematics because people around me think it is important to be intelligent.</td>
<td></td>
</tr>
<tr>
<td>I do mathematics to show others how good I am at it.</td>
<td></td>
</tr>
<tr>
<td>I do mathematics because it helps me maintain good relationships with my peers.</td>
<td></td>
</tr>
<tr>
<td>I do mathematics because it allows me to be well regarded by people that I know.</td>
<td></td>
</tr>
<tr>
<td>I do mathematics because, in my opinion, it is a good way to meet people.</td>
<td></td>
</tr>
<tr>
<td>I do mathematics because I would feel bad if I was not taking time to do it.</td>
<td></td>
</tr>
<tr>
<td>I do mathematics because it is one of the best ways to develop other aspects of myself.</td>
<td></td>
</tr>
<tr>
<td>I do mathematics because it is a good way to learn lots of things which could be useful to me in other areas of my life.</td>
<td></td>
</tr>
</tbody>
</table>
Table B1 (Continued)

<table>
<thead>
<tr>
<th>extrinsic motivation</th>
<th>Pelletier, et al., 1995</th>
<th>university athletes</th>
</tr>
</thead>
<tbody>
<tr>
<td>I do mathematics because it is absolutely necessary to do mathematics if one wants to understand the world.</td>
<td>university athletes</td>
<td></td>
</tr>
<tr>
<td>I do mathematics for the prestige of being mathematically literate.</td>
<td>university athletes</td>
<td></td>
</tr>
<tr>
<td>I make excellent grades on math tests.</td>
<td>university athletes</td>
<td></td>
</tr>
<tr>
<td>I have always been successful with math.</td>
<td>university athletes</td>
<td></td>
</tr>
<tr>
<td>*Even when I study very hard, I do poorly in my math.</td>
<td>university athletes</td>
<td></td>
</tr>
<tr>
<td>I got good grades in my math on my last report card.</td>
<td>university athletes</td>
<td></td>
</tr>
<tr>
<td>I do well on math assignments.</td>
<td>university athletes</td>
<td></td>
</tr>
<tr>
<td>I do well on even the most difficult math assignments.</td>
<td>university athletes</td>
<td></td>
</tr>
<tr>
<td>Seeing adults do well in my math pushes me to do better.</td>
<td>Usher &amp; Pajares, 2009</td>
<td>sixth through eighth grade students</td>
</tr>
<tr>
<td>When I see how my math teacher solves a problem, I can picture myself solving the problem in the same way.</td>
<td>Usher &amp; Pajares, 2009</td>
<td>sixth through eighth grade students</td>
</tr>
<tr>
<td>Seeing kids do better than me in my math pushes me to do better.</td>
<td>Usher &amp; Pajares, 2009</td>
<td>sixth through eighth grade students</td>
</tr>
<tr>
<td>When I see how another student solves a math problem, I can see myself solving the problem in the same way.</td>
<td>Usher &amp; Pajares, 2009</td>
<td>sixth through eighth grade students</td>
</tr>
<tr>
<td>I imagine myself working through challenging math problems successfully.</td>
<td>Usher &amp; Pajares, 2009</td>
<td>sixth through eighth grade students</td>
</tr>
<tr>
<td>I compete with myself in my math.</td>
<td>Usher &amp; Pajares, 2009</td>
<td>sixth through eighth grade students</td>
</tr>
<tr>
<td>My math teachers have told that I am good at learning math.</td>
<td>Usher &amp; Pajares, 2009</td>
<td>sixth through eighth grade students</td>
</tr>
<tr>
<td>People have told me that I have a talent for math.</td>
<td>Usher &amp; Pajares, 2009</td>
<td>sixth through eighth grade students</td>
</tr>
<tr>
<td>Adults in my family have told me what a good math student I am.</td>
<td>Usher &amp; Pajares, 2009</td>
<td>sixth through eighth grade students</td>
</tr>
<tr>
<td>I have been praised for my ability in my math.</td>
<td>Usher &amp; Pajares, 2009</td>
<td>sixth through eighth grade students</td>
</tr>
<tr>
<td>Other students have told me that I’m good at learning math.</td>
<td>Usher &amp; Pajares, 2009</td>
<td>sixth through eighth grade students</td>
</tr>
<tr>
<td>My classmates like to work with me in my math because they think I’m good at it.</td>
<td>Usher &amp; Pajares, 2009</td>
<td>sixth through eighth grade students</td>
</tr>
<tr>
<td>Just being in my math class makes feel stressed and nervous.</td>
<td>Usher &amp; Pajares, 2009</td>
<td>sixth through eighth grade students</td>
</tr>
<tr>
<td>Doing math work takes all of my energy.</td>
<td>Usher &amp; Pajares, 2009</td>
<td>sixth through eighth grade students</td>
</tr>
<tr>
<td>I start to feel stressed-out as soon as I begin my math work.</td>
<td>Usher &amp; Pajares, 2009</td>
<td>sixth through eighth grade students</td>
</tr>
<tr>
<td>My mind goes blank and I am unable to think clearly when doing math work.</td>
<td>Usher &amp; Pajares, 2009</td>
<td>sixth through eighth grade students</td>
</tr>
<tr>
<td>I get depressed when I think about learning math.</td>
<td>Usher &amp; Pajares, 2009</td>
<td>sixth through eighth grade students</td>
</tr>
<tr>
<td>My whole body becomes tense when I have to do math.</td>
<td>Usher &amp; Pajares, 2009</td>
<td>sixth through eighth grade students</td>
</tr>
</tbody>
</table>
Table B1 (Continued)

<table>
<thead>
<tr>
<th>Expectancy</th>
<th>Pintrich, 1991</th>
<th>undergraduate university students</th>
</tr>
</thead>
<tbody>
<tr>
<td>If I study in appropriate ways, then I will be able to learn the mathematics for this course.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>It is my own fault when I don’t learn mathematics.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>When I try hard enough, then I understand mathematics.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>When I don’t understand mathematics, it is because I didn’t try hard enough.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>*I believe I will receive excellent grades in a math class.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I'm certain I can understand the most difficult material presented in a math class.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>*I'm confident I can understand the basic concepts taught in a math class.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I'm confident I can understand the most complex material presented by the instructor in a math class.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I'm confident I can do an excellent job on the assignments and tests in a math class.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>*I expect to do well in a math class.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>*I'm certain I can master the skills being taught in a math class.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Considering the difficulty of mathematics and my skills, I think I will do well a math class.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Task-value</th>
<th>Miller, et al., 1999</th>
<th>university students</th>
</tr>
</thead>
<tbody>
<tr>
<td>I do mathematics because learning math plays a role in reaching my future goals.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I do mathematics because learning math is important for attaining my dreams.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I do mathematics because my achievement is important for attaining my dreams.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I do mathematics because my achievement plays a role in reaching my future goals.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I do mathematics because understanding math is important for becoming the person I want to be.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I think I will be able to use the mathematics I learn.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>It is important for me to learn mathematics.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am very interested in mathematics.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I think mathematics is useful for me to learn.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I like mathematics.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Understanding mathematics is very important to me.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Items that became part of the Motivation for Mathematics Abbreviated Instrument.
Appendix C: Phase 3 Consent Form.

Informed Consent to Participate in Research
Information to Consider Before Taking Part in this Research Study

Pro # Pro00024322

Researchers at the University of South Florida (USF) study many topics. To do this, we need the help of people who agree to take part in a research study. This form tells you about this research study. We are asking you to take part in a research study that is called: Motivation for Mathematics: Phase three of the development and initial validation of an abbreviated instrument. The person who is in charge of this research study is Kenneth L. Butler. This person is called the Principal Investigator.

Purpose of the Study
The purpose of this study is to develop and validate a survey that will be used in future educational research into students’ motivation for mathematics. During this study a survey will be given to all Intermediate Algebra classes, to measure student motivation for mathematics.

Why are you being asked to take part?
We are asking you to take part in this research study because you are a student in an Intermediate Algebra course.

Study Procedures
If you take part in this study, you will be asked to complete a paper survey. The data will be collected anonymously, and will not be linked to any individual participants. The research will be done at the University of South Florida in your mathematics classroom.

Alternatives / Voluntary Participation / Withdrawal
You have the alternative to choose not to participate in this research study. If you choose not to participate you should return your unanswered survey.

You should only take part in this study if you want to volunteer; you are free to participate in this research or withdraw at any time. There will be no penalty or loss of benefits you are entitled to receive if you stop taking part in this study. Your decision to participate or not to participate will not affect your student status or your course grade.

Benefits and Risks
You will receive no benefit from this study. This research is considered to be minimal risk.

Compensation
We will not pay you for the time you volunteer while being in this study.
Privacy and Confidentiality

We must keep your study records as confidential as possible. No identifiers will be collected, however, certain people may need to see your study records. By law, anyone who looks at your records must keep them completely confidential. The only people who will be allowed to see these records are: Kenneth L. Butler the Principal Investigator, Eugenia Vomvoridi-Ivanovic the Faculty Advisor, and The University of South Florida Institutional Review Board (IRB).

Contact Information

If you have any questions about your rights as a research participant, please contact the USF IRB at 974-5638. If you have questions regarding the research, please contact the Principal Investigator Kenneth L. Butler at 863-370-1100 or send email to butlerk1@usf.edu.

We may publish what we learn from this study. If we do, we will not let anyone know your name. We will not publish anything else that would let people know who you are. You have been given a copy of this consent form for your records.

I freely give my consent to take part in this study. I understand that by proceeding with this survey that I am agreeing to take part in research and I am 18 years of age or older.
Appendix D: Effect Sizes for Survey Comments.

Table D1. Effect sizes for survey comments. Unit of measure is a concept phrase (n=489).

<table>
<thead>
<tr>
<th>codes</th>
<th>effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDT</td>
<td></td>
</tr>
<tr>
<td>intrinsic</td>
<td>0.11</td>
</tr>
<tr>
<td>extrinsic</td>
<td>0.09</td>
</tr>
<tr>
<td>achievement goals</td>
<td></td>
</tr>
<tr>
<td>mastery orientation</td>
<td>0.09</td>
</tr>
<tr>
<td>mastery structure</td>
<td>0.08</td>
</tr>
<tr>
<td>performance orientation</td>
<td>0.11</td>
</tr>
<tr>
<td>performance structure</td>
<td>0.03</td>
</tr>
<tr>
<td>self-efficacy</td>
<td></td>
</tr>
<tr>
<td>expectancy</td>
<td>0.07</td>
</tr>
<tr>
<td>utility</td>
<td>0.09</td>
</tr>
<tr>
<td>attainment</td>
<td>0.04</td>
</tr>
<tr>
<td>liking</td>
<td>0.05</td>
</tr>
<tr>
<td>cost</td>
<td>0.02</td>
</tr>
<tr>
<td>expectancy-value</td>
<td></td>
</tr>
<tr>
<td>autonomy</td>
<td>0.02</td>
</tr>
<tr>
<td>competence</td>
<td>0.06</td>
</tr>
<tr>
<td>relatedness</td>
<td>0.08</td>
</tr>
<tr>
<td>psychological needs</td>
<td></td>
</tr>
<tr>
<td>academics</td>
<td></td>
</tr>
<tr>
<td>improvement / achievement</td>
<td>0.03</td>
</tr>
<tr>
<td>grade</td>
<td>0.04</td>
</tr>
<tr>
<td>pedagogy</td>
<td>0.03</td>
</tr>
<tr>
<td>math</td>
<td>0.14</td>
</tr>
<tr>
<td>epistemology</td>
<td></td>
</tr>
<tr>
<td>knowledge / learning</td>
<td>0.03</td>
</tr>
<tr>
<td>metacognition</td>
<td>0.03</td>
</tr>
<tr>
<td>engagement / effort</td>
<td>0.03</td>
</tr>
<tr>
<td>affect</td>
<td>0.12</td>
</tr>
<tr>
<td>critiques</td>
<td></td>
</tr>
<tr>
<td>wording</td>
<td>0.08</td>
</tr>
<tr>
<td>theoretical</td>
<td>0.26</td>
</tr>
<tr>
<td>survey</td>
<td>0.42</td>
</tr>
</tbody>
</table>
Appendix E: Phase 2 Intra-Respondent Matrix

Table E1. Effect sizes per code per item. Unit of measure is a concept phrase.

<table>
<thead>
<tr>
<th>intrinsic motivation</th>
<th>fun</th>
<th>master</th>
<th>perform</th>
<th>relevant</th>
<th>efficacy</th>
<th>engage</th>
<th>affect</th>
<th>related</th>
<th>multilevel</th>
<th>wording</th>
</tr>
</thead>
<tbody>
<tr>
<td>I do mathematics because I like the feeling of being totally immersed in the activity.</td>
<td>.16</td>
<td>.05</td>
<td>.02</td>
<td>.03</td>
<td>.17</td>
<td>.17</td>
<td>.19</td>
<td>.02</td>
<td>.02</td>
<td>.13</td>
</tr>
<tr>
<td>I would describe mathematics as very interesting.</td>
<td>.13</td>
<td>.07</td>
<td>.00</td>
<td>.22</td>
<td>.00</td>
<td>.24</td>
<td>.07</td>
<td>.00</td>
<td>.02</td>
<td>.09</td>
</tr>
<tr>
<td>I do mathematics for the excitement I feel when I am really involved in the activity.</td>
<td>.24</td>
<td>.02</td>
<td>.00</td>
<td>.00</td>
<td>.18</td>
<td>.20</td>
<td>.31</td>
<td>.00</td>
<td>.07</td>
<td>.09</td>
</tr>
<tr>
<td>I think mathematics is enjoyable.</td>
<td>.31</td>
<td>.14</td>
<td>.03</td>
<td>.00</td>
<td>.21</td>
<td>.17</td>
<td>.14</td>
<td>.00</td>
<td>.03</td>
<td>.07</td>
</tr>
<tr>
<td>Mathematics is fun to do.</td>
<td>.17</td>
<td>.05</td>
<td>.05</td>
<td>.07</td>
<td>.07</td>
<td>.01</td>
<td>.02</td>
<td>.01</td>
<td>.01</td>
<td>.14</td>
</tr>
<tr>
<td>I enjoy doing mathematics very much.</td>
<td>.35</td>
<td>.00</td>
<td>.04</td>
<td>.00</td>
<td>.10</td>
<td>.06</td>
<td>.10</td>
<td>.02</td>
<td>.04</td>
<td>.25</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mastery orientations</th>
<th>fun</th>
<th>master</th>
<th>perform</th>
<th>relevant</th>
<th>efficacy</th>
<th>engage</th>
<th>affect</th>
<th>related</th>
<th>multilevel</th>
<th>wording</th>
</tr>
</thead>
<tbody>
<tr>
<td>I like mathematics that I’ve learned from even if I make a lot of mistakes.</td>
<td>.25</td>
<td>.22</td>
<td>.18</td>
<td>.00</td>
<td>.20</td>
<td>.12</td>
<td>.14</td>
<td>.04</td>
<td>.04</td>
<td>.14</td>
</tr>
<tr>
<td>It’s important to me that I learn a lot of new math concepts this year.</td>
<td>.10</td>
<td>.19</td>
<td>.06</td>
<td>.21</td>
<td>.10</td>
<td>.00</td>
<td>.00</td>
<td>.04</td>
<td>.19</td>
<td>.04</td>
</tr>
<tr>
<td>It’s important to me that I improve my math skills this year.</td>
<td>.02</td>
<td>.22</td>
<td>.15</td>
<td>.11</td>
<td>.15</td>
<td>.04</td>
<td>.04</td>
<td>.00</td>
<td>.11</td>
<td>.11</td>
</tr>
<tr>
<td>One of my goals is to master a lot of new mathematics this year. (semester)</td>
<td>.05</td>
<td>.31</td>
<td>.10</td>
<td>.12</td>
<td>.07</td>
<td>.02</td>
<td>.02</td>
<td>.02</td>
<td>.26</td>
<td>.19</td>
</tr>
<tr>
<td>It’s important to me that I thoroughly understand mathematics.</td>
<td>.06</td>
<td>.26</td>
<td>.03</td>
<td>.26</td>
<td>.34</td>
<td>.09</td>
<td>.03</td>
<td>.09</td>
<td>.00</td>
<td>.17</td>
</tr>
</tbody>
</table>

172
Table E1 (Continued)

<table>
<thead>
<tr>
<th>An important reason why I do</th>
<th>fun</th>
<th>master</th>
<th>perform</th>
<th>relevant</th>
<th>efficacy</th>
<th>engage</th>
<th>affect</th>
<th>related</th>
<th>multi-level</th>
<th>wording</th>
</tr>
</thead>
<tbody>
<tr>
<td>mathematics is because I want to get</td>
<td>.02</td>
<td>.22</td>
<td>.07</td>
<td>.05</td>
<td>.15</td>
<td>.10</td>
<td>.05</td>
<td>.00</td>
<td>.12</td>
<td>.10</td>
</tr>
<tr>
<td>better at it.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>One of my goals in my math courses</td>
<td>.03</td>
<td>.35</td>
<td>.16</td>
<td>.16</td>
<td>.21</td>
<td>.10</td>
<td>.06</td>
<td>.05</td>
<td>.13</td>
<td>.10</td>
</tr>
<tr>
<td>has been to learn as much as I can.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Mastery structures**

| In my math courses it has been      | fun | master | perform | relevant | efficacy | engage | affect | related | multi-level | wording |
| important to understand mathematics,| .02 | .47    | .00     | .08      | .32      | .00    | .00    | .00     | .04         | .17     |
| not just memorize it.               |     |        |         |          |          |        |        |         |             |         |
| My math teachers have thought      | .02 | .33    | .45     | .18      | .06      | .16    | .04    | .08     | .12         | .04     |
| making mistakes was okay, as long as|     |        |         |          |          |        |        |         |             |         |
| I was learning and improving.       |     |        |         |          |          |        |        |         |             |         |
| My math teachers have made a real   | .00 | .25    | .00     | .03      | .08      | .05    | .12    | .18     | .40         | .02     |
| effort to recognize students for    |     |        |         |          |          |        |        |         |             |         |
| effort and improvement.             |     |        |         |          |          |        |        |         |             |         |
| In my math courses, how much I      | .03 | .30    | .22     | .14      | .08      | .05    | .03    | .00     | .22         | .16     |
| improve has been really important.  |     |        |         |          |          |        |        |         |             |         |
| My math teachers have emphasized    |     |        |         |          |          |        |        |         |             |         |
| really understanding math not       |     |        |         |          |          |        |        |         |             |         |
| memorizing it.                      |     |        |         |          |          |        |        |         |             |         |
| In my math course it has been okay to | .02 | .47    | .02     | .00      | .05      | .07    | .07    | .02     | .14         | .19     |
| make mistakes as long as I’m        |     |        |         |          |          |        |        |         |             |         |
| learning.                           |     |        |         |          |          |        |        |         |             |         |
| In my math courses, really          | .03 | .30    | .22     | .14      | .08      | .05    | .03    | .00     | .22         | .16     |
| understanding the mathematics has    |     |        |         |          |          |        |        |         |             |         |
| been the main goal.                 |     |        |         |          |          |        |        |         |             |         |
Table E1 (Continued)

<table>
<thead>
<tr>
<th>Extrinsic Motivation</th>
<th>fun</th>
<th>master</th>
<th>perform</th>
<th>relevant</th>
<th>efficacy</th>
<th>engage</th>
<th>affect</th>
<th>related</th>
<th>multi-level</th>
<th>wording</th>
</tr>
</thead>
<tbody>
<tr>
<td>I want to do well in my math courses because it is important to show my ability to</td>
<td>.04</td>
<td>.06</td>
<td>.18</td>
<td>.26</td>
<td>.04</td>
<td>.08</td>
<td>.02</td>
<td>.40</td>
<td>.18</td>
<td>.04</td>
</tr>
<tr>
<td>my family, friends, employers or others.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I do mathematics because it allows me to be well regarded by people that I know</td>
<td>.05</td>
<td>.05</td>
<td>.15</td>
<td>.09</td>
<td>.05</td>
<td>.02</td>
<td>.00</td>
<td>.40</td>
<td>.02</td>
<td>.20</td>
</tr>
<tr>
<td>Getting a good grade in math courses has been the most satisfying thing for me</td>
<td>.04</td>
<td>.15</td>
<td>.42</td>
<td>.04</td>
<td>.08</td>
<td>.19</td>
<td>.08</td>
<td>.04</td>
<td>.15</td>
<td>.04</td>
</tr>
<tr>
<td>I do mathematics because people around me think it’s important to be intelligent.</td>
<td>.03</td>
<td>.03</td>
<td>.05</td>
<td>.13</td>
<td>.33</td>
<td>.13</td>
<td>.03</td>
<td>.26</td>
<td>.03</td>
<td>.21</td>
</tr>
<tr>
<td>I do mathematics for the prestige of being mathematically literate.</td>
<td>.04</td>
<td>.12</td>
<td>.08</td>
<td>.14</td>
<td>.20</td>
<td>.00</td>
<td>.04</td>
<td>.29</td>
<td>.00</td>
<td>.24</td>
</tr>
</tbody>
</table>

| Performance Orientations                                                              |     |        |         |          |          |        |        |         |             |         |
| I have liked showing math teachers that I am smarter than the other students.         | .09 | .03    | .31     | .00      | .20      | .20    | .09    | .31     | .14         | .03     |
| In my math courses one of my goals has been to look smart in comparison to other     | .09 | .00    | .37     | .00      | .11      | .07    | .13    | .48     | .24         | .04     |
| students.                                                                             |     |        |         |          |          |        |        |         |             |         |
| I have felt successful in my math courses when I did better than the other students?| .03 | .03    | .33     | .09      | .14      | .09    | .08    | .20     | .11         | .05     |
| In math courses, I have wanted to do better than the other students                  | .06 | .02    | .52     | .04      | .06      | .06    | .09    | .22     | .04         | .02     |
Table E1 (Continued)

<table>
<thead>
<tr>
<th></th>
<th>fun</th>
<th>master</th>
<th>perform</th>
<th>relevant</th>
<th>efficacy</th>
<th>engage</th>
<th>affect</th>
<th>related</th>
<th>multi-level</th>
<th>wording</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doing better than other students in my math courses has been important to me.</td>
<td>.12</td>
<td>.00</td>
<td>.45</td>
<td>.06</td>
<td>.00</td>
<td>.06</td>
<td>.15</td>
<td>.09</td>
<td>.24</td>
<td></td>
</tr>
<tr>
<td><strong>Performance Structures</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In my math courses, getting good grades has been the main goal.</td>
<td>.00</td>
<td>.08</td>
<td>.56</td>
<td>.06</td>
<td>.00</td>
<td>.11</td>
<td>.00</td>
<td>.22</td>
<td>.14</td>
<td>.03</td>
</tr>
<tr>
<td>My math teachers have made it easy to tell which students get the highest grades and which students get the lowest grades.</td>
<td>.00</td>
<td>.00</td>
<td>.39</td>
<td>.00</td>
<td>.06</td>
<td>.03</td>
<td>.03</td>
<td>.50</td>
<td>.36</td>
<td>.11</td>
</tr>
<tr>
<td>My math teachers have pointed out who gets good grades as an example to others.</td>
<td>.02</td>
<td>.00</td>
<td>.30</td>
<td>.02</td>
<td>.00</td>
<td>.02</td>
<td>.09</td>
<td>.21</td>
<td>.19</td>
<td>.09</td>
</tr>
<tr>
<td>My math teachers have talked a lot about the importance of getting high test scores.</td>
<td>.00</td>
<td>.07</td>
<td>.39</td>
<td>.28</td>
<td>.00</td>
<td>.04</td>
<td>.02</td>
<td>.09</td>
<td>.43</td>
<td>.07</td>
</tr>
<tr>
<td>My math teachers have encouraged students to compete with each other academically.</td>
<td>.05</td>
<td>.05</td>
<td>.42</td>
<td>.00</td>
<td>.00</td>
<td>.02</td>
<td>.02</td>
<td>.16</td>
<td>.42</td>
<td>.02</td>
</tr>
<tr>
<td><strong>Self-efficacy</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I do well on math assignments.</td>
<td>.00</td>
<td>.09</td>
<td>.34</td>
<td>.00</td>
<td>.03</td>
<td>.16</td>
<td>.00</td>
<td>.00</td>
<td>.16</td>
<td>.00</td>
</tr>
<tr>
<td>I do well on even the most difficult math assignments.</td>
<td>.00</td>
<td>.04</td>
<td>.20</td>
<td>.00</td>
<td>.32</td>
<td>.20</td>
<td>.00</td>
<td>.12</td>
<td>.08</td>
<td>.08</td>
</tr>
<tr>
<td>When I see how my math teacher solves a problem, I can picture myself solving the problem in the same way?</td>
<td>.00</td>
<td>.03</td>
<td>.05</td>
<td>.03</td>
<td>.20</td>
<td>.00</td>
<td>.03</td>
<td>.15</td>
<td>.28</td>
<td>.00</td>
</tr>
</tbody>
</table>
Table E1 (Continued)

<table>
<thead>
<tr>
<th></th>
<th>fun</th>
<th>master</th>
<th>perform</th>
<th>relevant</th>
<th>efficacy</th>
<th>engage</th>
<th>affect</th>
<th>related</th>
<th>multi-level</th>
<th>wording</th>
</tr>
</thead>
<tbody>
<tr>
<td>When I see how another student solves a math problem, I could see myself solving the problem in the same way.</td>
<td>.00</td>
<td>.27</td>
<td>.17</td>
<td>.00</td>
<td>.10</td>
<td>.07</td>
<td>.07</td>
<td>.27</td>
<td>.00</td>
<td>.00</td>
</tr>
<tr>
<td>My math teachers have told me that I am good at learning math.</td>
<td>.00</td>
<td>.04</td>
<td>.36</td>
<td>.00</td>
<td>.18</td>
<td>.04</td>
<td>.00</td>
<td>.21</td>
<td>.39</td>
<td>.00</td>
</tr>
<tr>
<td>Other students have told me that I am good at learning math.</td>
<td>.00</td>
<td>.00</td>
<td>.19</td>
<td>.00</td>
<td>.25</td>
<td>.06</td>
<td>.00</td>
<td>.13</td>
<td>.25</td>
<td>.00</td>
</tr>
<tr>
<td><strong>Task-value</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I do mathematics because learning math is important for attaining my dreams.</td>
<td>.04</td>
<td>.04</td>
<td>.09</td>
<td>.61</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
<td>.09</td>
<td>.13</td>
<td></td>
</tr>
<tr>
<td>I do mathematics because understanding math is important for becoming the person I want to be.</td>
<td>.00</td>
<td>.10</td>
<td>.07</td>
<td>.28</td>
<td>.14</td>
<td>.00</td>
<td>.00</td>
<td>.10</td>
<td>.03</td>
<td></td>
</tr>
<tr>
<td>I do mathematics because my achievement plays a role in reaching my future goals.</td>
<td>.00</td>
<td>.21</td>
<td>.21</td>
<td>.46</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
<td>.08</td>
<td>.08</td>
<td></td>
</tr>
<tr>
<td>I think I’ll be able to use the mathematics I learn.</td>
<td>.00</td>
<td>.19</td>
<td>.04</td>
<td>.42</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
<td>.08</td>
<td>.08</td>
</tr>
<tr>
<td>I think mathematics is useful for me to learn</td>
<td>.02</td>
<td>.04</td>
<td>.00</td>
<td>.37</td>
<td>.02</td>
<td>.07</td>
<td>.04</td>
<td>.04</td>
<td>.02</td>
<td>.22</td>
</tr>
<tr>
<td>I do mathematics because learning math plays a role in reaching my future goals.</td>
<td>.00</td>
<td>.30</td>
<td>.20</td>
<td>.34</td>
<td>.02</td>
<td>.02</td>
<td>.00</td>
<td>.05</td>
<td>.05</td>
<td>.20</td>
</tr>
</tbody>
</table>
Table E1 (Continued)

<table>
<thead>
<tr>
<th>Expectancy</th>
<th>fun</th>
<th>master</th>
<th>perform</th>
<th>relevant</th>
<th>efficacy</th>
<th>engage</th>
<th>affect</th>
<th>related</th>
<th>multi-level</th>
<th>wording</th>
</tr>
</thead>
<tbody>
<tr>
<td>I’m confident I can understand the basic concepts taught in a math class.</td>
<td>.03</td>
<td>.58</td>
<td>.00</td>
<td>.00</td>
<td>.16</td>
<td>.11</td>
<td>.00</td>
<td>.03</td>
<td>.32</td>
<td>.21</td>
</tr>
<tr>
<td>I believe I will receive excellent grades in a math class.</td>
<td>.00</td>
<td>.10</td>
<td>.45</td>
<td>.05</td>
<td>.15</td>
<td>.45</td>
<td>.00</td>
<td>.05</td>
<td>.25</td>
<td>.00</td>
</tr>
<tr>
<td>I’m certain I can understand the most difficult material presented in a math class.</td>
<td>.00</td>
<td>.10</td>
<td>.10</td>
<td>.00</td>
<td>.50</td>
<td>.15</td>
<td>.03</td>
<td>.03</td>
<td>.15</td>
<td>.10</td>
</tr>
<tr>
<td>I’m certain I can master the skills being taught in a math class.</td>
<td>.04</td>
<td>.32</td>
<td>.04</td>
<td>.00</td>
<td>.29</td>
<td>.29</td>
<td>.07</td>
<td>.04</td>
<td>.11</td>
<td>.18</td>
</tr>
<tr>
<td>I expect to do well in a math class.</td>
<td>.00</td>
<td>.06</td>
<td>.52</td>
<td>.03</td>
<td>.06</td>
<td>.00</td>
<td>.00</td>
<td>.18</td>
<td>.15</td>
<td>.03</td>
</tr>
</tbody>
</table>
### Appendix F: Expert Endorsement Percentage

**Table F1.** Percentage endorsement per item for phase two survey.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Items</th>
<th>endorse (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>intrinsic motivation</td>
<td><strong>im6</strong> I do mathematics because I like the feeling of being totally immersed in the activity.</td>
<td>42.10%</td>
</tr>
<tr>
<td>intrinsic motivation</td>
<td><strong>im17</strong> I would describe mathematics as very interesting.</td>
<td>43.90%</td>
</tr>
<tr>
<td>intrinsic motivation</td>
<td><strong>im4</strong> I do mathematics for the excitement I feel when I am really involved in the activity.</td>
<td>45.60%</td>
</tr>
<tr>
<td>intrinsic motivation</td>
<td><strong>im18</strong> I think mathematics is enjoyable.</td>
<td>47.40%</td>
</tr>
<tr>
<td>intrinsic motivation</td>
<td><strong>im16</strong> Mathematics is fun to do.</td>
<td>50.90%</td>
</tr>
<tr>
<td>intrinsic motivation</td>
<td><strong>im15</strong> I enjoy doing mathematics very much.</td>
<td>66.70%</td>
</tr>
<tr>
<td>extrinsic motivation</td>
<td><strong>em4</strong> I want to do well in my math courses because it is important to show my ability to my family, friends, employer, or others.</td>
<td>40.00%</td>
</tr>
<tr>
<td>extrinsic motivation</td>
<td><strong>em9</strong> I do mathematics because it allows me to be well regarded by people that I know.</td>
<td>40.00%</td>
</tr>
<tr>
<td>extrinsic motivation</td>
<td><strong>em1</strong> Getting a good grade in my math courses has been the most satisfying thing for me.</td>
<td>44.00%</td>
</tr>
<tr>
<td>extrinsic motivation</td>
<td><strong>em6</strong> I do mathematics because people around me think it is important to be intelligent.</td>
<td>44.00%</td>
</tr>
<tr>
<td>extrinsic motivation</td>
<td><strong>em15</strong> I do mathematics for the prestige of being mathematically literate.</td>
<td>44.00%</td>
</tr>
<tr>
<td>mastery orientations</td>
<td><strong>mo1</strong> I like mathematics that I'll learn from even if I make a lot of mistakes.</td>
<td>43.90%</td>
</tr>
<tr>
<td>mastery orientations</td>
<td><strong>mo7</strong> It’s important to me that I learn a lot of new math concepts this year.</td>
<td>43.90%</td>
</tr>
<tr>
<td>mastery orientations</td>
<td><strong>mo11</strong> It’s important to me that I improve my math skills this year</td>
<td>47.40%</td>
</tr>
<tr>
<td>mastery orientations</td>
<td><strong>mo9</strong> One of my goals is to master a lot of new mathematics this year.</td>
<td>49.10%</td>
</tr>
<tr>
<td>mastery orientations</td>
<td><strong>mo10</strong> It’s important to me that I thoroughly understand mathematics.</td>
<td>64.90%</td>
</tr>
<tr>
<td>mastery orientations</td>
<td><strong>mo4</strong> An important reason why I do mathematics is because I want to get better at it.</td>
<td>78.90%</td>
</tr>
<tr>
<td>mastery orientations</td>
<td><strong>mo8</strong> One of my goals in my math courses has been to learn as much as I can.</td>
<td>82.50%</td>
</tr>
<tr>
<td>mastery structures</td>
<td><strong>ms4</strong> In my math courses, it has been important to understand mathematics, not just memorize it.</td>
<td>43.90%</td>
</tr>
<tr>
<td>mastery structures</td>
<td><strong>ms8</strong> My math teachers have thought making mistakes was OK as long as I was learning and improving.</td>
<td>47.40%</td>
</tr>
<tr>
<td>Factor</td>
<td>Items</td>
<td>endorse</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>mastery structures</td>
<td>ms11 My math teachers have made real efforts to recognize students for effort and improvement.</td>
<td>49.10%</td>
</tr>
<tr>
<td>mastery structures</td>
<td>ms2 In my math courses, how much I improve has been really important.</td>
<td>50.90%</td>
</tr>
<tr>
<td>mastery structures</td>
<td>ms10 My math teachers have emphasized really understanding math, not just memorizing it.</td>
<td>50.90%</td>
</tr>
<tr>
<td>mastery structures</td>
<td>ms6 In my math courses, it has been OK to make mistakes as long as I am learning.</td>
<td>52.60%</td>
</tr>
<tr>
<td>mastery structures</td>
<td>ms3 In my math courses, really understanding the mathematics has been the main goal.</td>
<td>61.40%</td>
</tr>
<tr>
<td>performance orientations</td>
<td>po4 I have liked showing math teachers that I’m smarter than the other students.</td>
<td>44.00%</td>
</tr>
<tr>
<td>performance orientations</td>
<td>po9 In my math courses, one of my goals has been to look smart in comparison to the other students.</td>
<td>48.00%</td>
</tr>
<tr>
<td>performance orientations</td>
<td>po3 I have felt successful in my math courses when I did better than the other students.</td>
<td>52.00%</td>
</tr>
<tr>
<td>performance orientations</td>
<td>po7 One of my goals is to show others that I’m good at mathematics.</td>
<td>52.00%</td>
</tr>
<tr>
<td>performance orientations</td>
<td>po2 In math courses, I have wanted to do better than other students.</td>
<td>60.00%</td>
</tr>
<tr>
<td>performance orientations</td>
<td>po5 Doing better than other students in my math courses has been important to me.</td>
<td>64.00%</td>
</tr>
<tr>
<td>performance structures</td>
<td>ps1 In my math courses, getting good grades has been the main goal.</td>
<td>48.00%</td>
</tr>
<tr>
<td>performance structures</td>
<td>ps4 My math teachers have made it easy to tell which students get the highest grades and which students get the lowest grades.</td>
<td>60.00%</td>
</tr>
<tr>
<td>performance structures</td>
<td>ps5 My math teachers have pointed out who gets good grades as an example to others.</td>
<td>60.00%</td>
</tr>
<tr>
<td>performance structures</td>
<td>ps6 My math teachers have talked a lot about the importance of getting high test scores.</td>
<td>64.00%</td>
</tr>
<tr>
<td>performance structures</td>
<td>ps8 My math teachers have encouraged students to compete with each other academically.</td>
<td>76.00%</td>
</tr>
<tr>
<td>Self-efficacy Mastery</td>
<td>se5 I do well on math assignments.</td>
<td>48.80%</td>
</tr>
<tr>
<td>Self-efficacy Mastery</td>
<td>se6 I do well on even the most difficult math assignments.</td>
<td>48.80%</td>
</tr>
</tbody>
</table>
### Table F1 (Continued)

<table>
<thead>
<tr>
<th>Factor</th>
<th>Items</th>
<th>endorse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-efficacy Vicarious</td>
<td>When I see how my math teacher solves a problem, I can picture myself solving the problem in the same way.</td>
<td>63.40%</td>
</tr>
<tr>
<td>Self-efficacy Vicarious</td>
<td>When I see how another student solves a math problem, I can see myself solving the problem in the same way.</td>
<td>68.30%</td>
</tr>
<tr>
<td>Self-efficacy Social</td>
<td>My math teachers have told me that I am good at learning math.</td>
<td>34.10%</td>
</tr>
<tr>
<td>Self-efficacy Social</td>
<td>Other students have told me that I’m good at learning math.</td>
<td>43.90%</td>
</tr>
<tr>
<td>Task-value</td>
<td>I do mathematics because learning math is important for attaining my dreams.</td>
<td>41.50%</td>
</tr>
<tr>
<td>Task-value</td>
<td>I do mathematics because understanding math is important for becoming the person I want to be.</td>
<td>41.50%</td>
</tr>
<tr>
<td>Task-value</td>
<td>I do mathematics because my achievement plays a role in reaching my future goals.</td>
<td>53.70%</td>
</tr>
<tr>
<td>Task-value</td>
<td>I think I will be able to use the mathematics I learn.</td>
<td>58.50%</td>
</tr>
<tr>
<td>Task-value</td>
<td>I think mathematics is useful for me to learn.</td>
<td>61.00%</td>
</tr>
<tr>
<td>Task-value</td>
<td>I do mathematics because learning math plays a role in reaching my future goals.</td>
<td>82.90%</td>
</tr>
<tr>
<td>Expectancy</td>
<td>I'm confident I can understand the basic concepts taught in a math class.</td>
<td>43.90%</td>
</tr>
<tr>
<td>Expectancy</td>
<td>I believe I will receive excellent grades in a math class.</td>
<td>46.30%</td>
</tr>
<tr>
<td>Expectancy</td>
<td>I'm certain I can understand the most difficult material presented in a math class.</td>
<td>46.30%</td>
</tr>
<tr>
<td>Expectancy</td>
<td>I'm certain I can master the skills being taught in a math class.</td>
<td>58.50%</td>
</tr>
<tr>
<td>Expectancy</td>
<td>I expect to do well in a math class.</td>
<td>70.70%</td>
</tr>
</tbody>
</table>

I would describe mathematics as very interesting.

1 2 3 4 5
Not at all true Somewhat true Very true

I do mathematics for the excitement I feel when I am really involved in the activity.

1 2 3 4 5
Not at all true Somewhat true Very true

I think mathematics is enjoyable.

1 2 3 4 5
Not at all true Somewhat true Very true

Mathematics is fun to do.

1 2 3 4 5
Not at all true Somewhat true Very true

It’s important to me that I learn a lot of new math concepts this year.

1 2 3 4 5
Not at all true Somewhat true Very true

One of my goals is to master a lot of new mathematics this year.

1 2 3 4 5
Not at all true Somewhat true Very true

It’s important to me that I thoroughly understand mathematics.

1 2 3 4 5
Not at all true Somewhat true Very true

One of my goals in my math courses has been to learn as much as I can.

1 2 3 4 5
Not at all true Somewhat true Very true

I have liked showing math teachers that I’m smarter than the other students.

1 2 3 4 5
Not at all true Somewhat true Very true

I have felt successful in my math courses when I did better than the other students.

1 2 3 4 5
Not at all true Somewhat true Very true

In math courses, I have wanted to do better than other students.

1 2 3 4 5
Not at all true Somewhat true Very true
Doing better than other students in my math courses has been important to me.
1 2 3 4 5
Not at all true Somewhat true Very true

I'm confident I can understand the basic concepts taught in this math class.
1 2 3 4 5
Not at all true Somewhat true Very true

I believe I will receive excellent grades in this math class.
1 2 3 4 5
Not at all true Somewhat true Very true

I'm certain I can master the skills being taught in this math class.
1 2 3 4 5
Not at all true Somewhat true Very true

I expect to do well in this math class.
1 2 3 4 5
Not at all true Somewhat true Very true

5/22/2015

Ken Butler, Jr., M.A.
USF Teaching and Learning 4202 East Fowler Ave.
Tampa, FL 33620

RE: Exempt Certification
IRB#: Pro00022039
Title: Expert Review of items to be included in the development and validation of the motivation for mathematics survey.

Dear Mr. Butler:

On 5/22/2015, the Institutional Review Board (IRB) determined that your research meets criteria for exemption from the federal regulations as outlined by 45CFR46.101(b):

(2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless:
(i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

Approved Item(s): Protocol Document(s):


Consent/Assent Document(s):

Electronic informed consent Expert Review.pdf

As the principal investigator for this study, it is your responsibility to ensure that this research is conducted as outlined in your application and consistent with the ethical principles outlined in the Belmont Report and with USF IRB policies and procedures.
Please note, as per USF IRB Policy 303, "Once the Exempt determination is made, the application is closed in eIRB. Any proposed or anticipated changes to the study design that was previously declared exempt from IRB review must be submitted to the IRB as a new study prior to initiation of the change."

If alterations are made to the study design that change the review category from Exempt (i.e., adding a focus group, access to identifying information, adding a vulnerable population, or an intervention), these changes require a new application. However, administrative changes, including changes in research personnel, do not warrant an amendment or new application.

Given the determination of exemption, this application is being closed in ARC. This does not limit your ability to conduct your research project. Again, your research may continue as planned; only a change in the study design that would affect the exempt determination requires a new submission to the IRB.

We appreciate your dedication to the ethical conduct of human subject research at the University of South Florida and your continued commitment to human research protections. If you have any questions regarding this matter, please call 813-974-5638.

Sincerely,

[Signature]

John Schinka, Ph.D.,
Chairperson USF Institutional Review Board
November 16, 2015

Ken Butler, Jr., M.A. Teaching and Learning 4202 East Fowler Ave. Tampa, FL 33620

RE: Exempt Certification
IRB#: Pro00024322
Title: Motivation for Mathematics: Phase three of the development and initial validation of an abbreviated instrument

Dear Mr. Butler:

On 11/15/2015, the Institutional Review Board (IRB) determined that your research meets criteria for exemption from the federal regulations as outlined by 45CFR46.101(b):

(2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

Approved Items:

Protocol phase three survey Motivation for Mathematics.pdf
Paper informed consent phase 3.pdf

As the principal investigator for this study, it is your responsibility to ensure that this research is conducted as outlined in your application and consistent with the ethical principles outlined in the Belmont Report and with USF HRPP policies and procedures.

Please note, as per USF HRPP Policy, once the Exempt determination is made, the application is closed in ARC. Any proposed or anticipated changes to the study design that was previously declared exempt from IRB review must be submitted to the IRB as a new study prior to initiation.
of the change. However, administrative changes, including changes in research personnel, do not warrant an amendment or new application.

Given the determination of exemption, this application is being closed in ARC. This does not limit your ability to conduct your research project.

We appreciate your dedication to the ethical conduct of human subject research at the University of South Florida and your continued commitment to human research protections. If you have any questions regarding this matter, please call 813-974-5638.

Sincerely,

[Signature]

John Schinka, Ph.D., Chairperson USF Institutional Review Board