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DEVELOPMENT AND VALIDATION OF INDICATORS OF SECONDARY MATHEMATICS TEACHERS'
POSITIVE DISPOSITIONS TOWARD PROBLEM SOLVING

By

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B.A., Mathematics, University of Alaska Anchorage, 1994

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Graduate Certificate, Educational Leadership, University of Alaska Anchorage, 2006

A Dissertation

Submitted to the Faculty of the

College of Education and Human Development of the University of Louisville

in Partial Fulfillment of the Requirements

for the Degree of

Doctor of Philosophy

Curriculum and Instruction

University of Louisville

Louisville, Kentucky

May 2014

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A Dissertation Approved on

April 17, 2014

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Dr. Carl Lee

Dr. Judy R. Wilkerson

DEDICATION

This dissertation is dedicated to my parents

Mr. Martin “Duffy” Mall

and

Mrs. Karen Dee Mall

who guided me in finding the Self I am disposed to be.

ACKNOWLEDGEMENTS

Throughout my life I have been blessed with guardian angels, and 2007 was certainly no exception. So it is with gratitude that I begin by acknowledging Dr. Bill Bush, Dr. Vena Long and Dr. Carl Lee, along with all of the co-PIs and members of the management team, for creating and sustaining the Appalachian Collaborative Center for Learning, Assessment, and Instruction in Mathematics (ACCLAIM). This collaborative encouraged me to develop in new and exciting ways as a mathematics teacher and mathematics teacher educator. Due to my interactions with ACCLAIM faculty, particularly with respect to the mathematical diversions provided by Dr. Lee, Dr. Mays and Dr. Anderson, I found the heart of my research agenda: teachers' positive dispositions toward problem solving. Similarly, Dr. Jaci Webb-Dempsey's positive disposition toward qualitative research methodology inspired and grounded me during the study.

In 2007, I also began my work as faculty in the Master of Arts in Teaching (MAT) Program at the University of Alaska Anchorage. I would like to thank the Dean of the College of Education, Dr. Mary Snyder, and the Director of the MAT Program, Jim Seitz, for taking a chance on a variable quantity! Without the support of the staff in the College of Education, and the teacher candidates in the MAT Program, I would not have been able to complete my doctoral program. For this opportunity and experience, I am eternally grateful.

Every teacher has at least $n + 1$ great mentors. Recognizing that it is nearly impossible to list them all, I would like to acknowledge a few. First and foremost, I would like to express my gratitude to the entire faculty of the MAT Program, with specific acknowledgements to Jim Seitz, for his commitment to excellence in teacher education, Susan Barstow, for her commitment to

walking the talk, and Janet Steinhauser, for her graceful approach to mentoring. Looking back further to my years teaching high school mathematics, I would simply not be the same teacher dispositionally without the influences of Mary “Elvis” Moran, Martha Dennis, Jim Seitz, Alison Vail, Ruth Mount, Dagny Fritsche and David Souza, and the mathletes that graced the halls of Bartlett High School.

No better example of gracious and tireless mentoring exists than serving on a doctoral candidate’s dissertation committee. I would like to acknowledge my dissertation director, Dr. Bill Bush, for his guidance and positive disposition. This dissertation would not have been made possible without the patience and advice from additional committee members: Dr. Maggie McGatha, Dr. Ann Larson, Dr. Carl Lee and Dr. Judy Wilkerson. Without Dr. Wilkerson laying the foundation for assessing teachers’ dispositions, my study would not have been possible. The contributions of the entire committee ultimately strengthened my research and final product.

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ABSTRACT

DEVELOPMENT AND VALIDATION OF INDICATORS OF SECONDARY MATHEMATICS TEACHERS' POSITIVE DISPOSITIONS TOWARD PROBLEM SOLVING

Alison L. Mall

April 17, 2014

This dissertation examines disposition from a historical, theoretical and practical viewpoint. Chapter I introduces the purpose of the study: to apply Wilkerson and Lang's (2007) Disposition Assessment Aligned with Teacher Standards (DAATS) model to develop an assessment framework for measuring secondary mathematics teachers' dispositions toward mathematical problem solving. The study assumes secondary mathematics teachers' positive dispositions toward problem solving and students' productive dispositions toward problem solving are significant, beneficial factors in the mathematics classroom.

Chapter II examines the historical, theoretical and professional literature on teachers' dispositions and builds a case for: (1) the inherent value of teachers' dispositions toward problem solving and (2) the examination of teachers' dispositions toward problem solving from a normative theoretical perspective.

Chapter III outlines the research design for developing indicators of secondary mathematics teachers' positive dispositions toward problem solving. The study employed a mixed-methods design with two steps corresponding to the first two steps of Wilkerson and Lang's (2007) five-step DAATS model and informed by the foundations of psychological testing (i.e., *APA Standards for Educational and Psychological Testing*) outlined by Miller, McIntire and Lovler (2011). Chapter III provides the rationale and assumptions for the design, descriptions of

participants, data sources and data collection procedures, data analysis and validation procedures, methods for verification and trustworthiness, and limitations of the study.

Chapter IV presents the results of the study chronologically by D. The chapter presents the observable behaviors, attitudes, and practices that are likely to be consistent with a secondary mathematics teacher exhibiting a positive disposition toward problem solving. The chapter concludes with an assessment framework designed to generate assessment items and methods at varying levels of inference.

Chapter V examines the three central research questions, along with four refined research questions that emerged, and draws conclusions about assessing secondary mathematics teachers' positive dispositions toward problem solving. The chapter provides implications for practice and recommendations for further research, and concludes with personal insights on teachers' dispositions toward problem solving.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS	iv
ABSTRACT	vi
LIST OF TABLES	xi
LIST OF FIGURES	xiii
 CHAPTER I: INTRODUCTION	 1
Problem Statement	6
Purpose of the Study	9
Research Questions	10
Significance of the Study	11
Summary of Methodology	12
Delimitations	13
Limitations	13
Assumptions	14
Operational Definitions of Terms	15
Organization of Study	19
 CHAPTER II: LITERATURE REVIEW	 21
Introduction	21
Frameworks for Making Sense of Dispositions	24
Tripartite Theory of the Mind	24
The Nature and Value of Dispositions	27
Current Theoretical Approaches toward Teachers' Dispositions	32
Operationally Defining Dispositions	35
Systems for Assessing Teachers' Dispositions	46
Affective Assessment of Teachers' Dispositions	52
Methods for Assessing Teachers' Dispositions	54
Standards for Dispositions toward Problem Solving	57
Standards for Secondary Mathematics Students	60
Standards Secondary Mathematics Teachers and Teacher Candidates	63
Conclusion	70

CHAPTER III: METHODOLOGY	73
Introduction.....	73
Research Design	75
Participants	76
Participants' Backgrounds.....	76
Rationale for Selecting Participants	81
DAATS Step 1: Define Purpose, Use, Propositions, Content and Context	83
DAATS Step 2: Planning with a Continuing Eye on Valid Assessment Decisions	85
Methods for Verification and Trustworthiness of Qualitative Data.....	88
Delimitations	90
Limitations	90
Chapter Summary.....	91
CHAPTER IV: RESULTS	93
Introduction.....	93
Results of DAATS Step 1	94
Participants' Consensus on the Assessment Design Inputs.....	109
Results of DAATS Step 2	110
Indicators of Positive Dispositions	111
Indicators of Negative Dispositions	115
Affective Taxonomic Levels.....	117
Unaware Level	118
Receiving Level	120
Responding Level.....	122
Valuing Level.....	124
Organization Level	126
Characterization Level	129
Typical Teaching Behaviors at Each Taxonomic Level	133
Assessment Framework for Indicators of Positive Dispositions	142
Summary of Results.....	148
Concluding Remarks on the Relationship of Validity to the Major Findings.....	155
Chapter Summary.....	156
CHAPTER V: CONCLUSIONS.....	158
Introduction.....	158
Summary of Study	158
Purpose of the Study and Research Questions.....	159
Review of Methodology.....	162
Major Findings Related to the Literature	163

Central Research Question One.....	163
Teachers' Dispositions along a Continuum	164
Defining Dispositions.....	166
Normative Approach toward Dispositions	168
Central Research Question Two	169
Assessing Dispositions at Varying Levels of Inference	170
Using Dispositions Assessment for Teacher Development	172
Central Research Question Three	174
Relationship of Findings to Current Theoretical Perspectives on Dispositions	176
Surprises.....	180
Conclusions	183
Implications for Action	183
Recommendations for Further Research	185
Concluding Remarks	188
REFERENCES.....	191
APPENDICES	204
Appendix A	204
Appendix B	225
Appendix C	227
Appendix D	232
Appendix E	239
CURRICULUM VITAE.....	245

LIST OF TABLES

TABLE	PAGE
1. Increase of Research, Scholarship and Books on Teachers' Dispositions.....	23
2. Summary of Current Theoretical Approaches Toward Dispositions	33
3. Definitions of Dispositions	36
4. Definitions of Dispositions and Related Concepts.....	39
5. Examples of Dispositions and Related Concepts	43
6. Cognitive and Affective Domains.....	53
7. Methods for Measuring Dispositions or Affect.....	55
8. Standards and Expectations for Secondary Mathematics Teaching	59
9. Participants' Teaching and Educational Backgrounds	77
10. Reason for Choosing a Career in Mathematics Teaching and/or Teacher Education	81
11. Responses to the Purpose Section.....	96
12. Responses about Using Data	97
13. Responses to the Content Section.....	98
14. Responses to the Propositions Section.....	100
15. Responses to the Context Section	101
16. Importance of Using the Data for Teacher Development	106
17. Contextual Factors that Help or Hinder	108
18. Codes Used and Frequency for Positive Dispositions toward Problem Solving	112
19. Indicators of a Positive Disposition toward Problem Solving	114
20. Codes Used and Frequency for Negative Dispositions toward Problem Solving.....	116

21.	Phrases Used to Describe Teachers at the Unaware Level.....	118
22.	Descriptions of Teachers' Dispositions at the Unaware Level.....	119
23.	Phrases Used to Describe Teachers at the Receiving Level.....	120
24.	Descriptions of Teachers' Dispositions at the Receiving Level	121
25.	Phrases Used to Describe Teachers at the Responding Level	122
26.	Descriptions of Teachers' Dispositions at the Responding Level.....	123
27.	Phrases Used to Describe Teachers at the Valuing Level	124
28.	Descriptions of Teachers' Dispositions at the Valuing Level	125
29.	Phrases Used to Describe Teachers at the Organization Level.....	127
30.	Descriptions of Teachers' Dispositions at the Organization Level.....	127
31.	Phrases Used to Describe Teachers at the Characterization Level.....	129
32.	Descriptions of Teachers' Dispositions at the Characterization Level.....	130
33.	Assessment Framework for Indicators 1.1 to 1.6	143
34.	Assessment Framework for Indicators 2.1 to 2.5	144
35.	Assessment Framework for Indicators 3.1 to 3.6	145
36.	Assessment Framework for Indicators 4.1 to 4.3	146
37.	Assessment Framework for Indicators 5.1 to 5.5	147
38.	Alignment of Data Sources to Refined Research Questions.....	149
39.	Summary of Methodologies, Sample Items, Scoring Ease and Confidence Levels for Indicator 3.6.....	171
40.	Summary of Methodologies and Sample Items for Indicator 4.2.....	175

LIST OF FIGURES

FIGURE	PAGE
1. Pictorial Representation of the Historical Domains of the Mind	24
2. Disposition Assessments Aligned with Teacher Standards (DAATS) Model	51
3. Participants' Consensus on the Assessment Design Inputs.....	109
4. Typical Teaching Behaviors Using the Affective Taxonomy for General Indicator 1.....	134
5. Typical Teaching Behaviors Using the Affective Taxonomy for General Indicator 2.....	135
6. Typical Teaching Behaviors Using the Affective Taxonomy for General Indicator 3.....	136
7. Typical Teaching Behaviors Using the Affective Taxonomy for General Indicator 4.....	137
8. Typical Teaching Behaviors Using the Affective Taxonomy for General Indicator 5.....	138

CHAPTER I

INTRODUCTION

“Learning to solve problems is perhaps the most important skill that students can acquire. In professional contexts, people are paid to solve problems, not complete exams, and in everyday life, we constantly solve problems” (Jonassen, 2004, p. i).

Problem solving is an integral component of mathematics learning and an important aspect of life. To succeed in life, individuals must be able to solve problems. Both in everyday life and in the workplace, people who are good problem solvers generally hold an advantage over people who are not. A survey of 40 chief executives and managing directors from a variety of fields (i.e., engineering, banking, utilities, retail) indicated that the employable person is not only motivated, committed and a team player, but is also an innovator and problem solver (Clark, 1997). Furthermore, the *Job Outlook 2010* survey asked employers to rate the importance of various qualities of future employees. Topping the list were communication skills, a strong work ethic, initiative, interpersonal skills and problem-solving skills (National Association of Colleges and Employers, 2010, p. 23).

The National Council of Teachers of Mathematics (NCTM) recommends that problem solving be a focus of mathematics instruction. “Students should acquire ways of thinking, habits of persistence and curiosity, and confidence in unfamiliar situations that will serve them well outside the mathematics classroom” (2000, p. 52). Problem solving encompasses skills and processes that play an essential role in everyday life (NCTM, 1980). The NCTM’s *Principles and*

Standards for School Mathematics (PSSM) describe prekindergarten through grade 12

instructional programs that enable *all* students to:

- Build new mathematical knowledge through problem solving;
- Solve problems that arise in mathematics and in other contexts;
- Apply and adapt a variety of appropriate strategies to solve problems; and
- Monitor and reflect on the process of mathematical problem solving (2000, p. 52).

Furthermore, according to the Standards for Mathematical Practices as outlined by the National Governors Association Center for Best Practices in the *Common Core State Standards*,

“mathematically proficient students can apply the mathematics they know to solve problems arising in everyday life, society, and the workplace” (2010, p. 7). Students that possess the problem-solving qualities and skills, as communicated by the NCTM and National Governors Association in their respective visions for mathematics, would undoubtedly rank high among employers (Clark, 1997; National Association of Colleges and Employers, 2010; National Governors Association Center for Best Practices, 2010).

In order to realize NCTM’s vision, teachers are expected to make problem solving integral to mathematics teaching and learning, infusing worthwhile mathematical problems and tasks into the classroom. The selection of these worthwhile problems and mathematical tasks is a difficult decision, one that requires the wisdom and inclination of teachers who understand how to use problems to reach the mathematical expectations for their students. In essence, teachers must be able to select, analyze, and adapt problems, as well as anticipate questions from students that might arise. Clearly teachers “play an important role in the development of students’ problem-solving dispositions by creating and maintaining classroom environments, from pre-kindergarten on, in which students are encouraged to explore, take risks, share failures and successes, and question each other” (NCTM, 2000, p. 53).

The professional literature is replete with descriptive expectations for effective mathematics teaching. For example, the National Board for Professional Teaching Standards (NBPTS) defines twelve standards of accomplished practice for mathematics teachers working with adolescents and young adults. Outlined in these standards are the essential knowledge, skills, dispositions, habits of mind and commitments that characterize an effective mathematics teacher. According to the third standard, accomplished mathematics teachers “understand significant connections among mathematical ideas and the applications of these ideas to problem solving in mathematics, in other disciplines, and in the world outside of school” (2001, p. 5). According to the NBPTS, the accomplished mathematics teacher recognizes the importance of the problem-solving process, across **all** topic strands, and consistently supports students throughout the problem-solving process.

Each of the twelve standards for accomplished teaching, as outlined by the NBPTS, includes a succinct statement of the standard, followed by an elaborative passage explaining what teachers ought to know, value, and do to demonstrate accomplished teaching. Included within each standard is also a description of accomplished teachers’ dispositions. A disposition, as defined by the American Psychological Association, is “a recurrent behavioral or affective tendency that distinguishes an individual from others” (2007, p. 290). Specific to teacher education, in *Teaching as a Moral Practice: Defining, Developing, and Assessing Professional Dispositions*, dispositions are defined as:

. . . habits of professional action or moral commitments [and] refer to a teaching stance, a way or orienting oneself to the work and responsibilities of teachers. Those responsibilities are ultimately about moral practice in which the teacher mobilizes her knowledge and skills on behalf of the learners entrusted to her care (Diez & Murrell, 2010, p. 9).

Dispositions refer specifically to a “pattern of behavior that is exhibited frequently and in the absence of coercion and constituting a habit of mind under some conscious and voluntary

control, and that is intentional and oriented to broad goals” (Katz as cited in Wilkerson & Lang, 2007, p. 9).

Learning and teaching has a dispositional, or affective, component as evidenced in the professional literature of the NCTM, NBPTS, Council for the Accreditation of Educator Preparation (CAEP), National Council for Accreditation of Teacher Education (NCATE), Teacher Education Accreditation Council (TEAC), and in the *Common Core State Standards for Mathematics* (CCSS-M) set out by the National Governors Association Center for Best Practices. These organizations collectively describe, often in behavioral terms, the dispositions expected of teachers and students in mathematics classrooms. Assessing teachers’ dispositions is an activity originally associated with the national accreditation process for teacher education programs. For example, accreditation councils (i.e., NCATE, CAEP, TEAC) define appropriate dispositions and expect teacher education providers and institutions to assess teacher candidates’ dispositions. As part of the process to meet standards for accreditation, teacher education programs and providers are expected to assess teacher candidates’ dispositions at both the unit (i.e., college) and program (i.e., Master of Arts in Teaching) levels.

As part of the original NCATE accreditation process, the NCTM (2003) authored a set of *Program Standards for Initial Preparation of Mathematics Teachers* at the secondary level to achieve national recognition beyond institutional accreditation. This set of standards identified dispositions as one of sixteen standards for secondary mathematics teacher preparation programs to address. Standard 7 stated that teacher candidates should “support [in students] a positive disposition toward mathematical processes and mathematical learning” (p. 3). Mathematics teachers were expected to demonstrate an ability to support this disposition by attending to equity, using stimulating curricula, teaching effectively, committing to learning with understanding, using a variety of assessments, and using a variety of teaching instruments

including technology. The NCATE/NCTM (2003) program standards asserted that a positive disposition toward mathematical processes and mathematical learning is an expected inclination of all secondary mathematics teachers.

In the *NCTM CAEP Standards* for initial secondary mathematics teacher preparation programs, teacher candidates were still expected to demonstrate positive dispositions toward mathematical processes, practices, and learning. This revision of the 2003 standards also put forth productive disposition as an expectation for students. In essence, effective teachers of secondary mathematics are expected to “provide evidence demonstrating that, as a result of their instruction . . . secondary students’ mathematical proficiencies have increased” (2012a, p. 4). These proficiencies included a productive disposition toward mathematics.

Disposition has also been used to describe students’ mathematical inclinations. For example, the fifth strand of *mathematical proficiency*, as defined by the National Research Council (NRC) in *Adding it Up*, is *productive disposition* which is “the tendency to see sense in mathematics, to perceive it as both useful and worthwhile, to believe that steady effort in learning mathematics pays off, and to see oneself as an effective learner and doer of mathematics” (2001, p. 131). With the recent adoptions of the *Common Core State Standards for Mathematics (CCSS-M)* by 45 states, the District of Colombia, four territories and the Department of Defense Education Activity, secondary mathematics teachers have a refined set of standards for mathematical practice and content to achieve with their students. The CCSS-M’s *Standards for Mathematical Practice* list eight practices and describe “varieties of expertise that mathematics educators at all levels should seek to develop in their students” (p. 6). The first practice calls on students to make sense of problems and persevere in solving them. The *Standards for Mathematical Practice* combine the essential NCTM process standards (problem solving, reasoning and proof, communication, representation and connections) with additional

strands of mathematical proficiency and productive dispositions. Citing the NRC, the *CCSS-M* defines productive disposition as the “habitual inclination to see mathematics as sensible, useful, worthwhile, and coupled with a belief in diligence and one’s own efficacy” (National Governors Association Center for Best Practices, 2010, p. 6). Productive disposition is viewed as students’ tendencies to act or feel in a particular way, united with their belief that careful and persistent effort will produce a desired result.

The visions of the NCTM, NBPTS, CAEP, NRC and the National Governors Association Center for Best Practices collectively describe the knowledge, skills and dispositions that characterize a quality mathematics teacher and quality mathematics teaching for students. These organizations define the important role that teachers’ positive dispositions and students’ productive dispositions play in the teaching and learning of mathematics. From these definitions, an essential question emerges: *How do mathematics teacher educators assess the dispositions toward the mathematical processes, practices and learning that distinguish an effective mathematics teacher from an ineffective one?* In order to answer this question, it is necessary for mathematics teacher educators to have valid and reliable instruments to assess teachers’ dispositions toward the mathematical processes and, with respect to the focus of this study, teachers’ dispositions toward problem solving.

Problem Statement

Disposition, or affect, plays a role in the teaching and learning of mathematics. Studying teachers’ dispositions, and related concepts of affect and attitude, is an area of interest in the teacher education community. Teacher affect is *critically* important even though it has not been as widely studied as other concepts such as teachers’ beliefs or performance. “If prospective or practicing teachers are to develop deeper content knowledge and richer beliefs about mathematics, teaching, and learning, then positive affect must be considered” (Philipp, 2007, p.

309). Recent studies on teachers' dispositions have focused on *dispositions in action*, or how disposition plays out in the classroom and impacts the teaching and learning process. This focus has allowed researchers to better explicate the relationship between dispositions and related concepts, such as affect and attitudes. The following definition of *dispositions in action*, based on the work of Ritchhardt (2001; 2002) and Thornton (2006), emerged in the literature on teacher disposition:

Dispositions are habits of mind including both cognitive and affective attributes that filter one's knowledge, skills, and beliefs and impact the action one takes in a classroom or professional setting. They are manifested within relationships as meaning-making occurs with others and they are evidenced through interactions in the form of discourse (Thornton, 2006, p. 62).

According to this definition, dispositions are a juxtaposition of cognitive and affective characteristics that screen an individual's beliefs, knowledge and skills. Here beliefs are defined by Philipp (2007) as "psychologically held understandings thought to be true," knowledge as "beliefs held with certainty or justified belief," (p. 259) and skillful as the ability to do something well (e.g., teaching skills necessary to effectively teach secondary mathematics). Thus, dispositions represent an individual's habits of mind that translate knowledge, skills and beliefs into observable actions (e.g., verbal and non-verbal. More recently, Beyers (2011) proposed a conceptual framework rooted in the historical, tripartite view of mental processes of cognition, affection, and conation. He inferred the existence of cognitive, affective and conative mental functions with respect to students' mathematical dispositions (p. 71) in an effort to provide a framework that researchers and educators might use to systematically examine the development of dispositional cognitive, affective and conative mental functioning. According to the literature on which Beyer's framework rests, dispositions toward mathematics (as opposed to mathematical dispositions) focus primarily on dispositional affective and conative mental functioning, where conative mental function is a person's tendency or inclination to purposively

strive or to exercise diligence, effort, or persistence (English & English, 1958; APA, 2007; Beyers, 2011). The focus of this study will be on developing indicators of positive disposition toward problem solving as evidenced through a teacher's behavior.

Teachers' positive dispositions toward mathematical processes, such as problem solving, may play a role in supporting students' productive dispositions toward mathematics. While a definition of teachers' positive dispositions toward mathematical processes is absent from the literature, students' productive dispositions are defined by the NRC as the "habitual inclination[s] to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one's own efficacy" (National Governors Association Center for Best Practices, 2010, p. 6). Although not specifically stated in the *CAEP/NCTM Standards* for initial secondary mathematics teacher preparation programs, a mathematics teacher educator might infer that productive dispositions, as defined by the NRC, are expected in effective secondary mathematics teachers. While the relationship between teachers' positive dispositions toward problem solving and the development of students' productive dispositions toward making sense of problems and persevering in solving them has yet to be studied, a relationship is believed to exist, as described in the NCATE/NCTM (2003) *Program Standards for Initial Preparation of Mathematics Teachers: Standards for Secondary Mathematics Teachers* and the CAEP/NCTM (2012a) revision. The assessment of teachers' dispositions toward problem solving, particularly as they pertain to and influence the teaching and learning of problem solving in the classroom, could provide researchers critical verification in the examination and establishment of a relationship. Additionally, the development of valid and reliable methods for assessing teachers' dispositions toward problem solving could contribute to the improvement of both initial preparation and professional development programs for pre-service and in-service mathematics teachers.

Research linking teachers' dispositions, or affect, toward the teaching and learning of problem solving with the teacher's classroom instructional decisions is lacking. Philipp (2007) acknowledged:

Although few researchers have examined the relationship between mathematics teachers' affect and their instruction, the existing research shows that the feelings teachers experienced as learners carry forward to their adult lives, and these feelings are important factors in the ways teachers interpret their mathematical worlds (p. 28).

The research community needs to better understand and assess teachers' dispositions toward mathematical processes and practices. Furthermore, examining the extent to which teachers' dispositions toward problem solving impacts instructional choices that ultimately impact the development of students' productive dispositions toward mathematics is also needed.

Purpose of the Study

The primary purpose of this study was to apply Wilkerson and Lang's (2007) Disposition Assessment Aligned with Teacher Standards (DAATS) model to develop an assessment framework for selecting existing instruments or designing future instruments to assess secondary mathematics teachers' dispositions toward the mathematical process of problem solving. The assessment framework that results has the potential to provide a blueprint for valid assessment decisions and inferences about secondary mathematics teachers' dispositions toward problem solving. This framework could serve a variety of purposes such as:

- Assisting mathematics teacher educators in the identification of existing or creation of new instruments aligned with the standards and consistent with an assessment framework designed to measure secondary mathematics teacher candidates' dispositions toward problem solving;
- Assisting secondary mathematics teacher candidates in visualizing the affective targets that indicate a positive disposition toward problem solving;

- Providing evidence for accreditation, evaluation, and improvement of secondary mathematics teacher education programs;
- Providing an assessment framework for evaluating professional development programs focused on developing positive dispositions toward problem solving in secondary mathematics teachers; and
- Providing a framework for investigating the relationship between teachers' dispositions toward problem solving and students' productive dispositions toward problem solving.

Research Questions

The missing links and gaps in the existing research and professional literature, combined with the purpose of the study, motivated three central research questions examined through this study:

1. Based on the standards, what are observable (verbal and nonverbal) behaviors, attitudes, or practices that are likely to be consistent with secondary mathematics teachers exhibiting positive dispositions toward problem solving?
2. Using Wilkerson and Lang's (2007) Disposition Assessment Aligned with Teacher Standards (DAATS) model, to what extent can an assessment framework, with assessment methods at different levels of inference, be developed to assess secondary mathematics teachers' dispositions toward problem solving?
3. To what extent will the assessment framework provide a valid framework for selecting existing instruments (or designing future instruments) to measure secondary mathematics teachers' dispositions toward problem solving?

Significance of the Study

Dispositions, although challenging to operationally define and assess, are a significant construct in the field of teacher education. The debate surrounding dispositions is evident in an increase in research and scholarly articles in the literature on teacher education. Today the importance of assessing teachers' dispositions is supported by the NCATE and CAEP processes applied to teacher education programs, in the expectations outlined by the NBPTS for certification as an accomplished teacher, and in the hiring and selection process of teachers (Vergari & Hess, 2002; NBPTS, 2002; Wasicsko, 2004). As such, the results of this study have the potential to impact teacher education programs by providing a framework for mathematics teacher educators to examine and identify the nature of secondary mathematics teachers' dispositions toward problem solving and, if possible, remediate inclinations that are inconsistent with positive dispositions toward problem solving. In turn, the results of this study have the potential to have an impact on secondary mathematics teachers and their students.

As part of the national recognition process, secondary mathematics teacher education programs must demonstrate an eighty percent (80%) pass rate on state licensure tests and more than fifty percent (50%) of the elements of each standard must be at the acceptable or target level (NCTM, 2014). Assessing teacher candidates' dispositions, through total faculty input s required by NCTM, NCATE, and now CAEP, for any provider or education program charged with the initial preparation of mathematics teachers. The assessment framework that results from this study has the potential to assist faculty in responding to the national expectations related to secondary mathematics teachers' dispositions.

Once an assessment framework and instruments for measuring secondary mathematics teachers' dispositions toward problem solving are developed, researchers will be better equipped to design studies to investigate the relationship between secondary mathematics

teachers' positive dispositions toward problem solving and the development of students' productive dispositions toward problem solving. Finally, an assessment framework of this type could serve the accreditation, certification, professional development and research goals of individuals in mathematics education.

Summary of Methodology

This study employed a mixed-methods design with two steps corresponding to the first two steps of Wilkerson and Lang's (2007) five-step DAATS model and informed by the foundations of psychological testing (i.e, *APA Standards for Educational and Psychological Testing*) outlined by Miller, McIntire and Lovler (2011). The study was preceded by an analysis of the standards on secondary mathematics teachers' dispositions toward problem solving and culminated with the development and validation of indicators of secondary mathematics teachers' positive dispositions toward problem solving to generate an assessment framework. An abbreviated description of the steps in this study, adapted from the first two steps of Wilkerson and Lang's (2007) five-step DAATS model, is provided below:

DAATS Step 1: Assessment Design Inputs

Define purpose, use, propositions, principles, content and other contextual factors that will define the conceptual framework for an assessment system designed to measure secondary mathematics teachers' dispositions toward problem solving and ultimately guide the development and validation of indicators of secondary mathematics teachers' positive dispositions toward problem solving (p. 42).

DAATS Step 2: Planning with a continuing eye on valid assessment decisions

Identify and analyze standards and indicators of secondary mathematics teachers' positive dispositions toward problem solving. Visualize secondary mathematics teacher demonstrating the affective targets that indicate a positive disposition toward problem solving. Establish content validity of the indicators through an examination of agreement of experts on the applicability of values, domain coverage, and relevancy to the work of secondary mathematics teachers. Build an assessment framework that correlates standards and assessment methods (p. 62).

The researcher employed well-established qualitative research methods that ensured a faithful representation of secondary mathematics teachers' dispositions toward problem solving. The researcher selected a mixed-methods, concurrent triangulation strategy as it was best suited to compare and substantiate the findings of the study (Creswell, 2009).

Delimitations

The purpose of this study was to develop and validate indicators of secondary mathematics teachers' positive dispositions toward problem solving. The study was limited to three experienced NCATE/NCTM reviewers of secondary mathematics teacher preparation program reports, three experts in the area of problem solving, and one expert in the area of mathematics teaching and learning as described by the National Board of Professional Teaching Standards (NBPTS). One participant was both an expert in NCATE/NCTM standards and the area of problem solving. The individuals participating in the study were volunteers and had varying knowledge and views about national standards outlined by the NCTM, NBPTS, NCATE, CAEP, NRC and National Governors Association Center for Best Practices.

Limitations

Three limitations of this study were evident. First, the dispositional indicators generated were developed using expectations for effective, accomplished mathematics teachers as described by the NCTM, NBPTS, NCATE, CAEP, NRC and National Governors Association Center for Best Practices. Therefore, the dispositional indicators, assessment framework and suggested item pool were based on the standards produced by these organizations. These standards are valuable and important in defining the principles and responsibilities of secondary mathematics teachers. In order to establish an assessment framework based on data and decisions that would likely be replicable in other contexts, the researcher selected experts in the field and knowledgeable about and believed in the visions of the NCTM, NBPTS, NCATE, CAEP, NRC and

the National Governors Association Center for Best Practices. Researchers who use the results of this study need to review the results of the first two DAATS steps for applicability to their context in order to ensure validity of the assessment design inputs and planning with a continuing eye on valid assessment decisions (Wilkerson & Lang, 2007). Second, the consistency of the assessment frameworks (see Tables 33-37) was impacted by the small number of participants in this study. Although the researcher reviewed for consistency participants' selections of assessment methods where the responses were spread across the three categories (yes, possibly, no), the decision about *yes*, *possibly*, or *no* could be significantly impacted by a single participant's vote. Assessment developers should use the assessment framework as guide only, to be confirmed and adjusted locally. If developers are able to identify good items for an indicator with a corresponding assessment method classified as a *no*, they should be comfortable in using the items, since as many as four of the six respondents may have indicated that such items could be developed. Third, the psychometric quality of the suggested instruments and items that correspond to the assessment framework that resulted from this study was not ascertained. Validity, reliability and fairness for items and instruments should be established as they are developed or selected.

Assumptions

Three basic assumptions served as bases for this study. First, the visions, expectations, and standards, outlined by the NCTM, NBPTS, NCATE, CAEP, NRC and National Governors Association Center for Best Practices, describe reasonable and essential dispositions toward problem solving of effective and accomplished secondary mathematics teachers. Second, the participants were knowledgeable in and believed in the visions outlined by the NCTM, NBPTS, NCATE, CAEP, NRC and National Governors Association Center for Best Practices. This provided

construct and content validity to the assessment framework that resulted from this study. Third, participants in this study reported their thoughts and feelings honestly.

Operational Definitions of Terms

Provided below are the operational definitions of the technical terms used in this study.

Affect is a “disposition or tendency or emotion or feeling attached to an idea or object” (Philipp, 2007, p. 259).

Assessment framework refers to a sampling plan or test blueprint. It is a detailed outline of which affective measurements will be employed to measure secondary mathematics teachers’ dispositions toward problem solving. It assures a balanced and suitable set of assessments to measure secondary mathematics teachers’ dispositions toward problem solving.

Assessment system refers to the clearly defined process that connects outcomes of the DAATS model (e.g., purpose, use, propositions, contextual factors, assessment framework) in order to form a complex whole. The assessment system provides an organized method for assessing secondary mathematics teachers’ dispositions toward problem solving.

Attitude refers to “a relatively enduring and general evaluation of an object, person, group, issue, or concept on a scale ranging from negative to positive” (APA, 2007, p. 83). Attitudes are “manners of acting, feeling, or thinking that show one’s dispositions or opinion” (Philipp, 2007, p. 259).

Behavior refers to the conduct of or manner in which an individual functions or operates (Merriam-Webster Online Dictionary, 2011). Behavior is an action that is both observable and measureable (Miller et al., 2011). For the purposes of this study, behavior refers to the conduct of or manner in which secondary mathematics teachers function or operate within the context of their classrooms.

CAEP refers to the Council for the Accreditation of Educator Preparation whose mission is to advance “excellence in educator preparation through evidence-based accreditation that assures quality and supports continuous improvement to strengthen P-12 student learning” (CAEP, 2014).

Candidates are “individuals admitted to, or enrolled in, programs for the initial or advanced preparation of teachers . . . Candidates are distinguished from students in P-12 schools” (NCATE, 2008, p. 85).

Cognition refers to conscious intellectual activity and mental processes (Merriam-Webster Online Dictionary, 2011). For the purposes of this study, cognition refers specifically to the mental process of problem solving. The related concept, **knowledge**, refers to a set of “beliefs held with certainty or justified true belief” (Philipp, 2007, p. 259) and “knowing something with familiarity gained through experience” (Merriam-Webster Online Dictionary, 2011). For the purposes of this study, knowledge refers to beliefs held with certainty by secondary mathematics teachers about problem solving and the problem-solving process. An example of a belief would be a teacher stating that one of the main roles of a teacher is to encourage students to reflect on the problem-solving process. This same belief, as knowledge, would be the teacher’s awareness of the expectation and importance of students reflecting on the problem-solving process coupled with knowledge of how to enact the expectation in the classroom. The latter *knowledge* is more certain than the former *belief*.

Construct refers to an “attribute, trait or characteristic that is abstracted from observable behaviors” (Miller et al., 2011).

Content validity is “the extent to which items on a test or scale match the behavior, skill, or affect the researcher intends them to measure” (Merriam & Simpson, 2000, p. 226).

DAATS, or Disposition Assessments Aligned with Teacher Standards, refers to the five standards-based steps to valid measurement as described in Wilkerson and Lang's (2007) *Assessing Teacher Dispositions*.

Disposition is "recurrent behavioral or affective tendencies that distinguish an individual from others" (APA, 2007, p. 290). Dispositions encompass the "attitudes, values and beliefs that influence the application and use of knowledge and skills" (Wilkerson & Lang, 2007, p. 2). Dispositions manifest as a "pattern of behavior that is exhibited frequently and in the absence of coercion and constituting a habit of mind under some conscious and voluntary control, and that is intentional and oriented to broad goals" (Katz as cited in Wilkerson & Lang, 2007, p. 9).

Indicator refers to a behavior (verbal or nonverbal), attitude or practice that provides information about teachers' dispositions toward or commitment to problem solving.

InTASC refers to the Interstate Teacher Assessment and Support Consortium, a nationwide, nonpartisan, and nonprofit membership organization that brings together the top education leaders from every state in the United States of America (InTASC, 2013).

Knowledge is "information and understanding of a specific topic or of the world in general, usually acquired by experience or by learning" (APA, 2007, p. 516).

NBPTS refers to the National Board for Professional Teaching Standards whose mission "is to advance student learning and achievement by establishing the definitive standards and systems for certifying accomplished educators, providing programs and advocating policies that support excellence in teaching and leading, and engaging National Board Certified Teachers and leaders in that process" (NBPTS, 2012).

NCATE refers to the National Council for Accreditation of Teacher Education, a non-profit, non-governmental alliance, whose mission is to provide the profession with a

“mechanism to establish high quality teacher preparation [through the] process of professional accreditation of schools, colleges and departments of education” (NCATE, 2012).

NCTM refers to the National Council of Teachers of Mathematics and is the “public voice of mathematics education, supporting teachers to ensure equitable mathematics learning of the highest quality for all students through vision, leadership, professional development, and research” (NCTM, 20 October 2012).

NRC refers to the National Research Council whose “mission it is to improve government decision making and public policy, increase public understanding, and promote acquisition and dissemination of knowledge in matters involving science, engineering, technology, and health” (National Academy of Sciences, 2013).

Problem solving, according to the *Principles and Standards for School Mathematics*, is “engaging in a task for which the solution method is not known in advance” (NCTM, 2000, p. 52).

Secondary mathematics teachers are individuals that currently teach mathematics in a seventh through twelfth grade classroom.

Skill refers to the “ability to use one’s knowledge effectively and readily in execution or performance” (Merriam-Webster Online Dictionary, 2011). Examples of skills necessary to effectively teach secondary mathematics include planning, explaining, reinforcing, questioning, listening, generating hypotheses, probing, and decision making.

Standards refer to “written expectations for meeting a specified level of performance” (NCATE, 2008, p. 91).

Tripartite Theory of Attitudes refers to the theory that there are three components of an attitude: affective, cognitive and behavioral (APA, 2007; Breckler, 1983). Traditionally, the behavioral component is referred to as conative. The **affective domain** of mental functioning

refers to the experience of feeling or emotion, traditionally identified as one of three components of mental functioning (i.e., affective, cognitive, conative). The **cognitive domain** of mental functioning refers to the thought process, including application of knowledge and changing of preferences. The **conative domain** (i.e., behavioral) of mental functioning refers to the aspect of the mind that puts an individual's thoughts and feelings into action. The conative domain theoretically takes a person's beliefs and affect and puts them into action in the classroom.

Value refers to a "moral, social, or aesthetic principle accepted by an individual or society as a guide to what is good, desirable, or important" (APA, 2007, p. 295). A value is a deeply-held belief that one acts upon (Philipp, 2007).

Varying levels of inference refers to the confidence gained by measuring a construct through a "series of well-designed, progressive measures" (Wilkerson & Lang, 2007, p. 31). The second step of the DAATS model outlines a clear process for selecting assessment methods at different levels of inference to build an assessment framework that correlates standards and methods. This step ensures multiple measures of affective measurement and ultimately improves the level of confidence in the accuracy of inferences about secondary mathematics teachers' dispositions.

Organization of Study

This dissertation is organized into five chapters, a list of references, and appendices. Chapter II of the study presents a review of related literature and culminates in a summary of current procedures used to assess teachers' dispositions, or affect. Chapter III describes the research design and methodology of the study, based primarily on the foundations for psychological testing (i.e., *APA Standards for Educational and Psychological Testing*) described by Miller, McIntire and Lovler (2011) and the DAATS model outlined Wilkerson and Lang's (2007)

DAATS model. Included in the third chapter are descriptions of the participants, instrumentation, and procedures for the study. Chapter IV presents the results of the research study. This includes an analysis of the data used to elicit indicators of secondary mathematics teachers' positive dispositions toward problem solving and the development of an assessment framework for selecting assessment methods at varying levels of inference. Chapter V discusses the relationship of the results of this study to past research and theory on teacher disposition, and concludes with implications for practice and recommendations for further research.

CHAPTER II

REVIEW OF THE LITERATURE

“A cloudy day is no match for a sunny disposition” (Ward, as cited in Easter, 2008, p. 23).

Introduction

This inspirational motif serves as a focal point for this chapter and research study. With this quote, William Arthur Ward succinctly described the philosophical importance of individuals' dispositions. From the Latin *dispositionem*, meaning “arrangement, order, mood, state of mind,” the *Merriam-Webster Online Dictionary* defines dispositions as prevailing tendencies, moods or inclinations; temperamental makeups; the tendencies of things to act in certain manners under given circumstances. First used in the fourteenth century, synonyms for dispositions include tendencies, inclinations, temperaments, natures, characters, humors, attitudes and personalities. Dispositions generally refer to individuals' habits of mind and emotions displayed over a period of time. This chapter reviews the historical, theoretical, and professional literature on dispositions within the fields of psychology, philosophy, teacher education and, more specifically, secondary mathematics teacher education.

The primary purpose of this study was to develop an assessment framework as a framework for selecting existing instruments or designing future instruments to assess secondary mathematics teachers' dispositions toward the mathematical process of problem solving. Therefore, the central focus of the literature review will be secondary mathematics teachers' dispositions toward the mathematical process of problem solving. Based on the

research and professional literature, this review builds a case for the importance of teachers' dispositions toward mathematics, and more specifically, toward problem solving.

Assessing teachers' dispositions is an activity most closely linked to the national accreditation of teacher education programs. Assessing teacher candidates' dispositions' arose primarily as a result of the standards movement in teacher education in the 1990's. Both the Interstate New Teacher Assessment and Support Consortium (InTASC) and the National Board for Professional Teaching Standards (NBPTS) defined standards for teaching at the beginning and accomplished levels, respectively. These standards shifted the conversation from "knowledge, skills and attitudes" to "knowledge, skills and dispositions" (Freeman, 2007; Diez & Murrell, 2010). The foundation for the NBPTS is "cast in terms of actions that teachers take to advance student achievement [and incorporates] the essential knowledge, skills, dispositions, and commitments that allow teachers to practice at a high level" (2001, p. v). The term disposition was adopted by both the National Council for the Accreditation of Teacher Education (NCATE) and the Council for the Accreditation of Educator Preparation (CAEP), as part of the accreditation process for teacher education programs. Starting in 2002, NCATE began to hold education institutions accountable for assessing *professional dispositions*:

Candidates for all professional education roles develop and model dispositions that are expected of educators. The unit articulates candidate dispositions as part of its conceptual framework(s). The unit systematically assesses the development of appropriate professional dispositions by candidates. Dispositions are not usually assessed directly; instead they are assessed along with other performances in candidates' work with students, families, and communities (p. 19).

Since 2002, NCATE has provided further clarification on professional dispositions expected by teacher candidates. Today, institutions seeking CAEP accreditation and programs seeking CAEP/NCTM recognition are expected to examine and assess teachers' dispositions.

Dispositions, although challenging to operationally define, develop and assess, are a critically important theory in the field of teacher education. The importance of and debate

about dispositions in teacher education is evident by an increased presence of research and scholarly articles. For example, searches of ERIC, ProQuest Dissertations & Theses, ProQuest Education Journals and ProQuest Psychology Journals, using the query ti(disposition AND teacher*) OR ti(disposition* AND “teacher education”) provided 152 scholarly journal articles, 79 dissertations and theses, 20 reports, 13 trade journal articles and 3 books between the years 1958 to present. Table 1 illustrates the increase in publications on dispositions in the teaching and teacher education fields.

Table 1

Increase of Research, Scholarship and Books on Teachers’ Dispositions

Time Period	No. of Scholarly Works
1950 to 1959	2
1960 to 1969	2
1970 to 1979	5
1980 to 1989	6
1990 to 1999	21
2000 to 2009	176
2010 to Present	52

Table 1 illustrates the increased focus on and importance of disposition in the teaching profession. A sampling of the scholarly works from this table include a focus issue on teachers’ dispositions in the *Journal of Teacher Education* (2007) and several books summarizing the research about and theoretical perspectives toward dispositions and assessment of dispositions in teacher education. While Table 1 illustrates the increased discussion of dispositions, it does not reveal the debate concerning the nature, definition, and assessment of the dispositions. The

next section provides a summary of the literature and theoretical basis for the nature and definition of dispositions for the purposes of this study.

Frameworks for Making Sense of Dispositions

Seven theoretical frameworks from the literature have the potential to provide foundational support for this study. A discussion of these frameworks begins with the historical, tripartite theory of the mind followed by the normative theoretical perspective on disposition. While the latter two frameworks are central to the design of this study, five additional theoretical perspectives toward teachers' dispositions provide valuable support for the theoretical framework of this study. All seven theoretical frameworks inform the discussion on defining and assessing dispositions broadly as it applies to teacher education and, more specifically, in terms of secondary mathematics teachers' dispositions toward the problem-solving process. An overview and analysis of the seven frameworks follow.

The Tripartite Theory of the Mind

A model in modern psychology, that is widely known, yet still theoretical, suggests three components of the mind: cognitive, affective and conative. This division of the mind stems from the work of Plato and Aristotle, who believed three faculties motivated our thoughts, feelings and actions. In the field of psychology, cognition refers to "all forms of knowing and awareness, such as perceiving, conceiving, remembering, reasoning, judging, imagining, and problem solving" (APA, 2007, p. 187). Affect refers to "any experience or feeling or emotion, ranging from suffering to elation, from the simplest to the most complex sensations of feeling, and from the most normal to the most pathological emotional reactions" (p. 26). Conation, often referred to as *volition*, is the "proactive (as opposed to habitual) part of the motivation that connects knowledge, affect, drives, desires, and instincts of behavior" (p. 210). Thus it represents the

mental and behavioral tendencies of an individual to act or strive to act (Snow & Jackson, 1994). Theoretically conation is involved in teacher effort in the classroom.

The tripartite division of human consciousness parallels the tripartite theory of attitudes whereby an attitude consists of cognitive, affective and behavioral components (Breckler, 1983). In fact, the behavioral component of an attitude is sometimes referred to as the conative component (APA, 2007). Most educators are familiar with the first two faculties, cognitive and affective, with the conative faculty not widely used in the literature nor researched. However, the conative faculty has emerged in recent literature on student disposition (Beyers, 2011; Tait-McCutcheon, 2008; Brookhart, 1997). A pictorial representation of these faculties, along with working descriptions, is provided in Figure 1.

Figure 1. Pictorial representation of the historical domains of the mind with examples of how each aspect of the triad might manifest in the area of problem solving.

Combining the tripartite view of the mind with the NCTM (1989) suggestion that students' mathematical dispositions are a combination of attitudes and tendencies to think and act in positive manners, Beyers (2011) inferred the existence of dispositional cognitive, affective and conative mental functions to make sense of mathematical dispositions (p. 71). These dispositional functions manifest as thought processes (cognition), feelings and attitudes (affect), and inclinations to act purposefully (conation). According to Beyers, a person who exhibits a "tendency or inclination to engage (or not) in a particular cognitive mental process in mathematics" is demonstrating a dispositional cognitive mental function with respect to mathematics (p. 71). Similarly, a person who exhibits a "tendency or inclination to have or experience particular attitudes, beliefs, feelings, emotions, moods or temperaments" in mathematics is demonstrating a dispositional affective mental function with respect to mathematics (p. 71). Lastly, a person who exhibits a "tendency or inclination to purposively strive or to exercise diligence, effort, or persistence in the face of mathematical activity" is demonstrating a dispositional conative mental function with respect to mathematics (pp. 71-72). Framing disposition in terms of dispositional cognitive, affective and conative mental components emphasizes the equal footing and interplay between thought, feeling and action. Thus dispositions manifest as a composition of cognitive, affective and conative patterns. Practical examples of this composition in the field of teacher education are evident in the indicators describing each InTASC principle. That is, each principle is written in terms of specific knowledge, dispositions and performances, i.e., skills and actions (see Wilkerson & Lang, 2007, p. 6). Framing dispositions in this manner further supports the theory that a relationship between cognitive, affective and conative mental processes exists.

In 1980, Richard E. Snow, an educational psychologist at Stanford University, stated that "it is not unreasonable to hypothesize that both conative and affective aspects of persons and

situations influence the details of cognitive processing,” suggesting that researchers and academics need to synthesize cognition, affect and conation in order to define a theoretical framework for examining intelligent behavior in the real world (p. 194). In *Head and Heart: Affection, Cognition and Volition as Triune Consciousness*, Tallon (1997) interpreted human experience through phenomenological and ontological lenses and concluded “only when head and heart are integrated with will, in an operational synthesis of affection, cognition, and volition do we have an adequate idea of human consciousness” (p. 199). Only this synthesis of affection, cognition and volition, allows an individual to progress developmentally. If any of the aspects of this triad is “too dominant, or slighted, or suppressed, a functional imbalance results” (p. 290). Ritchhart (2001) stated that dispositions involve “not only what one can do, one’s abilities, but also what one is disposed to do. Thus dispositions address the often-noticed gap between our abilities and our actions” (as cited in Thornton, 2006, p. 54). The disconnection between a teacher’s ability and action motivates the inclusion of dispositions as potentially the most important element of an assessment framework (Wilkerson & Lang, 2007).

The Nature and Value of Dispositions

Currently a debate over the nature and value of dispositions in the field of teacher education exists (Borko, Liston, & Whitcomb, 2007). Dispositions are viewed as behavior tendencies, habits of mind or goals for teacher education, or as a juxtaposition of these constructs (Jung, 2004; Thornton, 2006). Similarly, in the field of psychology, dispositions are viewed from either a behavioral science or normative approach (Birmingham, 2009). A question that contextualizes and differentiates between the two theoretical approaches, specific to mathematics teaching, would be: *How can we know that teachers’ positive dispositions toward problem solving are valuable?* In theory, teachers’ positive dispositions toward problem solving is not only observable in the teachers’ behaviors, but should ultimately be linked to differences

in students' productive dispositions toward problem solving. A researcher using a behavioral science approach might claim that the students of teachers identified as having positive dispositions toward problem solving would have more productive dispositions toward problem solving in comparison to the students of teachers identified as having negative dispositions toward problem solving. In contrast, using a normative approach to dispositions, another researcher might argue that secondary mathematics teachers should demonstrate positive dispositions toward problem solving simply because of their inherent value in the study of mathematics, irrespective of whether or not students develop productive dispositions toward problem solving as a result.

Several researchers examining dispositions, a term originally borrowed from the behavioral sciences, advocate for an approach rooted in the moral, normative theoretical perspective (Burant, Chubbuck, & Whipp, 2007; Noddings, 1992; Van Manen, 2000, Osguthorpe, 2008). Similarly, Darling-Hammond and Bransford (2005), building on the work of Dewey (1902) and Ball and Cohen (1999), state that the interactions between the teacher, student and subject are "framed by two important conditions for practice: first, the fact that teaching is a profession with certain moral as well as technical expectations, and second, the fact that, in the United States, education must serve the purposes of democracy" (p. 10). Other researchers approach their studies on dispositions with behavioral and predictive models. For example, an approach consistent with a behavioral and predictive model might frame students' mathematics achievement as an outcome and teachers' dispositions as a predictor. The researchers using this framework do not focus on the *moral* or *character* aspect of dispositions (Jung, Larson, Mofese, & Thompson, 2008). In her analysis of the disposition of hope in teaching, Birmingham argued for a normative approach:

Ironically, even in a discussion about instrumental value, consideration of normative value is inevitable, for the value of the effects is ultimately a normative determination.

For example, one effect that is commonly selected as valuable is student performance on norm-referenced tests (p. 28).

Clearly a relationship between the behavioral science and normative approaches to studying dispositions exists. For example, the InTASC, NCATE, and now CAEP, standards describe dispositions in terms of the values, beliefs and commitments expected of beginning teachers, creating a model that approaches assessment of dispositions in terms of pedagogical practices and teaching behaviors in the school setting (Thornton, 2006). This model motivates assessing candidate abilities via checklists, rubrics, and rating scales that describe the professional characteristics and behaviors of teacher candidates (e.g., attendance, work ethic, pedagogical practices). Central to this model, at least from the NCATE and CAEP perspectives, is the focus on the moral and ethical dimensions of teaching. This focus is evident in the requirement that institutions ensure teacher candidates demonstrate dispositions in the school setting that indicate they value fairness and believe that all students can learn. Similarly, the Council of Chief State School Officers call on educator preparation programs to provide high quality education and experiences that are consistent with the knowledge, skills and dispositions necessary to positively impact the achievement of the diverse student population in today's public schools (2012, p. 20). Thus, national standards generally take a normative approach to teacher candidates' dispositions. As a result, this approach generally motivates teacher educators to take a behavioral approach to assessing teacher candidates' dispositions using a variety of data sources (e.g, performance on a belief scale or in a classroom observation).

Attempts to reconcile the relationship between the behavioral science and normative approaches to studying dispositions have been made. This conflict will ultimately result in a dialogue that will improve the conceptualization of teachers' dispositions and how to measure and develop them in teacher candidates. Some educational policy leaders, for example, insist

that the moral and ethical aspects of the debate surrounding dispositions be reclaimed – and suggest the elimination of the term *dispositions* from the field of teacher education:

We call on ourselves, our colleagues, and the bodies that represent the field of teacher education to reclaim the moral: to continue this discussion, to embrace the questions that will surely emerge, and to reach a place of clarity from which we can move forward with a unified voice (Burant, Chubbuck, & Whipp, 2007, p. 19).

These researchers propose eliminating *dispositions* as a concept in the field of teacher education altogether due to a perceived, problematic conflict between the historical use of the term in the field of psychology. In contrast, Wilkerson and Lang (2007) caution against focusing solely on morality and ethics when measuring teacher candidate dispositions:

Focusing on morality and ethics, rather than skill-based standards, is short sighted, bordering, in our view, on the *real* action, letting unmotivated teachers into the profession because of a failure to recognize the codependence of knowledge, skills, and dispositions (p. 13).

They recommend that institutions (i.e., colleges and districts) “merge and align their values, as expressed in a mission statement or a conceptual framework and the InTASC dispositional indicators, with national standards coming first and predominating, as a matter of validity and legal safety” (p. 10). While a moral rationale for attending to teacher candidates’ dispositions exists, the assessment of dispositions should be firmly grounded in clearly-defined, national standards and expectations and the conceptual framework of the institution (Wilkerson & Lang, 2007; Hampton, 2010; Damon, 2007). After all, these skills-based standards and expectations express the norms that, for example, professionals in the field of secondary mathematics education value. Gone unchecked, teacher candidates’ unfavorable dispositions identified during a teacher education program may hinder their success with students as in-service teachers (Hampton, 2010).

Another recent attempt focuses on *dispositions in action* (Ritchhardt, 2001; Freeman, 2007). *Dispositions in action* focus on “patterns of thinking and how one is disposed to act

[thereby moving] beyond personality traits and minimal behavior expectations” (Thornton, 2006, p. 56). Based on Ritchhardt’s framing of dispositions as active in nature, Thornton conducted a study that focused on how dispositions transpire in the classroom setting, including how dispositions impact the teaching and learning process. A definition for *dispositions in action* resulted from this study:

Dispositions are habits of mind including both cognitive and affective attributes that filter one’s knowledge, skills, and beliefs and impact the action one takes in a classroom or professional setting. They are manifested within relationships as meaning-making occurs with others and they are evidenced through interactions in the form of discourse (2006, p. 62).

Thornton’s approach to studying dispositions, along with Ritchhart’s definition of dispositions as overarching sets of behavior that motivate, activate and direct ability (2002, p. 21), inform the manner in which dispositions are assessed in the field of teacher education.

This research study is an examination of secondary mathematics teachers’ dispositions toward problem solving as evidenced through indicators developed from a normative theoretical perspective. That is, the rationale for examining teachers’ dispositions toward problem solving is based on the intrinsic value of *positive* dispositions toward problem solving as identified in the national expectations and standards for secondary mathematics teachers. The inclusion of dispositions within the teaching professional literature sends the message that the extent to which teachers use their knowledge and skills is in part determined by teachers’ dispositions (Carroll, 2007). Put another way, mathematics teacher education programs have an ethical responsibility to prepare secondary mathematics teachers who exhibit the positive dispositions toward problem solving necessary to support students’ productive dispositions toward problem solving. Osguthorpe (2008) suggests that prior to exploring “the place or importance of dispositions relative to knowledge and skills, [teacher educators] must ask a series of prior, more fundamental questions that address the fundamental purposes of

attending to the moral and ethical development of teacher candidates” (p. 298). These questions, written in terms of dispositions toward problem solving, would be:

1. Why do we want teachers with positive dispositions toward problem solving?
2. How positively disposed toward problem solving does a teacher need to be?
3. What if a teacher exhibits negative dispositions toward problem solving?

While not specifically the research question for this study, they guide secondary mathematics teacher educators in developing an assessment framework and instruments designed to infer the extent to which secondary mathematics teacher candidates exhibit positive dispositions toward problem solving using Wilkerson and Lang’s (2007) DAATS model. Choosing a normative approach to examining teachers’ dispositions further supports the significance of conation in describing the tendencies of diligence, effort and persistence exhibited by a committed secondary mathematics teacher in the mathematics classroom.

Current Theoretical Approaches toward Teacher Disposition

Additional, promising theoretical perspectives toward teachers’ dispositions that encourage a dialogue on and a debate about dispositions in the field of teacher education are discussed in the literature. Dispositions as a core requirement in the field of teacher preparation arrived abruptly and without much discussion in the early 1990’s (Freeman, 2007). As a result, “teacher education faculty find themselves now, in many cases for example, assessing dispositions of candidates without having a clear understanding of a program’s definition and development of dispositions” (Stooksberry, 2007, p. 220). Table 2 provides a summary of five prominent theoretical perspectives with the potential to inform the study of and debate about teachers’ dispositions. From these theoretical perspectives, three key issues emerged related to the topic of teachers’ dispositions: the definition of disposition, the development of dispositions in teacher candidates and the assessment of dispositions. Stooksberry (2007) framed these

issues with the succinct question: “What do teacher educators mean when they define, develop and assess dispositions in the preparation of teachers?” (p. 219).

Table 2

Summary of Current Theoretical Approaches toward Disposition

Researchers	Theoretical Underpinnings	Implications
<i>Social Cognitive Perspective</i> Breese, L. and Nawrocki-Chabin, R. (2007)	Based on the theoretical work of Bandura (1997) and self-analytical tools of Boyatzis (1982). Disposition manifests as behavior.	Teacher education candidates need to be consciously aware of positive teaching behaviors and reflect and grow from them (Breese and Nawrocki-Chabin, 2007, p. 35).
<i>The Perceptual Approach</i> Wasicko, M. M. (2007)	Based on the work of Arthur W. Combs et al. on identifying characteristics of individuals who are effective in the “helping” professions.	An individual’s perceptions of self, others, the world, and the nature and purpose of helping (and the helping professions) inform the identification, development and assessment of teachers’ dispositions.
<i>A Constructivist-Developmental Perspective</i> Oja, S. N., and Reiman, A. J. (2007)	Based primarily on the research of David Hunt (1975) in conceptual judgment, L. Kohlberg (1969) on moral judgment and J. Loevinger (1976; 1998) in the area of ego maturity and development.	It is useful to conceptualize teachers’ dispositions developmentally in order to nurture and assess this development.
<i>Teacher Dispositions in Context</i> Freeman, L. (2007)	Based on the idea that “dispositions manifest themselves at particular places at particular times and as a result it is virtually impossible to identify a priori the dispositions that enable an educator to be effective” (Freeman, 2007, p. 25).	Dispositions are a process rather than a concept or object to attend to. As such, metadisposition will be most effective in teacher development since this is a concept that is responsive to time and place.
<i>Teacher Formation: We Teach Who We Are</i> Hare, S. Z. (2007)	Based on the philosophy of Parker Palmer on teacher formation and focused on the idea that teachers must focus on knowing the self.	Formation of teachers’ dispositions is a process that should focus on a “series of discernments” about personal identity, integrity and the self in relationship to the role of the teacher.

Based on how dispositions are applied in the field of teacher education and examined in the research, and building on the theoretical perspectives in Table 2, Stooksberry frames the dialogue on dispositions in teacher education around three central questions:

- 1) Does the field need a common definition for dispositions?
- 2) How are dispositions part of a systemic, developmental program in which candidates are aware of and have multiple opportunities to demonstrate the dispositions expected upon program completion?
- 3) How does the assessment of candidates' dispositions provide evidence of strengths, weaknesses, and growth over time? (p. 230)

The first question is addressed in the next section through a discussion of the challenges of operationally defining dispositions. This discussion includes a comparative analysis of related conceptions and a review of the standards, expectations and norms that define mathematical dispositions (and dispositions toward mathematics) expected of mathematics students and secondary mathematics teachers as put forth by national organizations. The second and third questions were broader than the scope of this study. However, these two questions are revisited in Chapter V in the findings of the study as they related to recommendations for further research and implications for practice. The ultimate purpose of this study was to develop an assessment framework (i.e., assessment framework) that could be used in the assessment, and ultimately development, of secondary mathematics teachers' positive dispositions toward problem solving. By attending to the three questions above, the theoretical framework underlying this study unfolded as a practical structure for examining and developing secondary mathematics teachers' dispositions toward problem solving. The next section presents a discussion of the challenges in operationally defining disposition.

Operationally Defining Dispositions

Dispositions can be challenging to define and assess operationally (Damon, 2007; Murray, 2007). The research and professional literature in teaching and teacher education either fails to define dispositions or defines them in terms of a “nebulous overlap of behaviors, attitudes and beliefs with values and ethics . . . layered into the mix” (Stooksberry, Schussler, & Bercaw, 2009, p. 722). For example, in the *Adolescent and Young Adulthood Mathematics Standards*, the NBPTS consistently refers to the “essential knowledge, skills, dispositions and commitments that allow teachers to practice at a high level” (2001, p. v). However, at no point in this 72-page document are dispositions defined operationally. Instead, the NBPTS organizes each of the twelve standards for accomplished mathematics teaching with succinct statements written in terms of “observable teacher actions that have an impact on students” followed by elaborative passages that describe accomplished teachers’ “dispositions toward students, their distinctive roles and responsibilities, and their stances on a range of ethical and intellectual issues that regularly confront them” (p. 3). In this way, the NBPTS approaches dispositions from both behavioral science and normative theoretical perspectives. While the NBPTS elaborates on the knowledge, skills and dispositions of accomplished teachers, it does not operationally define the dispositions expected. In a similar manner, standards and expectations put forth by NCTM fail to operationally define teachers’ dispositions. Yet there are many definitions from the research and professional literature. Table 3 provides several definitions of dispositions from the research and professional literature relevant to this research study. Included in this table is the 2007 NCATE definition of *professional dispositions*.

Table 3

Definitions of Dispositions

Author/Organization	Definition
American Psychological Association	“recurrent behavioral or affective tendency that distinguish an individual from others” (2007, p. 290).
Katz and Rath	“an attributed characteristic of a teacher, one that summarizes the trend of a teachers’ actions in particular contexts” (1985, p. 301) referring specifically to the “relative frequency with which an action is manifested in a context” (p. 302).
Raths	“a tendency to exhibit frequently, consciously, and voluntarily a pattern of behavior that is directed to a broad goal” (2001, p. 1).
Ritchhart	“acquired patterns of behavior; under one’s control and will; overarching sets of behavior, rather than specific actions; dynamic and idiosyncratic, rather than prescribed; coupled with ability, they motivate, activate, and direct ability; contextualized rather than generic” (2002, p. 21) .
NCATE	“Professional attitudes, values, and beliefs demonstrated through both verbal and non-verbal behaviors as educators interact with students, families, colleagues, and communities. These positive behaviors support student learning and development. NCATE expects institutions to assess professional dispositions based on observable behaviors in educational settings. The two professional dispositions that NCATE expects institutions to assess are fairness and the belief that all students can learn. Based on their mission and conceptual framework, professional education units can identify, define, and operationalize additional professional dispositions” (2007).
Diez and Murrell	“Dispositions refer to a teaching stance, a way of orienting oneself to the work and responsibilities of teachers. Those responsibilities are ultimately about moral practice, in which the teacher mobilizes her knowledge and skills in behalf of the learners entrusted to her care” (2010, p. 9).

In order to see how dispositions might surface in teaching, it is helpful to envision how dispositions might actualize in terms of observable behaviors that secondary mathematics teacher candidates might exhibit while completing a secondary mathematics teacher education

program. Two descriptions, derived from unpublished case studies conducted prior to this study, are provided below. These descriptions are based on observational data as viewed through the definitions in Table 3 and inspired by the conceptualization of mathematical dispositions as a combination of attitudes and a tendency to think and act in a positive manner (NCTM, 1989).

Mathematics Teacher Candidate A. Graduating with a 3.8 GPA from a small private college focusing on mathematics, science and engineering, Candidate A clearly possessed the essential content knowledge to teach mathematics. Additionally, this candidate excelled in the teacher education program and demonstrated the necessary teaching skills (i.e., explaining, reinforcing, questioning, listening, generating hypotheses, probing, decision making) in both the university and high school classrooms. However, as the candidate progressed in the year-long teaching internship, things began to unravel. Not only was the candidate beginning to turn in university assignments late, it was unclear whether the candidate was putting forth effort in planning lessons, particularly for an introductory, two-year high school algebra course. Yet the candidate appeared enthusiastic about teaching, particularly when describing teaching, planning for and interacting with students enrolled in the pre-calculus courses that made up part of the internship experience. During a formative evaluation conference, the candidate expressed a lack of motivation to plan for and interact with the “challenging” students from the “remedial” algebra course. Candidate A appeared to be frustrated and distraught and resisted working cooperatively with the mentor teacher or clinical faculty, both within and beyond the school day, to become a better planner and deliverer of instruction. *This is a theoretical example of a teacher candidate who has the essential knowledge and many of the skills necessary to teach, yet is not demonstrating, through observable behaviors, the dispositions necessary to teach.*

Mathematics Teacher Candidate B. After graduating with a 2.7 GPA from a large public university in a field other than mathematics, Candidate B returned to college to complete the

required mathematics content coursework (with a GPA of 2.8) to become a secondary mathematics teacher. While Candidate B probably possessed sufficient content knowledge to teach mathematics, the candidate would occasionally make errors and often needed to refine in-class explanations about mathematical concepts. This candidate struggled with the necessary teaching skills (i.e., explaining, reinforcing, questioning, listening, generating hypotheses, probing, decision making) in both the university and high school classrooms. As the candidate progressed in the year-long teaching internship, things began to unravel. Not only was the candidate beginning to turn in university assignments late, it was unclear whether the candidate was putting forth effort in planning lessons. Generally the candidate expressed joy when describing teaching, planning for and interacting with all students enrolled in pre-algebra, algebra and advanced algebra coursework. Yet the candidate was frustrated and distraught when reflecting on an unsuccessful lesson. During a formative evaluation conference, the candidate expressed a desire to successfully plan for and interact with all student groups. The candidates actively sought out and considered advice from the mentor teacher and clinical faculty. The candidate consistently worked cooperatively with the mentor teacher, clinical faculty and more-skilled peers, often beyond the school day, to become a better planner and deliverer of instruction. *This is a theoretical example of a teacher candidate who struggled with the essential content knowledge and many of the skills necessary to teach, yet is demonstrating, through observable behaviors, the dispositions necessary to teach.*

Explication of dispositions as a construct. While the narratives of mathematics teacher candidates orient the reader to dispositions as viewed from a normative perspective, an operational definition of dispositions is still elusive. In order to better understand dispositions, it related concepts must be explicated, even if this explication reveals inconsistencies in the literature, particularly as viewed from different fields. Explication is an essential process in

defining and explaining any concept to be studied or assessed. This process involves identifying behaviors that relate to *dispositions*, identifying concepts related to *dispositions*, and identifying the degree to which these behaviors relate to each other (Murphy & Davidschofer, 1994, as cited in Miller, McIntire, & Lovler, 2011). Combining the broad definitions of dispositions provided in Table 3 with the narratives drawn from unpublished case studies of secondary mathematics teacher candidates, a variety of concepts related to teachers' dispositions emerge. These concepts include values, emotions, feelings, knowledge, skills, beliefs, attitudes, and affect. Table 4 provides definitions from the fields of psychology and teacher education for each of these concepts. The final row in the table provides the definition for dispositions used in this study.

Table 4

Definitions of Dispositions and Related Concepts

Concept	Field of Psychology	Field of Teacher Education
Beliefs	"In psychology of attitudes, an association of some characteristic or attribute, usually evaluative in nature, with an attitude object (e.g., this car is reliable)" (APA, 2007, p. 112).	"psychologically held understandings, premises, or propositions about the world that are thought to be true" (Philipp, 2007, p. 259).
Knowledge	"information and understanding of a specific topic or of the world in general, usually acquired by experience or by learning" (APA, 2007, p. 516).	"beliefs held with certainty or justified true belief" (Philipp, 2007, p. 259). Teacher knowledge is subdivided into subject matter knowledge (common, horizon and specialized content knowledge) and pedagogical content knowledge as it relates to students, teaching and the curriculum (Schulman, 1986; Ball, Thames & Phelps, 2008).
Skills	"An ability or proficiency acquired through training and practice" (APA, 2007, p. 857).	A skill is the ability to do something well. Examples of teaching skills necessary to effectively teach secondary mathematics are planning, explaining, reinforcing, questioning,

		listening, generating hypotheses, probing, decision making, etc.
Values	“A moral, social, or aesthetic principle accepted by an individual or society as a guide to what is good, desirable, or important” (APA, 2007, p. 295).	A value is a “belief one holds deeply, even to the point of cherishing, and acts upon” (Philipp, 2007, p. 259).
Emotions or Feelings	“A complex reaction pattern, involving experiential, behavioral, and physiological elements, by which the individual attempts to deal with a personally significant matter or event” (APA, 2007, p. 325). Feelings are “purely mental, whereas emotions are designed to engage with the world” (APA, 2007, p. 372).	Hargreaves (1998) argues that “good teaching is charged with positive emotion” (p. 835), concluding that teaching is a caring occupation requiring active emotional labor. “This labor requires one to induce or suppress feelings in order to sustain the outward countenance that produces the proper state of mind in others . . . This kind of labor calls for a coordination of mind and feeling, and it sometimes draws on a source of self that [teachers] honor as deep and integral to their personality” (Hochschild, as cited in Hargreaves, 1998, p. 840).
Attitudes	“a relatively enduring and general evaluation of an object, person, group, issue, or concept on a scale ranging from negative to positive” (APA, 2007, p. 83).	Attitudes are “manners of acting, feeling, or thinking that show one’s dispositions or opinion” (Philipp, 2007, p. 259).
Affect	“Any experience of feeling or emotion, ranging from suffering to elation, from the simplest to the most complex sensations of feeling, and from the most normal to the most pathological emotional reactions” (APA, 2007, p. 26).	“disposition or tendency or an emotion or feeling attached to an idea or object” (Philipp, 2007, p. 259).
Dispositions	“recurrent behavioral or affective tendency[ies] that distinguish an individual from others” (APA, 2007, p. 290). Dispositions are relatively stable and reflect constant attitudes (Wolman, 1989, p. 96).	Dispositions, or affect, refer to the “attitudes, values, and beliefs that influence the application and use of knowledge and skills” (Wilkerson & Lang, 2007, p. 2).

The professional literature abounds with descriptions of dispositions as highly influenced by and interacting with the related concepts listed in Table 4. From a practical stance, teacher educators attempting to define, develop and assess professional dispositions often understand “dispositions to be integrated with knowledge and skill and fostered in part through modeling by faculty” (Diez & Murrell, 2010, p. 2). In practice, the NCATE definition states that attitudes, values and beliefs drive dispositions (2002). Philosophical examples are also present in the literature. In *Dispositions Matter: Advancing Habits of the Mind for Social Justice*, Hill-Jackson and Lewis (2010) analogize the relationship between attitudes and dispositions in a poem by Frank Outlaw:

Watch your thoughts; they become words.
Watch your words; they become actions.
Watch your actions; they become habits.
Watch your habits; they become character.
Watch your character; it becomes your destiny (p. 61).

The poem suggests that our habits and behaviors result from our attitudes and beliefs. Similarly, S. Z. Hare (2007) employs a flowerpot metaphor to describe *dispositions* through the lens of teacher formation, with the core, or foundation, referring to what Parker Palmer calls the ground on which a teacher stands. The layers are described as follows:

Picture the uppermost layer of soil as dispositions. The second layer is thought, the thinking that informs the dispositions. Going a bit deeper, we find the third layer; feelings, which we know from current brain research are interdependent with thought, so the second and third layers are not cleanly separated, but each bleeds a bit into the other. Next we dig into the fourth layer; or values. The next layer, as we climb down into the flower pot, is composed of our beliefs, the perceptions in which our thoughts and feelings and values are grounded. At the bottom of the pot we find the most important layer, a vital and yet nameless core (pp. 142-143).

Both the poem and the metaphor, central to Hare’s theoretical perspective toward studying dispositions, characterize dispositions as a juxtaposition of several concepts, with attitudes, values and beliefs central in the mix. Furthermore, in the field of perceptual psychology,

dispositions and perceptions are used interchangeably and synonymously with “values, attitudes, and beliefs” (Wasicsko, 2005, p. 6).

Other researchers, such as Wilkerson and Lang (2007), explicitly equate dispositions with affect. More specifically, dispositions refer to the “attitudes, values and beliefs that influence the application of knowledge and skills” (p. 2). As a result, the aim of an assessor is to determine the extent to which a teacher exhibits specific behaviors described in the educational objectives from the Affective Domain taxonomy (Krathwohl, Bloom & Masia, 1956). Five hierarchical levels exist: *receiving*, *responding*, *valuing*, *organization*, and *characterization*. A description of the Affective Domain, along with examples of affective behaviors for each of the five categories of behavior and its application to disposition assessment, are presented later in this review.

In order to further explain how dispositions interact with similar concepts, and to arrive at an operational definition for the purposes of this research study, it is helpful to envision each related concept in terms of classroom practice. For example, the NCTM *Principles and Standards for School Mathematics* expect instructional programs to “enable all students to monitor and reflect on the process of mathematical problem solving” (2000, p. 402). Table 5 provides explanatory statements for each of the concepts defined in Table 4 for this particular NCTM problem solving expectation. The final row of Table 5 provides a *hypothetical* operational definition of secondary mathematics’ positive dispositions toward problem solving as they might be inferred from observable behaviors. In order to design methods for assessing disposition, it is essential for teacher educators to articulate a definition for disposition (Stooksberry, Schussler & Bercaw, 2009; Damon, 2007; Murray, 2007). The final row in Table 5 provides a possible definition of secondary mathematics teachers’ positive dispositions toward problem solving that would be consistent with the identified NCTM expectation.

Table 5

Examples of Dispositions and Related Concepts from a Normative Theoretical Framework

Concept	Example in Mathematics Education Specific to an NCTM Problem Solving Expectation
Belief	The teacher understands and believes that one of the main roles of the teacher is to encourage students to monitor and reflect on the problem-solving process.
Knowledge	The teacher is aware of the expectation that all students should monitor and reflect on the process of mathematical problem solving and knows how to enact the expectation in the classroom.
Skill	The teacher is proficient at the problem-solving process, including the ability to monitor and reflect on the process. Furthermore, the teacher is proficient in leading students in the problem-solving process, including monitoring and reflection on that process.
Value	The teacher agrees deeply with the NCTM expectation. That is, the teacher believes it is important to provide students with opportunities to monitor and reflect on the problem-solving process.
Emotion/Feeling	The teacher expresses joy while engaging students in the problem-solving process, perhaps exhibiting excitement and anticipation in listening to or reading about students' reflections on the process.
Attitude	A teacher expresses a feeling, thought or behavior that indicates a positive (or negative) attitude toward reflecting on the process of mathematical problem solving for a particular problem.
Affect	A teacher expresses an emotion, a tendency or a disposition that indicates a positive (or negative) feeling toward reflecting on the process of mathematical problem solving.
Disposition	<p>Positive Disposition:</p> <p>A teacher is committed to reflecting on the process of mathematical problem solving. The teacher willingly and consistently provides students with opportunities, either verbally or in writing, to monitor and reflect on their current knowledge, what they have learned and how their observations helped in the problem-solving process.</p>

The behavioral objectives in boldface type indicate the upper levels of the Affective Domain (e.g., *organization* and *characterization*). In order to further envision how dispositions might

interact with related concepts in Table 5, it is helpful to revisit the two theoretical secondary mathematics teacher candidates and envision the concepts as observable behaviors (i.e., actions or *moves* exhibited in particular classroom situations) in either a university or public school setting. Descriptions of the candidates' theoretical attitudes, values and beliefs, derived from unpublished case studies conducted prior to this study, are provided below. The descriptions are written in terms of behaviors that are consistent (or inconsistent) with the NCTM expectation of monitoring and reflecting on the process of mathematical problem solving. As indicated in boldface type, one mathematics teacher candidate may theoretically be missing positive dispositions toward problem solving whereas the other candidate may theoretically exhibit them.

Mathematics teacher candidates' theoretical attitudes, values and beliefs. When asked to engage in non-routine problem solving in a secondary mathematics methods classroom setting, both candidates were predisposed to act positively toward the exercise. This predisposition to act positively can be viewed as the candidates' *attitudes* toward the problem-solving process (Katz, 1993a). Both candidates showed genuine interest in solving the problem. They monitored, reflected on and shared their problem-solving processes. In essence, they believed in the utility of the problem-solving process, valued it and expressed a positive attitude toward it. Yet this predisposition, or *attitude*, did not necessarily result in both candidates displaying the necessary, observable behaviors in the secondary classroom that would ultimately encourage their students to monitor and reflect on the problem-solving process. Both candidates, for example, knew and understood this particular NCTM problem solving expectation. They both proclaimed to value problem solving. However, unless the candidates provided their students with *opportunities* to engage in the problem-solving process in a reflective manner, the candidates' tendencies would remain attitudes. Candidate A thought and

acted as if problem solving was important within the context of the university classroom and yet ***expressed reluctance*** to realize this particular NCTM expectation ***with all students*** in the secondary classroom even though the candidate had demonstrated the necessary content knowledge and teaching skills to enact the expectation. In contrast, Candidate B, after numerous unsuccessful attempts, was still ***eager*** to provide opportunities for students to monitor and reflect on the process of problem solving. Candidate B, while struggling with the content knowledge and teaching skills necessary to actualize this NCTM expectation in the secondary classroom, appeared to exhibit the necessary positive dispositions toward problem solving implied by this particular NCTM problem solving expectation.

Dispositions defined. According to this narrative, an overlap exists between dispositions and attitudes (i.e., Katz's construct *predisposition*), but they are not synonymous. With respect to this particular NCTM expectation, teacher candidates' positive dispositions would not only manifest as constant positive attitudes toward the expectation, but would also actualize in the classroom as a pattern of behavior that is exhibited frequently, consciously, intentionally and voluntarily. Furthermore, teacher candidates' dispositions should theoretically "deepen as candidates develop the understanding and skill that support, for example, a disposition to work to meet the needs of all learners in a class" (Diez, 2007, p. 198).

In conclusion, for the purposes of this research study, dispositions manifest as a "pattern of behavior that is exhibited frequently and in the absence of coercion and constituting a habit of mind under some conscious and voluntary control, and that is intentional and oriented to broad goals" (Katz as cited in Wilkerson & Lang, 2007, p. 9). The next section provides a summary of the literature on assessing teachers' dispositions and a rationale for the use of standards in developing indicators of secondary mathematics teachers' positive

dispositions toward problem solving to ground the conceptual framework of any system designed to assess said dispositions.

Systems for Assessing Teachers' Dispositions

Today the importance of assessing teachers' dispositions is evident in the accreditation process applied to teacher education programs, as well as in the expectations for NBPTS certification. For example, NCATE, and now CAEP, have held programs accountable for assessing *professional dispositions* in teacher candidates for nearly a decade. Additionally, mathematics teacher education programs seeking national recognition through NCATE, and now CAEP, must demonstrate an eighty percent (80%) pass rate on state licensure tests and that more than fifty percent (50%) of the elements of each standard are met at the acceptable or target level (NCTM, 2014). Assessing candidates' dispositions, through total faculty input, is an expectation for programs charged with the initial preparation of secondary mathematics teachers (NCTM, 2003). Furthermore, dispositions are a critically important and timely concept in the field of teacher education as evidenced by the increase of published literature and emphasis in standards (e.g., the November/December 2007 issue of *Journal of Teacher Education* highlighting teachers' dispositions). Yet the published literature on methods for assessing or measuring teachers' dispositions is scarce. A search of ERIC, ProQuest Dissertations & Theses, ProQuest Education Journals and ProQuest Psychology Journals, using the query ti(teacher) AND ti(disposition) AND tx(assessing OR measuring) provided a list of only fourteen scholarly journal articles, one dissertation, nine reports, one editorial, and two books since 2002.

While teachers' dispositions have been an expectation for teacher education programs since the early 1990's, useful assessment frameworks with instruments that provide for valid inferences about teachers' dispositions are still not commonplace. Teaching involves a complexity of behavior that is indeed challenging to assess. As such, it is incumbent upon

assessors to design systems that provide adequate evidence that is representative of an operational understanding of the standards on which the system is based (Wilkerson & Lang, 2007; Damon, 2007; Murray, 2007). As teacher education programs develop systems to assess teacher candidates' dispositions, four key recommendations should be considered (Diez, 2007). First, program faculty must articulate in its conceptual framework the "values, commitments, and professional ethics" that will guide all aspects of the program (e.g., coursework, field experiences, assessments). Second, assessors must acknowledge the interrelatedness of knowledge, skills and dispositions in order to "acquire the cognitive understanding and affective values they need to move toward a more comprehensive and meaningful approach to teacher assessments" (Wilkerson & Lang, 2007, p. 6). Third, the assessment framework should be overarching, ongoing, and use multiple measures (e.g., questionnaires, rating scales, interviews, periodic observation). The fourth and final consideration rests on two assumptions: teaching is a complex practice and candidates' growths in dispositions are developmental. As such, the "assessment of dispositions should be guided by what Wolf and others (1991) called an epistemology of mind and a culture of assessment, using qualitative, interpretivist approaches to look at each individual candidate's responses to the challenges of becoming a teacher" (p. 198). Assessing dispositions qualitatively ultimately respects the individual teacher candidates and allows assessors to gather cumulative evidence of candidates' performance.

In order to better understand these key considerations it is helpful to analyze an existing secondary mathematics teacher assessment framework with an underlying conceptual framework that includes teachers' dispositions. The National Board of Professional Teaching Standards uses a portfolio assessment framework to measure the essential knowledge, skills, dispositions, and commitments that allow a teacher to practice at a high level. Even though the NBPTS certification process is designed to identify accomplished teachers, rather than guide the

development of teacher candidates enrolled in secondary mathematics teacher preparation programs, assessors can examine characteristics of valid and useful assessment frameworks through an examination of the NBPTS's approach to teacher assessment.

With respect to the first of Diez's recommendation, the standards for each NBPTS certificate area are written in terms of actions that teachers ought to take in order to advance student achievement. The set of standards for the adolescence and young adulthood mathematics certificate outlines the mission of the National Board and the philosophical context of the standards (i.e., conceptual framework) followed by a clearly articulated set of expectations (i.e., knowledge, skills, dispositions and commitments) descriptive of accomplished mathematics teaching. The expectations for NBPTS certification are written in terms of behavioral objectives on the top level of the affective domain taxonomy (i.e., *characterization*).

With respect to the second recommendation, the NBPTS recognizes the interrelatedness of knowledge, skills and dispositions, with the added emphasis on commitments, in forming the standards that provide the foundation for the portfolio assessment framework. For example, accomplished teachers of mathematics are expected to have a rich understanding of mathematics (i.e., knowledge), have a vast instructional repertoire (i.e., skills) and appreciate how knowledge in mathematics is created (i.e., disposition). Even though the mission of the National Board is not specifically to develop dispositions in teacher candidates (i.e., accomplished teachers should already demonstrate a positive disposition toward problem solving), the assessment framework includes a scoring guide that walks candidates through the process of interpreting their results and matching their individual scores to the appropriate levels of performance.

With respect to the third and fourth recommendations, the NBPTS assessment framework meets all criteria. First, the assessment framework includes multiple measures: four

portfolio entries and a series of assessment center exercises. The assessment framework for the adolescence and young adulthood mathematics certificate, selected due to its relevancy to this research study, includes the following assessment components:

- Entry 1: Developing and Assessing Mathematical Thinking and Reasoning
- Entry 2: Instructional Analysis: Whole-Class Mathematical Discourse
- Entry 3: Instructional Analysis: Small-Group Mathematical Collaborations
- Entry 4: Documented Accomplishments: Contributions to Student Learning
- Assessment Center Exercises in algebra, calculus, discrete mathematics, geometry, statistics and data analysis, and families of functions

Qualified, trained professionals score each entry and exercise using scoring rubrics to determine teacher performance in relation to the standards. The scoring is evidence-based with each source (i.e., entry or exercise) providing assessors an opportunity to evaluate candidates' practices in terms of "conscious, analytical and reflective criteria" (NBPTS, 2011). Each of the entries and assessment center exercises require reflective responses on the part of teachers that are evaluated holistically against scoring rubrics (i.e., a qualitative, interpretivist approach to assessing candidate performance). Arguably the assessment framework falls short in providing assessors opportunities for *ongoing observation*. Only the second and third entries of the portfolio require assessors to evaluate candidate-selected, 15-minute video recordings of whole-group discussion and small-group discourse. One could argue, however, that the first entry provides an opportunity for assessors to evaluate candidates' abilities to develop and assess mathematical thinking and reasoning in students over time. Similarly, the fourth entry of the portfolio allows assessors to evaluate candidates' commitments to student learning over time as evidenced by partnering with students' families, through professional development and as collaborators and leaders in the field of education (NBPTS, 2011; 2012). Finally, NBPTS

certified teachers are expected to complete a profile of professional growth to renew the ten-year certification.

The structure of the NBPTS assessment framework provides assessors the tools necessary to holistically evaluate the knowledge, skills, dispositions and commitments of candidates applying for certification. As mentioned earlier, a debate exists regarding the nature and value of disposition (i.e., behavioral science versus normative approach). The five-step *Disposition Assessments Aligned with Teacher Standards (DAATS)* model, proposed by Wilkerson and Lang (2007), provides teacher educators a structure for designing an assessment framework to measure the attitudes, values, and beliefs that ultimately influence the application of knowledge and skills in the classroom (i.e., disposition). It is important to note that the Wilkerson and Lang (2007) model for disposition assessment focuses on skill-based standards, over traditional definitions of morality and ethics, and naturally integrates all four of Diez's key recommendations for assessing teachers' dispositions. Wilkerson and Lang's (2007) model addresses the confusion about disposition, concluding that disposition can be, and has been, measured directly using affective measurement techniques. In fact, the techniques and methods employed in the DAATS model are accepted methods for affective measurement that align with the foundations of psychological testing summarized by Miller, McIntire and Lovler (2011) and defined in the *Standards for Educational and Psychological Testing* (AERA, APA, and NCME, 1999). Figure 2 provides an abbreviated description of the steps in the DAATS model.

Figure 2. Disposition Assessments Aligned with Teacher Standards (DAATS) Model

**Disposition Assessments Aligned with Teacher Standards (DAATS) Model
Proposed by Wilkerson and Lang (2007)**

DAATS Step 1 – Define purpose, use, propositions, content, and other contextual factors.

- 1A: Define the purpose(s) and use(s) of the system.
 - 1B: Define the propositions or principles that guide the system.
 - 1C: Define the conceptual framework or content of the system.
 - 1D: Review local factors that impact the system.
-

DAATS Step 2 – Develop an assessment framework.

- 2A: Analyze standards and indicators.
 - 2B: Visualize the teacher demonstrating the affective targets.
 - 2C: Select assessment methods at different levels of inference.
 - 2D: Build an assessment framework correlating standards and methods.
-

DAATS Step 3 – Create instruments aligned with standards and consistent with the assessment framework.

- 3A: Draft items and directions for each instrument.
 - 3B: Review items for applicability to values, domain coverage, and job relevance.
-

DAATS Step 4 – Design and implement data aggregation, tracking, and management systems.

- 4A: Develop scoring rubrics.
 - 4B: Determine how data will be combined and used.
 - 4C: Develop implementation procedures and materials.
-

DAATS Step 5 – Ensure credibility and utility of data.

- 5A: Create a plan to provide evidence of validity, reliability, fairness, and utility.
 - 5B: Implement the plan conscientiously.
-

This research study employed the first two steps of the DAATS model with its accompanying tools and worksheets, to develop indicators of secondary mathematics teachers' positive dispositions toward problem solving and select assessment methods at varying levels of

inference as part of an assessment framework designed to measure secondary mathematics teachers' dispositions toward problem solving. The third, fourth and fifth steps, crucial to making valid inferences about secondary mathematics teachers' dispositions, are unfortunately beyond the scope of this study and will be revisited in Chapter V during the discussion of further research and implication for practice. The next section provides a summary of the Affective Domain as it relates to and is applied in this study.

Affective Assessment of Teachers' Dispositions

As noted earlier, a model in modern psychology, that is both widely known, yet still theoretical, suggests three components of the mind: cognitive, affective and conative. Taxonomies have been developed and consistently used to measure the hierarchical nature of the cognitive and affective domains. Krathwohl, Bloom, and Masia (1956; 1973) developed taxonomies for the cognitive and affective domains. In the original Affective Domain taxonomy, Krathwohl and Bloom (1956) defined five categories useful in describing affective characteristics of individuals: *receiving*, *responding*, *valuing*, *organization*, and *characterization*. As a result of more recent research on measurement and evaluation of teachers' dispositions, a sixth category (i.e., *unaware*) was added at the base of the taxonomy for assessment purposes (Wilkerson, 2012). This level emerged out of the necessity to describe teachers that are not yet at the *receiving* level. These are teachers who have not considered a particular skill in any meaningful way or may actually be opposed to the skill. The NCTM expects secondary mathematics programs to enable students to:

- Build new mathematical knowledge through problem solving;
- Solve problems that arise in mathematics and in other contexts;
- Apply and adapt a variety of appropriate strategies to solve problems; and
- Monitor and reflect on the process of mathematical problem solving (2000, p. 402).

Table 6 provides a synopsis of the hierarchical levels of the taxonomies for the original Cognitive and Affective Domains written as behavioral indicators of secondary teacher candidate performance with respect to the NCTM instructional expectations for the problem-solving process standard.

Table 6. Cognitive and Affective Domains

Cognitive and Affective Domains developed by Bloom et al. (1956), adapted from D. R. Clark's Bloom's Taxonomy of Learning Domains (2010), retrieved from <http://www.nwlink.com/~donclark/hrd/bloom.html>, and from Wilkerson and Lang's (2007) Assessing Teacher Dispositions: Five Standards-Based Steps to Valid Measurement Using the DAATS Model (pp. 25-26).

Cognitive Domain	Affective Domain
Knowledge: <i>Knows the NCTM problem solving expectations, i.e., is able to state the expectations.</i>	Receiving Phenomena: <i>Attends to and is open to the NCTM vision, i.e., reads and remembers the problem-solving expectations.</i>
Comprehension: <i>Explains the expectations in own words, i.e., gives examples of tasks representative of the expectations.</i>	Responding to Phenomena: <i>Demonstrates compliance with the expectations, i.e., willingly responds with satisfaction during class discussions.</i>
Application: <i>Uses knowledge without prompting, i.e., produces a lesson plan or task aligned with the expectations.</i>	Valuing: <i>Accepts the worth of the expectations, i.e., follows through on providing students with opportunities to reflect on the problem-solving process.</i>
Analysis: <i>Identifies practices consistent with the expectations, i.e., differentiates between lessons and tasks that are (or are not) aligned.</i>	Organization: <i>Synthesizes the expectations into educational philosophy, i.e., defends and prioritizes use of class time on problem solving.</i>
Evaluation: <i>Determines the value of tasks, i.e., selects the most effective task for students to accomplish a particular expectation.</i>	Characterization: <i>Displays a professional commitment to enacting the expectations in the classroom, i.e., demonstrates tendencies that are pervasive and predictable.</i>
Synthesis: <i>Integrates all aspects of the expectations to create a new structure, i.e., extends a task beyond its original design.</i>	

The Affective Domain describes the manner in which individuals deal with their feelings, values, appreciation, enthusiasm, motivation and attitudes. The Affective Domain is central to the learning and evaluation process and includes value systems that provide a basis for most of an individual's observed behaviors (Eiss & Harbeck, 1969). As such, the hierarchy for Affective

Domain will serve as a useful conceptual framework for this study in developing behavioral indicators of secondary mathematics teachers' positive dispositions toward problem solving that align with the national standards. In theory, secondary mathematics teachers exhibiting behaviors corresponding to the upper echelon of the Affective Domain (e.g., *valuing*, *organization* and *characterization*) would be attributed as having higher, and more positive, dispositions toward problem solving than secondary mathematics teachers exhibiting behaviors corresponding to the lower levels of the taxonomy (e.g., *receiving*, *responding*). The next section provides a review of the literature on assessment methods used in affective measurement.

Methods for Assessing Teachers' Dispositions

As with cognitive assessment, numerous methods are available for assessing affect, or dispositions. Behavioral assessment is fundamental to assessment in both the Cognitive and Affective Domains. For example, NCATE clarified the original 2002 definition of *professional dispositions* to better communicate the behavioral expectations for teacher candidates and the teacher educators tasked with evaluating them. Currently, NCATE, and now CAEP, defines *professional dispositions* as the "attitudes, values, and beliefs demonstrated through both verbal and non-verbal behaviors as educators interact with students, families, colleagues, and communities" (2007). Furthermore, teacher candidates are expected to exhibit *positive behaviors* that support the learning and development of all students. Therefore it is incumbent upon teacher educators to assess the conduct or manner in which individual teacher candidates interact with all stakeholders.

Behavioral assessment refers to the "wide variety of techniques for studying and evaluating behavior, including direct observation, interview, psychological tests, and other methods of sampling attitudes and feelings in a situational context" (APA, 2007, p. 107). In the field of psychology, behaviors are concrete, observable and measurable. In contrast, an attitude

is an abstract concept that exists only in the imagination (Miller et al., 2011). Behavioral assessment techniques provide methods for measuring abstract concepts, such as teachers' dispositions, at various levels of inference. Levels of inference refer to the degree of confidence an assessor places in the conclusions drawn from the premises on which a particular technique is based (APA, 2007). In other words, it is insufficient to simply categorize teacher candidates' behaviors. Rather, the goal of behavior assessment should be to draw reliable inferences about an individual's fundamental beliefs, values, and attitudes based on their actual behavior (Wasicsko, 2005). For this reason multiple techniques are required to increase the confidence teacher educators have in decisions made about teacher candidate disposition. Examples of behavioral assessment techniques useful to affective measurement fall into four categories: selected-response, constructed-response, observed performance and projective techniques (Wilkerson & Lang, 2007). The techniques are summarized in Table 7, along with corresponding advantages and disadvantages for each measurement method.

In addition to self-report response modes (e.g., interview, scales, projective techniques) and direct observation (e.g., checklists, event reports), the field of psychology also uses a third method referred to as psychophysiological assessment (Fernández-Ballesteros, 2003). The use of physiological measures (i.e., electroencephalography) to infer psychological processes and emotions are clearly beyond the scope of this study, although the possibility of using this method in the future to infer teachers' dispositions is certainly intriguing!

Table 7

Methods for Measuring Dispositions or Affect Adapted from Wilkerson and Lang's (2007) Assessing Teacher Dispositions: Five Standards-Based Steps to Valid Measurement Using the DAATS Model (pp. 26-31).

Methods for Measuring Disposition or Affect
Selected-Response Methods Self-report instruments with predetermined choices designed to assign scores to teachers based on a defined, numerical dimension. Examples: Likert scales, Thurstone agreement scales, semantic differential scales, rating scales <i>Advantage:</i> ease of scoring <i>Disadvantages:</i> difficult to write, responses can be faked
Constructed-Response Methods Self-report instruments without predetermined choices. Examples: questionnaires, interviews, focus groups, think-aloud-protocol, thought listing <i>Advantages:</i> ease of creating, faking is less likely <i>Disadvantages:</i> scoring is more complex, requiring rubrics and assessor training
Observed Performance An intentional examination of a teacher candidate's performance designed to obtain information about teacher affect based on what has been observed. Examples: behavioral checklists, observations, event reports <i>Advantage:</i> provides data over time <i>Disadvantages:</i> time consuming, difficulty in distinguishing between affect and skill
Projective Techniques Pictures designed to elicit a reaction or response. Examples: situational analysis test (e.g., Thematic Apperception Test) <i>Advantage:</i> allows for deep-seated motivations, including implicit attitudes, to surface <i>Disadvantage:</i> scoring can be subjective

In theory, a comprehensive assessment framework containing multiple measures at varying levels of inference will more accurately describe teacher candidate's disposition toward problem solving in the teaching and learning process. In *Mathematics Teaching Today: Improving Practice, Improving Student Learning*, NCTM describes several data sources useful for

observing, supervising and improving mathematics teaching (2007). All of these data sources (e.g., lesson plans, student work samples, classroom observation, interview of school principal, evidence of collaboration with colleagues) measure teacher knowledge and skills, and dispositions to varying degrees and at various levels of inference. In order to examine secondary mathematics teachers' dispositions toward problem solving, it is necessary to define and assess the target behaviors associated with this construct. Only then can instruments and assessment methods be developed that allow teacher educators to abstract, from observable behaviors, secondary mathematics teachers' positive dispositions toward problem solving.

All sources identified in this section have a place in an assessment framework designed to measure teachers' dispositions toward problem solving. As a result, the assessment framework that results from this study will include a variety of data sources and assessment methods. The next section provides a summary of the professional standards and expectations that describe secondary mathematics teachers' dispositions toward problem solving and includes behaviors that signify teachers' *positive dispositions*. This literature collectively provided a foundation for the assessment framework (i.e., blueprint) that resulted from this study.

Standards for Dispositions toward Problem Solving

Teacher educators must be confident that the teachers released into the classroom possess the attitudes, values and beliefs held to be important by practitioners in the field. Evaluating teachers' dispositions allows assessors to determine whether teacher candidates possess the necessary values and commitments it takes to teach (Wilkerson & Lang, 2007). An assessment framework that includes dispositions as an element must go beyond vague references to *positive dispositions* and be qualified in terms of observable behaviors. These behaviors, referred to as behavior criteria, or indicators, in the field of psychology, can be either

self-reported by or observed in a person (APA, 2007). The purpose of this study was to develop and validate indicators of secondary mathematics teachers' positive dispositions toward problem solving. The resulting indicators provided a foundation for the development of an assessment framework and suggested assessment methods at varying levels of inference as discussed in Chapter V. Since this study was an examination of dispositions toward problem solving from a normative theoretical perspective, the development of the indicators drew from a review of professional standards and expectations published about problem solving within the field of secondary mathematics teaching.

So what are the observable behaviors that allow us to infer secondary mathematics teachers' positive dispositions toward problem solving as actual attributes, traits, tendencies or characteristics? How would teachers with positive dispositions toward problem solving most likely act in the classroom? To varying degrees, several national organizations describe the problem solving attitudes, values, and beliefs expected of secondary mathematics teachers. Several national organizations describe standards and expectations about dispositions, problem solving and dispositions toward problem solving for secondary mathematics teaching and learning. Table 8 provides a summary of these national organizations, listed in chronological order, and the purposes of each set of standards.

Some sets of national expectations include explicit standards for teachers' dispositions with few illustrative classrooms examples. Other sets fail to include explicit references to dispositions or, more specifically, dispositions toward problem solving, yet provide the reader with a plethora of illustrative classroom examples. In order to develop indicators of secondary mathematics teachers' positive dispositions toward problem solving, it was necessary to review all sets of relevant standards.

Table 8

Standards and Expectations for Secondary Mathematics Teaching and Learning

Document & Author	Purpose
<i>The Principles and Standards for School Mathematics (PSSM)</i> The National Council for Teachers of Mathematics (2000)	Intended as a resource for all audiences involved in decisions that impact the mathematics education of P-12 students, the PSSM outlines recommendations and provides a vision for creating high-quality, engaging mathematics instruction for all students.
<i>Adolescence and Young Adulthood Mathematics Standards (AYAMS)</i> National Board for Professional Teaching Standards (2001)	Intended to advance the quality of teaching learning, the AYAMS provide a set of twelve standards that describe accomplished secondary mathematics teaching, in terms of knowledge, skills, dispositions and habits of mind.
<i>The Mathematical Education of Teachers (MET 1)</i> Conference Board of the Mathematical Sciences (2001)	Intended as a resource for all audiences involved in the education of mathematics teachers, the MET 1 focuses on specific expectations and recommendations for pre-service education.
<i>NCATE/NCTM Program Standards for Initial Preparation of Mathematics Teachers: Standards for Secondary Mathematics Teachers (PSPMT)</i> NCTM (2003)	Intended to guide programs seeking national recognition, the PSPMT outlines sixteen standards for pre-service secondary mathematics teachers (e.g., process, content, pedagogy, and field-based experiences standards).
<i>Mathematics Teaching Today: Improving Practice, Improving Student Learning (MTT)</i> NCTM (2007)	Intended as an update to the PSSM, the MTT provides an updated vision for effective mathematics teaching, including detailed sets of standards for the support systems necessary to achieve the vision.
<i>The Common Core State Standards for Mathematics (CCSS-M)</i> National Governors Association Center for Best Practices and the Council of Chief States School Officers (2010)	Intended primarily as a set of focuses and coherent Standards for Mathematical Practice and Content for students, the CCSS-M describes the “varieties of expertise that mathematics educators at all levels should seek to develop in their students” (p. 6).
<i>The Mathematical Education of Teachers II (MET 2)</i> CBMS (2012, February 9)	Intended as an update to the MET 1, the MET 2 updates recommendations for the mathematical preparation of teachers.
<i>NCTM CAEP Standards (PSPMT 2)</i> NCTM (2013)	This is an update of the PSPMT outlining seven standards for the initial preparation of secondary mathematics teachers in the areas of content knowledge, mathematical practices, content pedagogy, mathematical learning environment, impact on student learning, professional knowledge and skills, and secondary mathematics field experiences and clinical practice.

The next section provides a discussion of the attitudes, values and beliefs expected of secondary mathematics teachers, teacher candidates and students. References to dispositions toward problem solving are included in the discussion. The standards and expectations for students, as defined by the NRC and the NCTM, are presented first, followed by a summary of the standards and expectations for secondary mathematics teachers and teacher candidates as defined by NCATE, CAEP, NCTM, NBPTS and the Conference Board of Mathematical Sciences (CBMS). Collectively these standards and expectations define the *dispositions in action* that ultimately informed the development of indicators of secondary mathematics teachers' positive dispositions toward problem solving and served as the foundation for an assessment framework.

Standards for Secondary Mathematics Students

Three national organizations detail specific standards and expectations for secondary mathematics students in the United States. They are the NCTM *Principles and Standards for School Mathematics (PSSM)*, the NRC's *Adding it Up: Helping Children Learn Mathematics* and the *Common Core State Standards for Mathematics (CCSS-M)* put forth by the National Governors Association Center for Best Practices and the Council of Chief States School Officers. Problem solving is described in the *PSSM* and the *CCSS-M* as essential for the workplace. Both sets of standards provide guidance for secondary mathematics teachers tasked with addressing the need for an increased level of mathematical thinking and problem solving in the workplace.

The *PSSM* outlines broad goals for mathematical content and processes for prekindergarten through grade 12 instructional programs. The NCTM recommends that problem solving be at the center of mathematics instruction. Problem solving encompasses skills and processes that play an essential role in everyday life (NCTM, 1980). With respect to the

problem-solving process, which is defined as “engaging in a task for which the solution method is not known in advance,” the NCTM expects instructional programs to enable all students to:

- Build new mathematical knowledge through problem solving;
- Solve problems that arise in mathematics and in other contexts;
- Apply and adapt a variety of appropriate strategies to solve problems; and
- Monitor and reflect on the process of mathematical problem solving (p. 52).

Ultimately students should know what to do when they encounter unfamiliar problem situations. The *PSSM* describes problem solving as an integral aspect of mathematics learning that provides students with opportunities to “acquire ways of thinking, habits of persistence and curiosity, and confidence in unfamiliar situations that will serve them well outside the mathematics classroom” (2000, p. 52). Students should solve problems that involve all five content areas (e.g., numbers and operations, algebra, geometry, measurement, data analysis and probability), integrate numerous topics and involve significant, contextualized mathematics (e.g., student’s lives, the school day, scientific or workplace applications). As students solve problems, they are expected to use technological tools to focus on problem solving and the reflective process.

The *CCSS-M* defines what students should understand and be able to do as a result of their program of study in mathematics. Written as a series of focused and coherent standards addressing both mathematical practice and content, the *CCSS-M* provides a vision for school mathematics informed by mathematics education in high-performing countries. The *eight Standards for Mathematical Practice* are informed by the five NCTM process standards (i.e., problem solving, reasoning and proof, communication, connections, representation) and the five strands of mathematical proficiency described in the NRC’s report *Adding it Up* (i.e., adaptive reasoning, strategic, competence, conceptual understanding, procedural fluency, and

productive disposition). The first *Standard for Mathematical Practice* succinctly states that students should be able to “make sense of problems and persevere in solving them” (p. 6). An illustrative paragraph describes the behavioral objectives expected of students:

Mathematically proficient students start by explaining to themselves the meaning of a problem and looking for entry points to its solution. They analyze givens, constraints, relationships, and goals. They make conjectures about the form and meaning of the solution and plan a solution pathway rather than simply jumping into a solution attempt. They consider analogous problems, and try special cases and simpler forms of the original problem in order to gain insight into its solution. They monitor and evaluate their progress and change course if necessary. Older students might, depending on the context of the problem, transform algebraic expressions or change the viewing window on their graphing calculator to get the information they need. Mathematically proficient students can explain correspondences between equations, verbal descriptions, tables, and graphs or draw diagrams of important features and relationships, graph data, and search for regularity or trends. Younger students might rely on using concrete objects or pictures to help conceptualize and solve a problem. Mathematically proficient students check their answers to problems using a different method, and they continually ask themselves, “Does this make sense?” They can understand the approaches of others to solving complex problems and identify correspondences between different approaches (p. 6).

The fourth *Standard for Mathematical Practice* describes mathematically proficient students as individuals who apply mathematical knowledge and model mathematics to solve problems situated in a variety of contexts (e.g., everyday life, workplace, society). The fifth *Standard for Mathematical Practice* promotes the strategic and appropriate use of tools to pose and solve problems.

The expectations for students outlined by the *CCSS-M Standards for Mathematical Practice* are essentially equivalent to the expectations outlined by the NCTM for the problem-solving process. In the *PSSM*, for example, problem solving is described as a juxtaposition of mathematical content, problem-solving strategies, effective self-monitoring and a “productive disposition to pose and solve problems” (2000, p. 314). Similarly, building from the work of the NRC, the *CCSS-M* expects students to develop a productive disposition, defined as “habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in

diligence and one's own efficacy" (2010, p. 6). The significance of conation surfaces in the description of the tendencies, diligence, effort and persistence expected of students in the mathematics classrooms. While disposition is not explicitly defined in the *PPSM*, the use of the term in NCTM's standards is consistent with the NRC definition, as cited in the *CCSS-M*.

The *PSSM* and *CCSS-M* describe the attitudes, values and beliefs expected of secondary mathematics students; teachers are implicitly expected to model these same attitudes, values and beliefs for their students. In this study, and consistent with the first two steps in the DAATS model, participants prioritized and visualized these standards, along with the teacher standards described in the next section. This prioritization and visualization process ultimately resulted in a set of indicators of secondary mathematics teachers' positive dispositions toward problem solving. Participants also identified aspects of the standards that indicated teachers' dispositions (i.e., affective words such as appreciates, persists, is excited about, and appears comfortable and commits) as opposed to aspects indicating teachers' knowledge or skills.

Standards for Secondary Mathematics Teachers and Teacher Candidates

In the United States, there are four national organizations that publish standards on the specific knowledge, skills, dispositions and commitments secondary mathematics teachers and teacher candidates should possess. They are the NCTM, NCATE, NBPTS and the CBMS. Standards for education providers and programs preparing teacher candidates are outlined in the NCATE/NCTM publication *Program Standards for Initial Preparation of Mathematics Teachers: Standards for Secondary Mathematics Teachers* (2003) and in the revised NCTM CAEP Standards (2012). Standards for teacher candidates' content preparation are outlined in the CBMS publications *The Mathematical Education of Teachers* (2001) and *The Mathematical Education of Teachers II* (2012). The NCTM's *PSSM* and *Mathematics Teaching Today (MTT)* along with the NBPTS publication *Adolescence and Young Adulthood Mathematics Standards (AYAMS)* describe

the specific knowledge, skills, dispositions and commitments that secondary mathematics teachers should exhibit. The NCTM publications provide minimum expectations for teaching while the NBPTS publications outline expectations for accomplished teaching. Combined with the *CCSS-M*, these documents provide guidance for teacher educators tasked with assessing secondary mathematics teachers' dispositions toward problem solving.

As described earlier, the *PSSM* outlines broad goals for mathematical content and processes for prekindergarten through grade 12 instructional programs. In order to realize NCTM's vision, teachers are expected to make problem solving an integral component to all mathematics learning, infusing worthwhile mathematical problems and tasks into classroom instruction. The selection of these worthwhile problems and mathematical tasks is a difficult decision, one that requires the wisdom of teachers who understand how to use problems to further mathematical goals for their students. In essence, teachers must be able to select, analyze and adapt problems, as well as anticipate student questions that might arise. Teachers play an important role in the development of students' problem-solving dispositions "by creating and maintaining classroom environments, from prekindergarten on, in which students are encouraged to explore, take risks, share failures and successes, and question another" (NCTM, 2000, p. 53). Teaching is essentially a problem-solving activity, and "effective teachers of problem solving must themselves have the knowledge and dispositions of effective problem solvers" (p. 341).

While the *PSSM* does not specifically define teachers' dispositions toward problem solving, the NCTM defines dispositions of effective problem solvers as "an orientation toward problem finding and problem posing, an interest in, and capacity for, explaining and generalizing, and a propensity for reflecting on their work and monitoring their solutions" (2000, p. 258). It is important to identify the phrases in this definition that are conducive to affective

measurement (e.g., *orientation toward, interest in, propensity for*). The *PSSM* also provides illustrative behaviors to guide secondary mathematics teachers in actualizing the problem-solving process standard in the classroom. In grades 6-8, for example, secondary mathematics teachers are expected to make problem solving an integral aspect of the classroom by regularly asking students to formulate interesting problems and assist students in developing a problem-solving orientation (2000). Without listing disposition as a specific standard or expectation, the *PSSM* consistently takes a philosophical position that teachers' dispositions toward mathematics are key factors in shaping students' mathematical dispositions. By exhibiting the behaviors described in the *PSSM* narrative on problem solving, teachers will theoretically produce students with a productive disposition toward problem solving.

In 1991, the NCTM published *Professional Standards for Teaching Mathematics (PSTM)* in an attempt to describe effective mathematics teaching and identify specific support systems required to achieve that vision. The NCTM recently combined the visions of *PSTM* and *PSSM* for high-quality mathematics teaching into a single publication. In *Mathematics Teaching Today (MTT)*, the NCTM describes specific knowledge, skills and behaviors of mathematics teachers and provides recommendations for supervisors, teacher educators, mathematicians, professional developers, parents, politicians, community members and anyone desiring to improve the teaching and learning of mathematics. According to the expectations outlined in *MTT*, mathematics teachers have the responsibility to "ensure that every student is learning sound and significant mathematics and is developing a positive disposition toward mathematics" (2007, p. 55). Several expectations in *MTT* specifically address the teaching and learning of problem solving and dispositions toward problem solving. As in *PSSM*, teachers are expected to regularly provide opportunities for students to experience mathematical ideas and

skills by encouraging students to solve a variety of genuine problems. Additionally, many of the expectations in *MTT* have a dispositional, or affective, component:

Teachers must foster the disposition to use and engage in mathematics, an appreciation of its beauty and utility, and a tolerance for getting stuck or side-tracked. Teachers must help students realize that mathematical thinking may involve dead ends and detours, all the while encouraging them to persevere when confronted with a puzzling problem and to develop the self-confidence and interest to do so (2007, p. 17).

Several of the concepts in the narrative above are measurable within the affective domain (i.e., *appreciation, interest, encouraging*). Secondary mathematics teacher educators are responsible for holding teacher candidates to the standards and expectations outlined by the NCTM, NCATE and CAEP. Affective measurement is a valuable method for describing teachers' dispositions, provided that skills-based standards, such as those outlined in the *MTT*, are applied in the design and validation of any instruments (Wilkerson & Lang, 2007).

In the *Adolescent and Young Adulthood Mathematics Standards*, the NBPTS consistently refers to the essential knowledge, skills, dispositions and commitments that exemplify accomplished teaching (2001). Even though secondary mathematics teacher educators are not required to use the NBPTS standards in preparing secondary mathematics teachers, the standards describe expectations and observable teacher actions, and have an impact student learning. The elaborative passages about each of the twelve standards provide valuable information on teachers' dispositions toward problem solving. For example, several passages in the eighth standard, *Ways of Thinking Mathematically*, describe teachers' dispositions toward problem solving using affective conceptualizations:

Teachers know multiple ways to represent mathematical ideas, and they organize tasks so that students will learn that a single problem may have many representations. Accomplished teachers encourage students to distinguish between these representations and to select a compelling and efficient representation for a given problem or situation . . . provide many rich opportunities for students to apply mathematics to interesting problems . . . deliberately structure opportunities for students to use and develop appropriate mathematical discourse as they reason and solve problems . . . encourage students to confront and challenge ideas and to question

peers as they discuss mathematical ideas, develop mathematical understanding, and solve mathematical problems (2001, pp. 37-38).

Aspects of the twelve NBPTS standards, taken collectively, provide additional insight into the development of indicators of secondary mathematics teachers' positive dispositions toward problem solving at the higher levels of the affective domain (i.e., *valuing, organization, characterization*). In theory, teachers who attain certification have generalized their values into controlling tendencies and integrated these values fully into their philosophy of teaching. Thus, the standards put forth by the NBPTS provide standards useful in the development of indicators of secondary mathematics teachers' positive dispositions toward problem solving along with a corresponding assessment framework. Building an assessment framework correlating indicators and assessment methods at varying levels of inference will ultimately increase the level of confidence assessors have when making determinations about individual teachers' dispositions toward problem solving.

Four additional sets of standards provide guidance with respect to secondary teacher candidates' dispositions toward problem solving. Two of the sets, published by NCTM in cooperation with NCATE (and presently CAEP), guide institutions in preparing secondary mathematics teachers. The current set of standards, herein referred to as *PSPMT* (2003), along with the more recent standards, herein referred to as *PSPMT 2* (2012), outline expectations for teachers' dispositions. For example, the *PSPMT* describes dispositions as candidates' "nature and temperament relative to being a mathematician, an instructor, a facilitator of learning, a planner of lessons, a member of a professional community, and a communicator with learners and their families" (NCTM, 2003, p. 1). According to standard seven, programs seeking national recognition from NCATE must demonstrate, through total faculty input, that their candidates support positive dispositions toward mathematical processes and mathematical learning through an attention to equity, use of a stimulating curricula, effective teaching, commitment to

learning with understanding, use of various assessments and use of various teaching tools including technology (NCTM, 2003). This standard implies that teacher candidates and their students should exhibit positive dispositions toward mathematical processes and learning. While *PSPMT* provides examples of what using various teaching tools looks like (i.e., concrete materials, technology), elaboration on the behaviors that reflect positive dispositions is not provided. As a result, programs wishing to assess dispositions must look to other sources (e.g., *CCSS-M*, *PSSM*, *MTT*, and *AYAMS*) for guidance in specific teacher behaviors that indicate positive dispositions. In addition to the expectation that programs assess teachers' dispositions, *PSPMT 2* also expects programs to provide evidence that teacher candidates support the continual development of students' productive dispositions toward mathematics. The NCTM consistently communicates the importance of positive and productive dispositions toward mathematical processes and learning, and the *PSPMT 2* is no exception. Furthermore, the NCTM suggests that there exists a relationship between teachers' positive dispositions toward problem solving and students' productive dispositions toward problem solving:

As the teacher models encouragement and support for students and respects and accepts their ideas, so should students learn to support and respect one another and to work collaboratively and actively to solve problems and to validate proposed solutions (NCTM, 2007, p. 106).

Yet examples of behaviors indicative of positive dispositions in teachers and in support of productive dispositions in students are not provided in either set of program standards. Teacher educators must look to ancillary sources of professional values (e.g., *PSSM*, *CCSS-M*, *AYAMS*) to develop indicators of secondary mathematics teachers' positive disposition toward problem solving that are both observable and measurable.

The final two sets of standards on secondary mathematics teacher preparation are published by the CBMS. Both the *MET 1* (2001) and the *MET 2* (2012) refer to teachers' dispositions and are intended as a resource for all audiences involved in the education of

mathematics teachers. In preparing future high school mathematics teachers, the standards urge mathematics faculty to incorporate a *habits-of-mind* goal in their instruction:

Most mathematics faculty probably agree with such objectives and even argue that their courses include remarks or assignments designed to cultivate these desirable habits and dispositions. However, students often emerge from their undergraduate experiences with, at best, an unarticulated sense of what it means to be a mathematician. More explicit attention to this aspect of mathematical education may be needed in teacher preparation coursework (CBMS, 2001).

In the *MET 2*, the CBMS acknowledges that since the publication of the first *MET* standards, national reports and standards for teachers have “helped to clarify and elucidate aspects of mathematics that are ‘second nature’ to mathematicians, bringing mathematical dispositions and practices, as well as mathematical topics, before a national audience” (pp. 4-5). In addressing coursework and experiences future high school teachers should have, the *MET 2* recognizes the importance of both mathematical processes and mathematical topics. Deferring to the NRC’s five strands of mathematical proficiency (e.g., conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition) and the *CCSS-M Standards for Mathematical Practice*, the CBMS stresses that high school mathematics teachers must be responsible for developing in their students the five mathematical proficiencies expected of students at the national level.

According to the CBMS, future teachers should be provided with “opportunities for the full range of mathematical experience themselves: struggling with hard problems, discovering their own solutions, reasoning mathematically, modeling with mathematics, and developing mathematical habits of mind” (CBMS, 2012, pp. 34-35). Both the *MET 1* and *MET 2* provide ancillary visions that include cultivating in teachers desirable dispositions toward mathematical processes and learning.

Conclusion

Teachers' dispositions must be addressed in the field of teacher education. This chapter argued for the importance of dispositions toward problem solving in the field of secondary mathematics teaching, learning and teacher education. Holding teacher candidates accountable for only the skills and knowledge needed to teach is no longer sufficient (Da Ros-Voseles & Moss, 2007). Additionally, 656 NCATE-accredited, and presumably soon-to-be CAEP-accredited, institutions hold teacher candidates accountable for *professional dispositions*. This chapter presented a summary of the literature on dispositions from the fields of psychology, philosophy, teacher education and, more specifically, secondary mathematics teacher education.

Dispositions, along with the exploration of knowledge and skills, may in fact be the most important aspect of any teacher assessment framework (Wilkerson & Lang, 2007; Hill-Jackson & Lewis, 2010). Approaching teachers' dispositions from a normative perspective allows mathematics teacher educators to hold candidates accountable for the accepted professional standards for teachers of secondary mathematics. National organizations have consistently published standards and expectations emphasizing the importance of dispositions in the field of secondary mathematics education (NCTM, 2000, 2003, 2007, 2012; NBPTS, 2001; CBMS, 2001, 2012; National Governors Association Center for Best Practices and the Council of Chief States School Officers, 2010). These sets of national standards collectively articulate the knowledge, skills, values, dispositions and commitments expected of secondary mathematics teachers. By identifying and combining the standards, indicators and behaviors described in these expectations, teacher educators are able to operationalize secondary mathematics teachers' positive dispositions toward problem solving in terms of observable and measurable behavioral indicators. Approaching assessment in this manner ensures content domain coverage and content validity and ultimately provides assessors a higher level of confidence in the decisions

made about a teacher's disposition toward problem solving as inferred from observable behaviors (Wilkerson & Lang, 2007; Miller et al., 2011).

Scholars disagree about what teachers ought to know or be able to do, including the type of dispositions they ought to exhibit (Vergari, 2007). Even variation in the manner in which dispositions should be incorporated directly into teacher preparation programs is present among teacher educators (Borko et al., 2007). For example, some teacher educators advocate for direct and purposeful teaching of dispositions by “working through the various descriptors, providing concrete examples, and asking questions to stimulate critical thinking” (Koeppen & Davison-Jenkins, 2007, p. 97). Ultimately, the purpose of creating a system to assess secondary mathematics teachers' dispositions toward problem solving is similar to the purpose of the assessment of behavior in the field of psychology. In *Teaching as a Moral Practice: Defining, Developing, and Assessing Professional Dispositions in Teacher Education*, Murrell and others, articulate this purpose thusly:

An assessment by itself holds little value. Assessments possess value when they measure something meaningful. Assessments for dispositions are meaningful when they are used as tools for development. If other teacher educators would share their wisdom, making their methods of using assessments for the purposes of development more visible, it would not only benefit teacher candidates who are in the process of forging their professional identities, it could also serve as a resource to the field. Teacher educators are in many ways an untapped resource, as we are lacking the structures to take advantages of our collective wisdom regarding assessing for the purpose of developing dispositions. To capitalize on our collective wisdom and move toward a theory of disposition development, we suggest adopting a culture of critical collegueship (2010, p. 199).

The primary purpose of this study was to apply Wilkerson and Lang's (2007) Disposition Assessment Aligned with Teacher Standards (DAATS) model to develop an assessment framework for selecting existing instruments or designing future instruments to ensure valid inferences about secondary mathematics teachers' dispositions toward problem solving. The results of this study will potentially assist secondary mathematics teacher educators to infer

secondary mathematics teachers' dispositions toward problem solving from observable behaviors. The indicators and assessment framework that result from this study could assist in identifying potential instruments and items that are aligned with standards and consistent with the assessment framework, thereby providing the potential to identify, and eventually address, individual teachers' dispositions toward problem solving that are either not fully developed or missing altogether. Ultimately the results of this study have the potential to assist teacher educators in better understanding the relationships among observable behaviors and the positive dispositions toward problem solving expected of secondary mathematics teachers as expressed by the professional organizations discussed in this review.

CHAPTER III

METHODOLOGY

“When conducted appropriately, efforts to cultivate and assess dispositions for ambitious teaching serve to orient teacher candidates to the nature and responsibilities of the professional role in teaching. They are essential for developing the decision-making and judgment capacities necessary for enacting teaching that is guided by the wisdom of the professional community and that promotes the well-being of children” (Carroll, 2007).

Introduction

No research links prospective or practicing teachers’ disposition, or affect, toward problem solving to their classroom instructional decisions. Yet, it is reasonable to suspect, indeed hope, that they are connected. As a result, researchers need to look more closely at the role secondary mathematics teachers’ dispositions toward problem solving plays in mathematics instruction. The potential link between teachers’ dispositions and instructional decisions is important to investigate for several reasons. First, it is reasonable to suspect that teachers who have positive affect toward problem solving will value problem solving more, and as a result, teach it with a deeper sense of commitment and integrity. Second, teachers’ dispositions toward the mathematical process of problem solving may ultimately impact their instructional approach to problem solving in the classroom. Finally, teachers’ positive dispositions toward problem solving may help support in students more productive dispositions toward problem solving. In order to explore these links, developing an assessment framework comprised of valid and reliable instruments, to infer secondary mathematics teachers’ dispositions toward problem solving is needed.

The primary purpose of this study was to apply Wilkerson and Lang's (2007) Disposition Assessment Aligned with Teacher Standards (DAATS) model to develop an assessment framework for selecting existing instruments or designing future instruments to assess secondary mathematics teachers' dispositions toward mathematical problem solving. The major research questions addressed by this study were:

1. Based on the standards, what are observable (verbal and nonverbal) behaviors, attitudes, or practices that are likely to be consistent with secondary mathematics teachers exhibiting positive dispositions toward problem solving?
2. Using Wilkerson and Lang's (2007) Disposition Assessment Aligned with Teacher Standards (DAATS) model, to what extent can an assessment framework, with assessment methods at different levels of inference, be developed to assess secondary mathematics teachers' dispositions toward problem solving?
3. To what extent will the assessment framework provide a valid framework for selecting existing instruments (or designing future instruments) to measure secondary mathematics teachers' dispositions toward problem solving?

This study did not attempt to develop and validate instruments to assess all dispositional cognitive and affective mental functioning (i.e., scales, interviews, focus groups, etc.) necessary to accurately and fairly infer secondary mathematics teachers' dispositions toward problem solving. Instead, the researcher attempted a more global task of developing indicators of secondary mathematics teachers' positive dispositions toward problem solving within an assessment framework correlating indicators and assessment methods designed distinguish between teachers exhibiting more positive (or negative) dispositions toward problem solving.

This chapter describes the design of the research study and the methodology used in developing and validating indicators of secondary mathematics teachers' positive dispositions

toward problem solving. Included in this chapter are the rationale and assumptions for the mixed-methods design, population and participant descriptions, data sources and collection procedures, data analysis and validation procedures, methods for verification, trustworthiness, delimitations, and limitations of the study.

Research Design

This study employed a mixed-methods design with two steps corresponding to the first two steps of Wilkerson and Lang's (2007) five-step DAATS model and was informed by the foundations of psychological testing (i.e., *APA Standards for Educational and Psychological Testing*) outlined by Miller, McIntire and Lovler (2011). The researcher selected a mixed-methods, concurrent triangulation strategy because it was best suited to compare and substantiate the findings of the study (Creswell, 2009). The study began with an analysis of the standards on secondary mathematics teachers' dispositions toward problem solving and culminated with the development and validation of indicators of secondary mathematics teachers' positive dispositions toward problem solving along with an assessment framework correlating standards and methods. An abbreviated description of the steps in this study, adapted from the first two steps of Wilkerson and Lang's (2007) five-step DAATS model, is given below:

DAATS Step 1: Assessment Design Inputs

Define purpose, use, propositions, principles, content and other contextual factors that will define the conceptual framework for an assessment system designed to measure secondary mathematics teachers' dispositions toward problem solving and ultimately guide the development and validation of indicators of secondary mathematics teachers' positive dispositions toward problem solving (p. 42).

DAATS Step 2: Planning with a continuing eye on valid assessment decisions

Identify and analyze standards and indicators of secondary mathematics teachers' positive dispositions toward problem solving. Visualize secondary mathematics teacher demonstrating the affective targets that indicate a positive disposition toward problem solving. Establish content validity of the indicators through an

examination of agreement of experts on the applicability of values, domain coverage, and relevancy to the work of secondary mathematics teachers. Build an assessment framework that correlates standards and assessment methods (p. 62).

The population and participant descriptions, data sources and collection procedures, and data analysis and validation procedures, are provided for each step of the study.

Participants

Six teachers participated in this study. They included three experienced NCATE/NCTM reviewers of secondary mathematics teacher preparation program reports, three experts in the area of problem solving, and one expert in the area of mathematics teaching and learning as described by the National Board of Professional Teaching Standards (NBPTS). One participant was both an expert in NCATE/NCTM standards and the area of problem solving. A holistic summary of the group, presented in Table 9, is provided first and followed by narratives describing: (1) participants; (2) their mathematics education backgrounds; and (3) their individual reasons for choosing a career in mathematics education.

Participants' Backgrounds

Each of the six participants had a variety of experiences related to the purpose of this study, which was, to assess secondary mathematics teachers' dispositions toward problem solving. Jane, Anna and Dumaine were experienced NCATE/NCTM reviewers of secondary mathematics teacher preparation program SPA reports. Cathy, Andrew and Beth had expertise in the area of problem solving, and both Beth and Jane had expertise in the area of mathematics teaching and learning as described by the NBPTS at the Early Adolescent (EA) and Adolescent Young Adulthood (AYA) levels, respectively. Table 9 provides a summary of the participants', their roles in mathematics education, years in teaching, and educational backgrounds.

Table 9

Participants' Teaching and Educational Backgrounds

Participant	Role(s)	Years in Teaching	Educational Background
Jane	Classroom Teacher (K-12) University Faculty	18	BS in Mathematics MA in Teaching PhD in Curriculum and Instruction, Mathematics Education
Cathy	Classroom Teacher (6-12) Administrator University Faculty Author	30	BA in Mathematics BEd in Secondary Mathematics Education MEd in Mathematics Education PhD in Curriculum and Instruction, Mathematics Education
Anna	Classroom Teacher (8-12) University Faculty	31	BA in Mathematics with secondary certification MS in Mathematics with an emphasis in mathematics education PhD in Mathematics Education
Beth	Classroom Teacher (K-8) University Faculty	23	BEd in Elementary Education BS in Mathematics MS in Mathematics, Mathematics Education option
Andrew	Classroom Teacher (6-8) Administrator Author	34	BA in Spanish with a math minor MA in Curriculum and Instruction with an emphasis in technology
Dumaine	Classroom Teacher (K-12) University Faculty	33	BS in Physical Education MA in Teaching secondary mathematics PhD in Curriculum and Instruction, Mathematics Education

Jane. Jane has worked in mathematics education for 18 years. She was a classroom teacher at all grade levels, including 10 years as a high school mathematics teacher. Her current role is as a university mathematics teacher educator. She received National Board Certification in mathematics teaching at the Adolescent Young Adulthood (AYA) level in 2005. She is due to renew her certification in 2015 and has mentored five secondary mathematics teachers in their pursuit of AYA mathematics national board certification. She is an experienced writer and reviewer for the NCATE/NCTM accreditation process for secondary mathematics teacher preparation programs. The university where Jane teaches has a recognized NCATE/NCTM secondary mathematics teacher preparation program. One of Jane's major professional goals coincides with this study: to learn more about how to support secondary mathematics teachers in developing more positive dispositions toward mathematics and how these dispositions will ultimately support students to develop more productive dispositions toward mathematics.

Cathy. Cathy has worked in mathematics education for 30 years. She was an experienced classroom teacher with three years at the middle level and seven years at the high school level. She served five years as a district-level mathematics curriculum coordinator, provided professional development, and taught teacher education courses for fifteen years at the university level. She worked as a consultant to develop and implement professional development that promoted problem-solving strategies and the application of mathematics knowledge to solve problems. She has presented widely at the local, state and national levels on the topic of problem solving. She has co-authored or edited numerous scholarly and practical publications focused on problem solving as it relates to mathematics teaching and learning. She was an experienced report writer for the NCATE/NCTM accreditation process for secondary mathematics teacher preparation programs. The university where Cathy teaches has a recognized NCATE/NCTM secondary mathematics teacher preparation program. While she has

not served as a reviewer, she was very familiar with all versions of the NCATE/NCTM standards for secondary mathematics teacher preparation programs, including the more recent NCTM/CAEP revision. Cathy viewed dispositions as key factors in teacher success and had always wanted to learn more about it, particularly with regard to how to measure and fairly assess dispositions of the teachers she prepares for the classroom.

Anna. Anna has worked in mathematics education for 31 years. After four years of teaching high school mathematics, she pursued her graduate degrees and subsequently worked at the university level for 20 years. Presently she is a faculty member at a secondary level laboratory school where she serves as mentor and master teacher for aspiring high school mathematics teachers. She is an experienced writer and lead reviewer for the NCATE/NCTM accreditation process for secondary mathematics teacher preparation programs. Anna also was on a pilot team when NCTM revised the NCATE standards for secondary mathematics teacher preparation programs in 2004. The university where Anna currently teaches has NCATE accreditation; however, it does not have a recognized NCATE/NCTM secondary mathematics teacher preparation program. Anna's interest in this study was primarily to facilitate the process of furthering the knowledge needed in developing secondary mathematics teacher candidates.

Beth. Beth has worked in mathematics education for 23 years. She was a classroom teacher at grades K-8 and provided K-12 mathematics professional development and K-6 mathematics methods coursework to prospective teachers. Currently she is a retired consultant and actively volunteers with classroom teachers in implementing the CCSS-M. She received her initial national board certification in mathematics teaching at the Early Adolescence (EA) level in 2003 and renewed it in 2013. She mentored three teachers in their pursuit of EA mathematics national board certification and served as an assessor for the National Board for Professional Teaching Standards. Beth was excited about the movement to adopt the Common Core State

Standards at the national level due to its focus on problem solving and the Standards for Mathematical Practice. Her current role, of supporting classroom teachers in adopting the CCSS-M, has been inspired by her concern regarding the low levels of problem-solving ability among classroom teachers.

Andrew. Andrew has worked in mathematics education for 34 years. He recently retired as a classroom teacher with two years at the middle school level and considerable teaching experience at grades 9-12. He specialized in teaching students who struggled with high school mathematics (i.e., remedial mathematics and algebra coursework). He served as a mentor and lecturer on the topic of problem solving and as an administrator of English Language Learner (ELL) programs. He was author and contributing writer of problem-solving books and a textbook series. He was a knowledgeable author and experienced teacher of mathematical problem solving at the state and national level. More recently, he combined his interests in Spanish, mathematics and computer science, to support learners in an ELL Program in developing problem-solving and critical-thinking skills.

Dumaine. Dumaine has worked in mathematics education for 33 years. She was a classroom teacher at grades 4-12, including 17 years as a high school mathematics teacher. Presently, she is a mathematics teacher educator at the university level. She is an experienced lead reviewer for the NCATE/NCTM accreditation process for secondary mathematics teacher preparation programs and has served as a member of the NCATE Board of Examiners at the unit level. The university where Dumaine teaches has an NCATE/NCTM secondary mathematics teacher preparation program. Dumaine's interest in this study was two-fold. First, she hoped future teachers would aspire to include a problem-solving focus along with inquiry teaching models (e.g., Bybee's 5 E's model) in their teaching. Second, she believed that the focus of this study (i.e., teachers' dispositions toward problem solving) was important. She was concerned

about our new generation of teachers, who seemed excited, but also a little scared, about teaching. From this study, she hoped the next generation of teachers would value teaching mathematics as a problem-solving endeavor. She hoped that her teachers would cease saying “this is a new way of teaching” because it was simply a “different” way of teaching based on NCTM’s *Principles and Standards for School Mathematics* (2001).

Rationale for Selecting Participants

The six participants in this study were selected primarily on the basis of their experiences and expertise in the broad areas underlying this study (i.e., problem solving, teachers’ dispositions, teacher development, standards-based accreditation processes). Table 10 provides participants’ responses to the question: Why did you choose a career in mathematics teaching and/or teacher education? The phrases highlighted in bold are revisited in Chapter V.

Table 10

Reason for Choosing a Career in Mathematics Teaching and/or Teacher Education

Participant	Reason
Jane	I chose to become a teacher because I have always enjoyed playing school even from a small age. I also enjoyed helping others through tutoring a variety of subjects. I was very athletic in my younger years and decided to major in mathematics and then pursue a graduate degree in teaching with certification upon completing my math degree. I love mathematics , the way it "works" and also the ability to explain to students how to problem solve their own way to a solution .
Cathy	I struggled a lot as a mathematics learner in my K-12 schooling, especially in high school where geometry really challenged me. I actually stopped mathematics at advanced algebra. My school only required two-and-a half years of math for graduation, and I was <i>done</i> . It wasn't until college that I was inspired by my second semester calculus teacher to pursue a math degree and ultimately go into teaching math. I think I was meant to be a teacher and that this was always a calling, but I wasn't sure about which subject until college. Eventually I decided to go back to school to become a math teacher educator to really make a difference in how mathematics is taught, especially in high school where I struggled so much.
Anna	My original part with mathematics education happened when I was in second grade. I always knew I really liked math and wanted to be a teacher . When I

went off to college, that didn't really change. I taught for four years and then I had a friend who went to grad school. So because **I missed mathematics class and going to school**, I went back to get a graduate degree in education with an emphasis in mathematics education. I worked for one year in a lab school and two years as an instructor in a mathematics department. Early on, during this experience, I realized I wanted to work with mathematics teachers. Another part of this is that I'm from a small town (about 800) and **wanted to be a teacher educator to prepare teachers well for small schools so that students wouldn't be 'stuck' with a poor math teacher** multiple years in a row. **My calling** has been to prepare stronger teachers for smaller settings. I have also **had strong mentors and teacher educators that inspired me** during my graduate degree programs. During the first two years, I wasn't necessarily set on going for a doctorate, but **my professors inspired me** to do this.

Beth I have **always enjoyed mathematics** myself and then I started in elementary education, which was very helpful because I got the affective stuff there, but then **I felt that I could share my love of math more by moving to the secondary level**. With mathematics education I just felt that, if **I wanted to help more kids love mathematics, then I would be more productive if I helped teachers become better teachers**. I felt that I would reach more kids by going through teachers. When I went back to finish my graduate degree toward the end of my career, I chose mathematics education, which was a personal journey. **I was doing this more for myself, to challenge myself, and to go through some of the struggles that kids go through by striving to learn more mathematics**.

Andrew I was **inspired to become a teacher** by my high school Spanish teacher. I majored in math, computer science and Spanish in college. **I see the connections between language and mathematics and have pursued this as a result and want to help others see these connections**. I like the 'right or wrong' aspect of mathematics even though this is a gross simplification.

Dumaine Even though my first degree is not in mathematics education, **I really love math and find it fun to help others understand it**. One of my most fun experiences in teaching is that I spent nine years working at a school for the gifted. They accepted me and said I was *nerdy* enough for them. At the time, I was working on my certification for gifted education. I started a doctoral program, and I'm not quite sure what drew me to working with pre-service teachers, rather than doing the math route, but **I guess I must love it because I've been enjoying it for fourteen years**.

DAATS Step 1: Define Purpose, Use, Propositions, Content and Context

The purpose of the first step in this study was to clearly articulate the reasons for developing a system for assessing secondary mathematics teachers' dispositions. This step included defining the body of knowledge or behaviors that the assessment framework would be based on, along with the target audience and the propositions and principles. This step ultimately guided the development of an initial list of indicators of secondary mathematics teachers' positive dispositions toward problem solving. The first step began with the researcher's analysis of the standards on secondary mathematics teachers' dispositions toward problem solving and culminated with identifying the content, propositions and principles that would define the assessment framework and ultimately guide the development and validation of indicators of secondary mathematics teachers' positive dispositions toward problem solving.

DAATS Step 1 is divided into four sub-steps, as outlined by Wilkerson and Lang (2007):

DAATS Step 1A: Define the purpose(s) and use(s) of the system.

DAATS Step 1B: Define the propositions or principles that guide the system.

DAATS Step 1C: Define the conceptual framework or content of the system.

DAATS Step 1D: Review local factors that impact the system (p. 42).

Steps 1A-1D identified the purpose, use and content of an assessment process designed to measure secondary mathematics teachers' dispositions toward problem solving. The NCATE/NCTM *Program Standards for Initial Preparation of Mathematics Teachers* (2003) recommended total faculty input (e.g., mathematics content, mathematics education, education and field-experience faculty) to the disposition response (p. 1). Therefore, to best understand secondary mathematics teachers' dispositions toward problem solving, the researcher employed purposeful sampling to select individuals and sites. Participants in this phase included three experienced NCATE/NCTM reviewers of secondary mathematics teacher preparation

program reports, three experts in the area of problem solving, and one NBPTS expert. The participants completed versions of DAATS' Worksheets 1.1, 1.2, 1.3 and 1.4 (see Appendix A), which were adapted to the focus of this study: secondary mathematics teachers' dispositions toward problem solving. Minor adaptations of the language of the worksheets provided clarity for the participants and focused their attention on the construct of secondary mathematics teachers' dispositions toward problem solving. The six participants also responded to the following questions underlying DAATS Step 1:

- **Purpose:** Why would secondary mathematics teacher educators assess secondary mathematics teachers' dispositions toward problem solving?
- **Use:** What decisions could be made with the data? How could educators use the results?
- **Content:** What will be assessed? Which standards will serve as the foundation for our assessment framework?
- **Context:** What factors will help or hinder implementation of the assessment framework? (Wilkerson & Lang, 2007)

Data from the worksheets and interviews were transcribed, compiled and presented in table format in Chapter IV (see Tables 11-15) to allow the purpose, use, content, and context to emerge from the data. Prominent themes that emerged were aggregated to create a valid conceptual framework for an assessment system designed to measure secondary mathematics teachers' dispositions toward problem solving (see Figure 2). The results were also used as a validity check to verify the propositions (i.e., fundamental truths underlying the system) and content (e.g., national standards) identified in the review of the standards. The propositions, principles and standards identified in this stage ultimately guided the development of an assessment framework that would correlate standards and indicators of secondary mathematics

teachers' dispositions toward problem solving with corresponding affective assessment methods.

DAATS Step 2: Planning with a Continuing Eye on Valid Assessment Decisions

The purpose of the second step in this study was to develop indicators of secondary mathematics teachers' positive dispositions toward problem solving. This step began with an analysis and synthesis of the two sets of national standards that were identified by participants during DAATS Step 1 of the study. Additional sets of national standards, identified by the researcher during the review of standards addressing secondary mathematics teachers' dispositions toward problem solving, were juxtaposed with those identified by participants (see Appendix B). DAATS Step 2 culminated with the development of indicators of secondary mathematics teachers' positive dispositions toward problem solving within an assessment framework that correlated standards and affective assessment methods (see results of Worksheets 2.3 and 2.4). DAATS Step 2 is divided into four sub-steps, as outlined by Wilkerson and Lang (2007):

DAATS Step 2A: Analyze standards and indicators.

DAATS Step 2B: Visualize the teacher demonstrating the affective targets.

DAATS Step 2C: Select assessment methods at different levels of inference.

DAATS Step 2D: Build an assessment framework correlating standards and methods (p. 62).

The purpose of Step 2A was to define clearly the testing domain at the indicator level. Based on a review of the standards and data collected during DAATS Step 1, and in order to create a domain from which to sample, the researcher completed DAATS Step 2A using the standards identified by participants during DAATS Step 1 of this study. For DAATS Step 2B and 2C, the researcher created versions of Worksheet 2.2 and the Affective Domain taxonomic levels

worksheets adapted by Wilkerson and Lang (2007) from the Krathwohl and Bloom (1956) Affective Domain (see Appendix D). The content of these worksheets was based on the participant-identified standards that described secondary mathematics teachers' dispositions toward problem solving. The qualitative analysis and coding process for Worksheet 2.2 and the Affective Domain taxonomic levels worksheets began with reading through all the data from all six participants to obtain a general sense of the overall meaning of participants' responses. This reading provided an overall impression of the depth, credibility and use of the information provided by participants. Spreadsheet software was employed to organize the behavioral indicators of positive and negative dispositions (from Worksheet 2.2) and typical teaching behaviors for each of the levels (from the Affective Domain taxonomic levels worksheet) as statements based in the actual language of the participants. The researcher used a combination of codes predetermined through a review of the standards along with codes that emerged from DAATS Step 2A and participants' responses to the worksheets.

The purpose of Step 2B was to elicit the behaviors indicating that secondary mathematics teachers value and display positive (or negative) dispositions toward problem solving. Each participant completed DAATS' Worksheet 2.2 (see Appendix A) adapted for the content identified in Step 2A of this study. Specifically, participants listed behaviors that they believed indicated positive dispositions toward problem solving in secondary mathematics teachers according to the standards identified in DAATS Step 1 and analyzed in DAATS Step 2A in this study. They also listed the behaviors that indicated the values were missing in teachers. Finally, participants responded to the guiding questions for this step of the study:

- What does this problem-solving standard (or principle or indicator) look like in practice when applied by a good teacher?

- How do observers know that a secondary mathematics teacher exhibits a positive disposition toward problem solving as identified in the standards?
- Imagine secondary mathematics teachers with more positive (or more negative) dispositions toward problem solving. What do they demonstrate along this continuum?

Steps 2A and 2B provided the vision of teachers demonstrating positive dispositions toward problem solving. Indicators of secondary mathematics teachers' positive dispositions toward problem solving emerged from participants' responses to this vision and ultimately guided the development of an assessment framework correlating indicators and affective assessment methods. Results from Steps 2A and 2B of this study were compiled and used to refine Worksheet 2.3 and create a version of Worksheets 2.4 specific to this study for use in Steps 2C and 2D of this study (see Appendix A).

The purposes of Steps 2C and 2D of this study were to identify a set of assessment methods using different instruments in different contexts (e.g., scales, questionnaires, interviews, focus groups, observations, behavioral observation instruments, event reports, and situational analysis tests) and build an assessment framework that correlates indicators with the selected affective assessment methods. The primary goal was to suggest possible methods for making valid inferences about teachers' positive disposition based on the indicators generated in Step 2B of this study. Each participant from Step 1 completed versions of DAATS' Worksheets 2.3 and 2.4 adapted to include the indicators of secondary mathematics teachers' positive dispositions toward problem solving. The researcher compiled and analyzed data from the worksheets to create an assessment framework that addressed each indicator and suggested which indicators would be best assessed through particular affective assessment methods (see

Tables 34-38). The assessment framework developed during DAATS Step 2 ultimately guided the suggestion of preliminary items as presented in Chapter V (see Table 39 and 40).

Methods for Verification and Trustworthiness of Qualitative Data

Each step in this study included interview data. Each interview was recorded and transcribed. The researcher reviewed the interview data a minimum of two times before developing a preliminary list of categories based on prominent themes that emerged from participants' responses. After each theme was assigned an initial coding, the researcher read all responses for each worksheet and question in order to develop a master code list of response categories. Using the master code list, the researcher coded the full transcript for each worksheet and the interview for each participant. The researcher noted when more than a single reference was made in a response category. Conducting a thorough analysis of each response for each worksheet and for each interview allowed themes and patterns to emerge during every step in each phase of this study. The researcher reviewed all interview transcripts to verify that the findings (i.e., main themes and patterns) were consistent with the qualitative data. Where applicable, the findings from the worksheet and interview data were analyzed to determine consistency with the literature on teachers' dispositions and secondary mathematics teachers' dispositions toward problem solving.

The researcher employed well-established qualitative research methods that ensured a faithful representation of secondary mathematics teachers' dispositions toward problem solving. This study employed a mixed-methods design with two steps corresponding to the first two steps of Wilkerson and Lang's (2007) five-step DAATS model and informed by the foundations of psychological testing (i.e., *APA Standards for Educational and Psychological Testing*) outlined by Miller, McIntire and Lovler (2011). The researcher selected a mixed-methods, concurrent triangulation strategy as it was best suited to compare and substantiate

the findings of the study (Creswell, 2009). Triangulation further ensured credibility of the findings of this study. This study employed a variety of documents (i.e., DAATS worksheets) and employed a wide range of participants. This allowed the researcher to generate a rich picture of the attitudes, behaviors and practices indicating positive disposition in secondary mathematics teachers (Shenton, 2004). Several tactics were employed to ensure participants were honest in their responses. The researcher found it easy to establish rapport with participants and gave each participant the opportunity to refuse participation at every stage in the study. The researcher also encouraged participants to be frank in their responses to the DAATS worksheets and advised participants that there were no right answers to the worksheets (pp. 66-67). The researcher employed iterative questioning techniques through the use of DAATS worksheets that rephrased prompts to ensure that contradictions in the data could be removed prior to presenting the results. The researcher holds NBPTS certification and has authored and reviewed NCATE/NCTM program recognition reports. The background, qualifications and experience of the investigator are provided in more detail in the curriculum vitae at the end of the study. Finally participants were asked to read their transcripts to ensure their intentions were accurately presented (p. 67).

To address transferability, the researcher provided ample detail regarding the context of this study to include the number of participants involved in the study and the rationale for selecting them, the data collection methods that were employed, and the number of data collection instruments used to collect the data (p. 70). To address dependability, the researcher provided a detailed description of the methodology to include the research design, instrumentation and implementation (p. 71). To address confirmability, the data collection procedures, along with methods of triangulation, ensured that the findings of the study were representative of participants' intentions rather than the researcher's (p. 73).

Delimitations

The purpose of this study was to develop and validate indicators of secondary mathematics teachers' positive dispositions toward problem solving. The study was limited to three experienced NCATE/NCTM reviewers of secondary mathematics teacher preparation program reports, three experts in the area of problem solving, and one expert in the area of mathematics teaching and learning as described by the National Board of Professional Teaching Standards (NBPTS). One participant was both an expert in NCATE/NCTM standards and the area of problem solving. The individuals participating in the study were volunteers and had varying knowledge and views about national standards outlined by the NCTM, NBPTS, NCATE, CAEP, NRC and National Governors Association Center for Best Practices.

Limitations

Three limitations of this study were evident. First, the dispositional indicators generated were developed using expectations for effective, accomplished mathematics teachers as described by the NCTM, NBPTS, NCATE, CAEP, NRC and National Governors Association Center for Best Practices. Therefore, the dispositional indicators, assessment framework and suggested item pool were based on the standards produced by these organizations. These standards are valuable and important in defining the principles and responsibilities of secondary mathematics teachers. In order to establish an assessment framework based on data and decisions that would likely be replicable in other contexts, the researcher selected experts in the field and knowledgeable about and believed in the visions of the NCTM, NBPTS, NCATE, CAEP, NRC and the National Governors Association Center for Best Practices. Researchers who use the results of this study need to review the results of the first two DAATS steps for applicability to their context in order to ensure validity of the assessment design inputs and planning with a

continuing eye on valid assessment decisions (Wilkerson & Lang, 2007). Second, the consistency of the assessment frameworks (see Tables 33-37) was impacted by the small number of participants in this study. Although the researcher reviewed for consistency participants' selections of assessment methods where the responses were spread across the three categories (yes, possibly, no), the decision about *yes*, *possibly*, or *no* could be significantly impacted by a single participant's vote. Assessment developers should use the assessment framework as guide only, to be confirmed and adjusted locally. If developers are able to identify good items for an indicator with a corresponding assessment method classified as a *no*, they should be comfortable in using the items, since as many as four of the six respondents may have indicated that such items could be developed. Third, the psychometric quality of the suggested instruments and items that correspond to the assessment framework that resulted from this study was not ascertained. Validity, reliability and fairness for items and instruments should be established as they are developed or selected.

Chapter Summary

The chapter described how the researcher applied Wilkerson and Lang's (2007) Disposition Assessment Aligned with Teacher Standards (DAATS) model to develop indicators of secondary mathematics teachers' positive dispositions toward problem solving and suggest an assessment framework and assessment framework for selecting existing instruments or designing future instruments to assess secondary mathematics teachers' dispositions toward the mathematical process of problem solving. The methods and procedures of this study were presented and organized in two steps that allowed the researcher to develop and validate indicators of secondary mathematics teachers' positive dispositions toward problem solving along with a preliminary assessment framework to suggest a preliminary item pool for measuring disposition toward problem solving. The results of the concurrent triangulation

strategy employed in this study, including a review of the qualitative collection procedures and themes that emerged from the analysis of the data collected, are presented in Chapter IV.

CHAPTER IV

RESULTS

“How is it possible that the field of teacher education continues to regurgitate the same inert policies and uncontested teacher preparation programs while expecting different results for underserved learners?” (Hill-Jackson and Lewis, 2010, p. xxiv).

Introduction

As stated in Chapter I, this study examined the application of Wilkerson and Lang’s (2007) Disposition Assessment Aligned with Teacher Standards (DAATS) model in the development of an assessment framework used to select existing instruments or design future instruments to assess secondary mathematics teachers’ dispositions toward mathematical problem solving. This study used a mixed-methods design with two steps corresponding to the first two steps of Wilkerson and Lang’s (2007) five-step DAATS model. This chapter presents the results for each step of the study, organized by worksheet, in chronological order. The chapter concludes with an examination of the three central research questions along with four refined research questions that emerged from the data collection and analysis process during each phase of the study. The three central research questions of this study were:

1. Based on the standards, what are observable (verbal and nonverbal) behaviors, attitudes, or practices that are likely to be consistent with secondary mathematics teachers exhibiting positive dispositions toward problem solving?
2. Using Wilkerson and Lang’s (2007) Disposition Assessment Aligned with Teacher Standards (DAATS) model, to what extent can an assessment framework, with assessment methods at different levels of inference, be developed to assess secondary mathematics teachers’ dispositions toward problem solving?

3. To what extent will the assessment framework provide a valid framework for selecting existing instruments (or designing future instruments) to measure secondary mathematics teachers' dispositions toward problem solving?

The results that follow are presented in chronological order. The results of DAATS Step 1 established likely purposes and uses for an assessment system targeting secondary mathematics teachers' dispositions toward problem solving. The results of DAATS Step 2 provided measurable, standards-based indicators of secondary mathematics teachers' positive dispositions toward problem solving. The results of the Krathwohl and Bloom (1956) Affective Taxonomy established a range of typical teaching behaviors for the standards-based indicators. The final steps of DAATS Step 2 resulted in an assessment framework for measuring a secondary mathematics teacher's disposition toward problem solving. Ultimately this assessment framework could be used to develop items and instruments that could be used, modified, or expanded for a variety of purposes, such as demonstrating expectations related to teaching problem solving to secondary mathematics teacher candidates.

Results of DAATS Step 1

The purpose of the first step in this study was to clearly articulate the purpose of a system designed to assess secondary mathematics teachers' dispositions toward problem solving. The data collected from Worksheets 1.1, 1.2, 1.3 and 1.4 (see Appendix A), are reported along with participants' responses to the guiding questions underlying DAATS Step 1:

- **Purpose:** Why would secondary mathematics teacher educators assess secondary mathematics teachers' dispositions toward problem solving?
- **Use:** What decisions could be made with the data? How could educators use the results?

- **Content:** What will be assessed? Which standards will serve as the foundation for our assessment framework?
- **Context:** What factors will help or hinder implementation of the assessment framework? (Wilkerson & Lang, 2007)

The following results are organized by worksheet and imbed participants' responses to the four questions above. The original worksheets, as set forth in Wilkerson and Lang's (2007) DAATS model for assessing teachers' dispositions, and the modified versions of the worksheets designed specifically to suit the purpose of assessing secondary mathematics teachers' dispositions toward problem solving, are provided in Appendix A.

Worksheet 1.1

The purpose of Worksheet 1.1 was to establish a foundation for the design of the process for assessing secondary mathematics teachers' dispositions toward problem solving. Each of the six participants responded to the worksheet individually. Results are presented by section: purpose, use, content, propositions (or principles) and context.

Purpose. This section of Worksheet 1.1 assisted in developing the purpose for assessing disposition in teachers. The purpose should ultimately ensure teacher commitment to learning by all children (Wilkerson & Lang, 2007). Table 11 provides a summary of participants' responses regarding the primary purpose of assessing secondary mathematics teachers' dispositions toward problem solving. Every participant expressed that some teacher candidates and teachers have excellent attitudes and values while others clearly do not, and that it is critical to determine their attitudes and values. However, participants were less likely to support a purpose when it involved higher stakes (e.g., selection of secondary mathematics teacher candidates) or was broader in scope than the mathematics teaching and learning process (e.g., justify funding of programs).

Table 11

Responses to the Purpose Section

Purpose	<i>n</i>	Percent
Ensure a common set of values in secondary mathematics teachers	6	100
Improve the performance of individual secondary mathematics teachers	6	100
Improve pre-service teacher preparation programs	6	100
Impact the value systems of children (e.g., motivation to learn)	6	100
Receive national accreditation or state program approval	3	50
Encourage teachers to seek NBPTS certification	3	50
Conduct research on teaching	5	83
Justify funding of programs	3	50
Select secondary mathematics teacher candidates	3	50
Demonstrate effectiveness of license or graduation decisions	3	50

Participants who were not nationally board certified were less likely to make a connection between this certification and the development and assessment of secondary mathematics teachers' dispositions toward problem solving. For example, Anna agreed that a dispositional component should be part of the teacher selection process, but she expressed reservations when making high stakes decisions regarding selection, graduation and licensure. Similarly, Cathy was less inclined to think the purpose underlying the system should include justification of program funding, selection of candidates and decisions about licensure and graduation. Both Cathy and Jane emphasized that, in order to include high stakes decision-making as an outcome of the assessment framework, a process that produces fair, valid and reliable data was critical. While Andrew acknowledged that some teachers have excellent attitudes and values, while others clearly do not, he emphasized the importance of developing a system that has a variety of valid and reliable assessments to ensure fair decisions about teachers.

Participants cited other purposes beyond those listed in Table 11. Jane, Andrew and Beth talked at length about the potential of the system to have a variety of purposes depending upon whether a teacher is in pre-service selection, preparation, graduation, or in-service/professional development phases of their careers. According to Beth, it could be helpful for individual teachers to see their scores during professional development experiences. This information could help teachers establish professional development goals based on their individual strengths and challenges. Andrew added that the system could identify teachers who have positive dispositions toward developing themselves in the future.

Use. This section of Worksheet 1.1 assisted participants in describing what will be done with the data collected. Table 12 provides a summary of participants' responses about the possible uses of data collected within a system designed to assess secondary mathematics teachers' dispositions toward problem solving.

Table 12

Responses about Using Data

Use	<i>n</i>	Percent
Advising or remediation only (low stakes)	6	100
Program improvement (low stakes)	5	83
Continuation in the profession (rehire – high stakes)	2	33
Entry into the profession (graduation and licensure – high stakes)	1	17

The majority of participants stated that the system could be used for a combination of low-stakes and high-stakes decisions. However, they hesitated to include high-stakes decisions as mandatory uses of the data collected without assurances that the assessments were fair, valid, and reliable. For example, Cathy and Andrew preferred not to deny entry to the profession to an aspiring teacher candidate even, if at first, she exhibited a negative attitude. They were inclined

to view entry and continuation decisions as potential uses, but with strong reservations, and only if the process was valid and reliable. All six participants preferred to use the data from the system to develop and support teachers rather than deny them entry or continuation in the profession. While Jane agreed with colleagues about developing and supporting teachers, she also insisted that if teacher candidates or practicing teachers do not aspire to remediate, they should not be granted entry into the profession or be counseled out of continuing in the profession.

Content. This section of Worksheet 1.1 assisted participants in defining what content would serve as the foundation of a system designed to assess secondary mathematics teachers' dispositions toward problem solving. Table 13 provides a summary of participants' responses to the possible core foundational content of the assessment design process.

Table 13

Responses to the Content Section

Content	<i>n</i>	Percent
Other national professional association standards (i.e, NCTM, CCSS-M)	6	100
NCTM NCATE (or CAEP) <i>Program Standards for Initial Preparation of Secondary Mathematics Teachers</i>	5	83
NBPTS <i>Adolescence and Young Adulthood Mathematics Standards for Teachers</i> (2001)	3	50
Other locally defined values	0	0
Other state, district, and school standards	0	0

Participants agreed that basing the content on values and standards defined at the state, district, local or school level would ultimately be unnecessary. Anna pointed out that using state-level standards could make sense, but employing a local component would not be productive since mathematics teaching and learning at the local level would be working within, and be guided by, a state-level system. All participants agreed that the content should rely

heavily on the mathematics content and processes described in the NCTM *Principles and Standards for School Mathematics* (PSSM) and the *Common Core State Standards for Mathematics* (CCSS-M). Beth, Jane and Cathy emphasized the importance of the *Standards for Mathematical Practice* when looking at problem-solving and dispositional indicators. Cathy added that “locally defined values are certainly important, but with the move to a national set of common values, this content is less important in the big scheme of assessing teachers’ dispositions toward problem solving.” Half of the teachers indicated that the NBPTS Mathematics Standards for Teachers should be included in the content of the assessment framework. The two NBPTS-certified participants (Jane and Beth) were not strong advocates for inclusion. Cathy, who supported inclusion of the NBPTS *Adolescence and Young Adulthood Mathematics Standards for Teachers*, was concerned that this set of standards would set beginning teachers up for failure in terms of meeting the standards for entry into the profession. Andrew asserted that any set of standards is values-based, and the assessment of these standards must be values-based. For him, the big question was “Who would be writing and conducting the assessments and interpreting the data?” Two-thirds of the participants indicated that assessing the content must extend beyond a simple checklist.

Propositions. This section of Worksheet 1.1 assisted participants in defining the values and beliefs that would drive a system designed to assess secondary mathematics teachers’ dispositions toward problem solving. Ideally, statements should describe which dispositions are critically important and must be assessed to ensure that secondary mathematics teachers will do what they are expected to do simply because they believe it to be important. Table 14 provides a summary of participants’ responses to the propositions section of Worksheet 1.1.

Table 14

Responses to the Propositions Section

Proposition	<i>n</i>	Percent
A positive disposition toward problem solving is critical to effective mathematics teaching.	6	100
National standards contribute to the identification of this disposition.	6	100
This disposition can be identified and measured.	6	100
Using appropriate theories of affective measurement, measures of this disposition can be developed based on the standards and values identified.	6	100
Teachers with high scores on affective measures of this disposition are likely to be better teachers who can have a higher impact on students' productive disposition toward problem solving.	4	67
Teachers with low scores on affective measures of this disposition are likely to be poorer teachers who may harm students' productive disposition toward problem solving.	4	67
Local missions and values contribute to the identification of this disposition.	3	50

Jane and Cathy asserted that it would be impossible to effectively teach mathematics without having positive dispositions toward problem solving. Andrew, Anna and Dumaine expressed some hesitation in their responses to whether or not dispositions can be identified and measured using appropriate theories of affective measurement. However, they ultimately agreed that dispositions are (1) identifiable and measurable, provided that assessments are valid and reliable, and (2) dispositions include beliefs, attitudes and patterns of behavior.

Fundamentally all participants agreed that a relationship between teachers' dispositions and students' dispositions existed. However, Anna and Dumaine only partially agreed that high (or low scores) on affective measures would indicate teacher quality and teacher impact on students' dispositions toward problem solving. Dumaine pointed out that the teaching and learning process is highly complex and that the role of the students in that process cannot be ignored. She added that higher measures would put teachers in the best position to be stronger,

but she did not know if the teacher alone would be able to address all aspects of the teaching and learning process. Anna voiced a similar sentiment, stating that she was not yet able to see how affective measures would be able to assess all dispositional components and their relationships to the teaching and learning process. In the end, Dumaine felt stronger about the efficacy of higher scores revealing more about teacher quality in comparison to what lower scores might reveal.

Context. This section of Worksheet 1.1 assisted in determining external factors that would either support or undermine the assessment of secondary mathematics teachers' dispositions toward problem solving. Table 15 provides a summary of participants' responses to the context section.

Table 15

Responses to the Context Section

Context	<i>n</i>	Percent
Faculty support level	6	100
Fiscal resources available	6	100
Personnel resources available	6	100
Time available	6	100
NCATE status	3	50

Participants identified additional external factors that could potentially help or hinder the assessment of secondary mathematics teachers' dispositions toward problem solving. A synopsis of each participant's response follows:

Jane. Jane cited confusion about the definition of *disposition* as a potential hindrance. More specifically, she was concerned about the lack of familiarity that mathematics teachers and mathematics teacher educators had with the NCATE/NCTM standards for secondary teacher preparation programs, especially the standards that include dispositional factors. She also cited

teacher candidates' willingness to reflect on their practices and adjust them as needed as either a help or a hindrance, depending upon whether they were willing to reflect or not.

Cathy. Cathy stated that she had seen all factors impact the development and implementation of a variety of processes during her tenure at the district and university levels. She emphasized that time was always an issue. For example, during an NCATE review year, the faculty was "stretched pretty thin" in terms of attending multiple meetings and authoring numerous reports. She elaborated that a process was needed that is "worth" implementing as measured by what faculty and teacher candidates gained from the process in relation to the amount of time and effort they had put into the process.

Anna. Anna commented that when faculty expressed concerns about a teacher candidate, it was usually about dispositions. Therefore, faculty needed to be supportive of assessing teacher candidates' dispositions. Anytime something programmatic was done at the university level, it became a workload issue. Workload issues do not always hinder implementation, but they could. If things are set up well for faculty, the influence of workload would not be strong. Yet in some settings, workload issues may have a stronger impact since faculty need time to do things in which they believe. These additional projects, as well as the timing of NCATE accreditation for the unit, could impact the implementation of the system.

Beth. Beth agreed that the level of faculty support, the availability of fiscal and personnel resources and the amount of dedicated time were important factors. However, she also believed that more important than any of these resources was whether or not individuals would make it a priority. While she agreed that fiscal constraints could be a factor, she asserted that people can be "pretty creative" with how to use resources. She also believed that teachers were on a developmental continuum and needed someone who understood this continuum and was able to help support them and move them along that continuum.

Andrew. Andrew's concerns focused on the practicality of developing and implementing an assessment framework. He reiterated that the system – and instruments within the system – were only as good as the person developing and implementing them. To support the development and implementation, qualified personnel who can ensure the process is valid and reliable will need to be identified, and these individuals will need to find the time on a single day, and especially over multiples days to do the job right. Finally, fiscal constraints were cited multiple times by Andrew, and he emphasized the possibility of potential bias that might result from particular perspectives of agencies that provided the fiscal support for the development and implementation of the system.

Dumaine. Dumaine's response focused on the word "support" which she interpreted in two distinct ways. She viewed support first and foremost in terms of faculty believing this was important and wanting to participate in the process. However, at the university level, another way of viewing support was in terms of how workloads were determined. Dumaine emphasized that, at the university level, faculty members' workloads are closely related to each of the five contextual factors listed in Table 15, as seen in the feasibility of fulltime faculty to be out in the schools working with teachers. How the faculty spends time was often determined by the availability of fiscal and personnel resources as well as how this time was divided among service, teaching and research responsibilities.

Worksheet 1.2

Worksheet 1.2 furthered the design process through establishing formal statements for the purpose, use, and content of a system for assessing secondary mathematics teachers' dispositions toward problem solving. Results are presented according to three central questions essential to the design process:

- **Purpose:** Why should secondary mathematics teacher educators assess secondary mathematics teachers' dispositions toward problem solving?
- **Use:** What decisions could be made with these data? How could educators use the results?
- **Content:** What will be assessed? Which standards will serve as the foundation for our assessment framework? (Wilkerson & Lang, 2007)

The following results are combinations of participants' responses to the three questions above and the relevant participants' responses collected through Worksheets 1.1 and 1.2. Aggregated data are presented to provide a holistic view of the carefully defined purpose and the use and content of a system designed to assess secondary mathematics teachers' dispositions toward problem solving.

Purpose. Five major purposes were agreed upon by the participants for inclusion in the design process. They were: (1) to ensure a common set of values in secondary mathematics teachers; (2) improve the performance of individual secondary mathematics teachers; (3) improve pre-service teacher preparation programs; (4) influence the value systems of children (e.g., motivation to learn); and (5) conduct research on teaching.

Specific to the design of a system to assess secondary mathematics teachers' dispositions toward problem solving, each participant indicated, to varying degrees, the importance of creating a system that allows for assessment, follow-up and improvement. Beth summarized this importance as follows:

An assessment framework will help both the teacher and teacher educator. There is a continuum that teachers are on, and this process serves as a tool for professional growth. It also has the potential to break down the components that define the disposition. This system will ultimately help teachers and teacher educators identify strengths and weaknesses.

Participants also agreed that measuring dispositions toward problem solving would help “get at” which vision of mathematics a particular teacher is trying to implement. According to four participants, a teacher’s beliefs, attitudes, and actions, can reveal this vision along with teachers’ dispositions. Andrew stated that it is important that teachers “do” problem solving well. Dumaine added that teachers simply cannot do as good a job if they are not thinking about problem solving in the “right” way, and this way includes how teachers’ dispositions influences their approaches to and thinking about problem solving.

Use. In terms of what decisions could be made with the data generated from a system designed to assess secondary mathematics teachers’ dispositions toward problem solving, two major uses were agreed upon by the participants. They reported using the results for advising and remediation of teachers and teacher candidates, along with program improvement. All participants emphasized low-stakes (over high-stakes) uses of the data. Participants’ responses also emphasized using the results for teacher development as summarized in Table 16.

Content. Two sets of national standards agreed upon by participants were used as a basis for the design process – the NCTM *Principles and Standards for School Mathematics* (PSSM) and the *Common Core State Standards for Mathematics* (CCSS-M). Four participants specifically referenced the eight *Standards for Mathematical Practice*. Beth emphasized that the eight practices were based on mathematics education research, stating that this is why she did not believe that local standards were as important since they were not always research-based. When asked specifically about the NCATE/NCTM *Program Standards for Initial Preparation of Secondary Mathematics Teachers*, five of the six participants agreed that these standards would be appropriate content to include in the design process, even though only half of them were familiar with this content.

Table 16

Importance of Using the Data for Teacher Development

Participant	Response
Jane	The data could be used to find how committed a teacher is to problem solving and to students' learning. The data could be used to exit teachers from the profession if they aren't committed, but there needs to be multiple data points to get at this fairly. I wouldn't want to say "no" if there is hope for the teacher to grow and demonstrate their commitment to students in measurable ways.
Cathy	The use of the data is where my greatest concern is. I wouldn't want data to be used only to make punitive decisions such as whether someone is allowed to become a teacher or not, or to keep working as a teacher or not. Someone could use the results in this way, provided the data and conclusions drawn are valid. I think the best use of the data would be to help faculty develop good math teachers. Sometimes it's hard to pinpoint what isn't working for a beginning teacher, especially when it comes to dispositional factors. A good system for measuring this could make improvement more likely when we have the data. I also think that could incorporate some of the instruments into a mathematics methods course easily and use the results to help my students grow and learn.
Anna	I think that in some sense you always want future teachers to develop from their strengths. I think that there are a lot of things that we want our candidates to do but we don't always want them to look identical. We want their individual strengths and passions to come through. I really work on helping students see things from multiple perspectives so that they are better positioned to meet their professional development needs. I just feel that has to be part of their values and beliefs. If you really do feel that all students can learn mathematics, then you can see this in your practice. The data could be used to help teachers find their strengths and weaknesses. Realizing that you have to respect their personal beliefs, but also that their perspectives might be narrow, from this data we could provide opportunities for teachers to expand their ideas and vision.
Beth	I'm going to reemphasize how a math teacher educator could use the data: to help teachers move and grow. It could be used to look at a program at the district, school or state level and see what is going well and how to improve the program. The data could also be used to determine what type of professional development is needed to improve programs and teacher growth in dispositions.
Andrew	The data could be used for professional development, which would be extremely appropriate. It could also be used to inform high stakes decisions about entry and exit. I have reservations the higher that the stakes are, and prefer to use it as a development tool, prior to a high stakes decision being made.
Dumaine	If we had a teacher candidate that had overall good disposition then I would use the data and instruments to help the candidate remediate in the area of, for example, mathematics or pedagogy or both. I would focus on using the data for remediation rather than helping the candidate find a new career.

Worksheet 1.3

Worksheet 1.3 assisted in establishing formal statements for the propositions that would guide the design of a system for assessing secondary mathematics teachers' dispositions toward problem solving. Participants were interviewed individually and asked the following central question: *What are the fundamental truths about teaching and assessing dispositions that will guide our thinking?* Four propositions surfaced as a result of aggregating the participants' responses to Worksheet 1.1 with the themes that emerged from responses to the prompt from Worksheet 1.3. They were:

- A positive disposition toward problem solving is critical to effective mathematics teaching.
- A positive disposition toward problem solving can be identified and measured.
- National standards contribute to the identification of a positive disposition toward problem solving.
- Measures of affect can be developed on the basis of the national standards identified.

Worksheet 1.4

Worksheet 1.4 served to provide a contextual analysis within which a system for assessing secondary mathematics teachers' dispositions toward problem solving could be built and used. Participants were interviewed individually and asked to respond to the following question: *What are the factors that will help or hinder implementation of the envisioned assessment framework?* Participants' responses from Worksheet 1.1 were combined with the themes that emerged from participants' responses to the prompt from Worksheet 1.4. Responses were categorized into three contextual factors to consider: structural, resources and

commitment (Wilkerson & Lang, 2007). Table 17 lists potential contextual factors that surfaced in participants' responses:

Table 17

Contextual Factors that Help or Hinder

Factor	Help	Hinder
Structural	<ul style="list-style-type: none"> • Using the system as a growth model for teachers and their professional learning • Teachers viewing the system as a useful tool • A political climate that values data-driven instruction and decision making 	<ul style="list-style-type: none"> • Using the system for teacher evaluation in a punitive manner • Teachers viewing the system as an imposition • A political climate where teachers, administrators and community members disagree about what is "best" or should be "valued"
Resources	<ul style="list-style-type: none"> • Trained faculty and district personnel to assess • Trained psychometricians to develop instrumentation, especially when data is used for high stakes decisions 	<ul style="list-style-type: none"> • Untrained or biased assessors • Poor instrumentation that produces unfair, invalid and/or unreliable data
Commitment	<ul style="list-style-type: none"> • Willingness of faculty, district personnel, and teachers to dedicate the time required to use the system as intended • Willingness to make decisions based on the data 	<ul style="list-style-type: none"> • Lack of faculty, district personnel and/or teacher buy-in (i.e., not valuing the system enough to take the time to use it)

Political climate was cited by three of the six participants as a contextual factor that could either help or hinder the structure and implementation of the system. Andrew framed the impact of the political climate as follows:

In general, education is moving toward data-driven instruction and decision-making. This assessment framework would be helpful in regards to this. The political climate will help implementation of this assessment framework. The political climate can also hinder the implementation of this system. An example would be a colleague who recently gave me a flyer about a group of people who are organizing against the common core. Many educators strongly support the CCSS-M and, having been through the math wars I have

experienced the debate over how and what is taught and how values inform this debate. People who are involved in the profession disagree with what is "best" or what should be "valued." There is also the community aspect and what they believe should be happening in the classroom. This is a constant battle, involving multiple perspectives from individuals, which is a concern.

Participants' Consensus on the Assessment Design Inputs

During DAATS Step 1, participants came to consensus on the purpose, use, propositions, and content of an assessment system designed to measure secondary mathematics teachers' dispositions toward problem solving. Figure 3 provides a summary of the major agreements of the six participants during the first step of the DAATS model. Contextual factors were not included in this figure as consensus was not achieved since participants were working in a variety of contexts (see Table 17 for participants' responses to factors that help or hinder their contexts).

Figure 3. Participants' Consensus on the Assessment Design Inputs

Assessment Design Inputs	Participants' Agreements on Assessment Design Inputs
Purpose	<ul style="list-style-type: none"> • Ensure a common set of values in secondary mathematics teachers • Improve the performance of individual secondary mathematics teachers • Improve pre-service teacher preparation programs • Impact the value systems of children (e.g., motivation to learn)
Use	<ul style="list-style-type: none"> • Advising or remediation only (low stakes) • Program improvement (low stakes)
Propositions	<ul style="list-style-type: none"> • A positive disposition toward problem solving is critical to effective mathematics teaching. • This disposition can be identified and measured. • National standards contribute to the identification of this disposition. • Using appropriate theories of affective measurement, measures of this disposition can be developed based on the standards and values identified.
Content	<ul style="list-style-type: none"> • <i>Common Core State Standards for Mathematics (CCSS-M)</i> • <i>NCTM Principles and Standards for School Mathematics</i> • <i>NCTM NCATE (or CAEP) Program Standards for Initial Preparation of Secondary Mathematics Teachers</i>

Results of DAATS Step 2

The purpose of the second step in this study was to develop indicators of secondary mathematics teachers' positive dispositions toward problem solving. This step began with an analysis and synthesis of the two sets of national standards that were identified by participants during the first step of the study. Additional sets of national standards, identified by the researcher during the review of the standards on secondary mathematics teachers' dispositions toward problem solving, were juxtaposed with those identified by participants. As a result of this process, two broad standards emerged:

1. Effective teachers know and understand the importance of problem solving and demonstrate positive dispositions toward problem solving.
2. Effective teachers of secondary mathematics verify (i.e., provide evidence) that secondary students demonstrate productive dispositions toward mathematics.

The two standards and elaborative descriptions for each are listed in Appendix B, along with an alignment to the sets of national standards reviewed by the researcher. Using these two broad standards, the researcher generated versions of Worksheet 2.2 and the Affective Domain taxonomic levels worksheets (see Appendix A) designed to elicit from participants a set of behaviors that would indicate teachers' positive (or negative) dispositions toward problem solving. The Affective Domain taxonomic levels worksheets were designed to elicit descriptions of what teachers "look like" along the Krathwohl and Bloom (1956) affective continuum (i.e., *receiving, responding, valuing, organization, and characterization*) combined with the *unaware* level added for assessment purposes (Wilkerson, 2012). A sample participant response for a single elaborative description is provided in Appendix C.

Worksheet 2.2

The qualitative analysis and coding process for Worksheet 2.2 and the Affective Domain taxonomic levels worksheets began by reading through the data from all six participants to obtain a general sense of the overall meaning of participants' responses. This reading provided an overall impression of the depth, credibility and use of the information provided by participants. The detailed analysis and coding of the data from Worksheet 2.2 was divided into two categories of teacher behavior. The first category was teacher behavior indicating positive dispositions toward problem solving. The second category was teacher behavior indicating positive dispositions toward problem solving were "missing." Spreadsheet software was employed to organize the material for both categories and for each of the six taxonomic levels to generate indicators that were based in the actual language of the participants. The researcher used a combination of codes predetermined through a review of the standards along with codes that emerged during the first step of the study and from participants' responses.

Indicators of positive dispositions. Table 18 contains a list of predetermined and emergent codes with their respective frequencies in data collected through Worksheet 2.2. After the participants' responses were coded, the list was re-examined to ensure that no additional codes were needed. Participants' responses were re-coded to confirm the frequency count for each code. This process ensured that the count accurately represented the number of participants describing teaching behaviors as indicative of positive dispositions toward problem solving falling within each code.

Table 18

Codes Used and Frequency for Positive Dispositions toward Problem Solving

Code	Frequency
Encouraging a variety of student responses (G2)	6
Solving worthwhile mathematical tasks (e.g., open-ended) (G1)	6
Using a variety of tools (other than technology) (G4)	6
Individualizing problem solving instruction (G3)	5
Providing a risk-free problem-solving environment (G3)	5
Teaching “through” problem solving (as opposed to “for” or “about” it)	5
Using a variety of strategies (G1, G2)	5
Using technology (G4)	5
Appreciating mathematical rigor (G1)	4
Building new math knowledge (G1)	4
Monitoring and reflecting (G2)	4
Students’ disposition (i.e., productive traits such as confidence, interest, enjoyment, and perseverance) (G5)	4
Reasoning about mathematics (G2)	3
Using a variety of assessments (G2, G5)	3
Using a variety of mathematical representations (G2)	3
Appreciating mathematical inquiry (G1, G2)	2
Attending to developmental needs of students (G3, G5)	2
Constructing mathematical arguments	2
Evaluating mathematical arguments (G2)	1

Note. G1 = teacher values worthwhile mathematically rigorous problem solving; G2 = teacher values diversity of students’ explanations, ideas, and observations about mathematical problems; G3 = teacher values a risk-free problem-solving environment that encourages all students; G4 = teacher values a variety of tools, including technology, to solve problems; G5 = teacher believes that all students must develop a productive disposition toward problem solving

Participants' responses were reviewed a final time to reveal interrelationships among teaching behaviors and to identify general overarching indicators of secondary mathematics teachers' positive dispositions toward problem solving. Five general indicators surfaced:

1. The teacher values worthwhile and mathematically rigorous problem solving.
2. The teacher values diversity of students' explanations, ideas and observations about mathematical problems.
3. The teacher values a risk-free problem-solving environment that ensures success of all students.
4. The teacher values the use of a variety of tools including technology to solve problems.
5. The teacher believes that all students must demonstrate a productive disposition toward problem solving (i.e., confidence, interest, appreciation, enjoyment, and perseverance).

The data were recoded to ensure that any teaching behavior described by three or more participants would "fit" within the scope of the general indicators. Teaching behaviors that one would expect to find (based on the standards) along with unanticipated and unusual responses easily fit within the five general indicators. Table 19 summarizes the general and specific indicators drawn from the combined review of the standards and analysis of participants' responses.

Table 19

Indicators of Positive Dispositions toward Problem Solving

General Indicator(s)	Specific Indicator(s)
1. The teacher values worthwhile mathematically rigorous problem solving.	<p>As part of teaching through problem solving, the teacher:</p> <ul style="list-style-type: none"> 1.1 Values open-ended problems that have multiple and/or unclear paths to a solution. 1.2 Values purposeful problems that encourage students to apply specific mathematical content and processes to other subjects and in real-world contexts. 1.3 Values problems that highlight a variety of problem solving strategies. 1.4 Values problems that require students to build new mathematics knowledge through problem solving. 1.5 Values cognitively demanding tasks that stretch students. 1.6 Believes that ample class time must be dedicated to student solution and discussion of problems.
2. The teacher values diversity of students' explanations, ideas and observations about mathematical problems.	<p>As part of teaching through problem solving, the teacher:</p> <ul style="list-style-type: none"> 2.1 Believes all students have unique ways of expressing their mathematical thinking and reasoning. 2.2 Values both written and verbal explanations of reasoning. 2.3 Values a variety of problem-solving strategies, including solution paths that vary from what was taught in class. 2.4 Values use of various representations, highlighting them whenever possible. 2.5 Values varying opinions and different ways of thinking.
3. The teacher values a risk-free problem-solving environment that encourages all students.	<p>As part of teaching through problem solving, the teacher:</p> <ul style="list-style-type: none"> 3.1 Values respectful discourse. 3.2 Values an environment where students are problem-solving authorities. 3.3 Believes all students' comments are valuable. 3.4 Believes students learn through their mistakes. 3.5 Is committed to individualized instructional support to ensure success of all students. 3.6 Believes every student is capable of solving rigorous mathematical problems.

4. The teacher values a variety of tools, including technology, to solve problems.	As part of teaching through problem solving, the teacher: 4.1 Values using a variety of tools to solve problems. 4.2 Is committed to providing tools to students at all times. 4.3 Is committed to discovering new tools (or novel uses of traditional tools) to solve problems.
5. The teacher believes that all students must develop productive dispositions toward problem solving (i.e., confidence, interest, appreciation, enjoyment, and perseverance).	As part of teaching through problem solving, the teacher: 5.1 Values problem-solving experiences that support the development of positive dispositions in students. 5.2 Attends to students' dispositions in the planning and delivery of instruction. 5.3 Values feedback given to students that fosters a productive disposition (i.e., commitment, perseverance, confidence). 5.4 Values a variety of assessments to measure student disposition (e.g., observations, interviews, exit slips, journal writing, and self-assessments). 5.5. Believes challenging tasks motivate students.

Indicators of negative dispositions. Table 20 contains a list of predetermined and emergent codes with their respective frequencies in data collected through Worksheet 2.2. After the participants' responses had been coded, the list was re-examined to ensure that no additional codes were needed. Participants' responses were re-coded to confirm that the frequency count accurately represented the number of participants who described a teaching behavior indicative of negative (or missing) dispositions toward problem solving that fell within each code. The primary purpose of this study was to develop and validate indicators of secondary mathematics teachers' positive dispositions toward problem solving. As a result, indicators of negative (or missing) dispositions were not explored in detail in this study. However, these dispositions could theoretically be deduced from participants' responses to Worksheet 2.2 and participants' descriptions of teaching behaviors at the *unaware* level on the Affective Domain taxonomic levels worksheets.

Table 20

Codes Used and Frequency for Negative Dispositions toward Problem Solving

Code	Frequency
Discouraging a variety of mathematical representations (G2)	6
Discouraging a variety of strategies (G1, G2)	6
Discouraging a variety of student responses (G2)	6
Omitting worthwhile mathematical tasks (e.g., open-ended) (G1)	6
Discouraging use of a variety of tools (other than technology) (G3)	5
Ignoring students' disposition (i.e., productive traits such as confidence, interest, enjoyment, and perseverance) (G4)	5
Teaching "about" or "for" problem solving (as opposed to "through") (G1-G4)	5
Devaluing reasoning about mathematics (G1, G2)	3
Discouraging use of technology (G3)	3
Disregarding mathematical rigor (G1)	3
Devaluing mathematical arguments (G2)	2
Discouraging a risk-free problem-solving environment (G2)	2
Discouraging monitoring and reflecting (G2)	2
Excluding a variety of assessments (G2, G4)	2
Refusing to individualize problem-solving instruction (G2)	2

Note. G1 = teacher omits worthwhile and mathematically rigorous problem solving; G2 = teacher discourages diversity of students' explanations, ideas and observations about mathematical problems; G3 = teacher discourages the use of a variety of tools, including technology, to solve problems; G4 = teacher ignores students' disposition toward problem solving in the planning and delivery of instruction

Participants' responses were reviewed a final time to show interrelationships between teaching behaviors and identify general overarching traits that indicate secondary mathematics teachers who are missing positive dispositions toward problem solving. Four general indicators emerged:

1. The teacher omits worthwhile and mathematically rigorous problem solving.
2. The teacher discourages diversity of students' explanations, ideas and observations about mathematical problems.

3. The teacher discourages the use of a variety of tools, including technology, to solve problems.
4. The teacher ignores students' dispositions toward problem solving in the planning and delivery of instruction.

In order to ensure fidelity to the DAATS model, the data drawn from Worksheet 2.2 about negative (or missing) dispositions in Worksheet 2.2 were included in the results of DAATS Step 2 and in refining the typical teaching behaviors at the *unaware* levels (see Figures 4 through 8) for the five general indicators of secondary mathematics teachers' positive dispositions toward problem solving (see Table 19). Chapter V includes a discussion of potential uses of these data in addressing the overall goal of the study: to provide an assessment framework for measuring secondary mathematics teachers' dispositions toward problem solving.

Affective Taxonomic Levels

The data for the six levels of the affective taxonomy (i.e., *unaware*, *receiving*, *responding*, *valuing*, *organization*, and *characterization*) were analyzed individually and collectively to obtain a descriptive sense of teaching behaviors at varying levels of the taxonomy. A second more detailed analysis of the data revealed five, emergent categories used in the coding process. Categories of teacher behavior identified from participants' responses were a (a) teacher's approach to problem-solving instruction, (b) teacher's approach to problem selection, (c) teacher's approach to students, (d) teacher's approach to problem-solving assessment, and (e) teacher's approach to professionalism. Participants' responses for each of the six levels were then re-examined to ensure that no additional categories were needed. Appendix D provides tables with descriptions of typical teaching behaviors for the six affective taxonomic levels. Each table lists specific teaching behaviors categorized by four of the five emergent codes (i.e., approach to problem-solving instruction, approach to problem selection,

approach to students and approach to problem-solving assessment). Behaviors and teacher characteristics falling within the fifth category, professionalism, are discussed following the presentation of the results for the six Affective Domain taxonomic levels.

Unaware level. In the original Affective Domain taxonomy, Krathwohl and Bloom (1956) defined five categories useful in describing affective characteristics of individuals: *receiving*, *responding*, *valuing*, *organizing*, and *characterizing*. As a result of more recent research on measurement and evaluation of teachers' dispositions, a sixth category (i.e., *unaware*) was added at the base of the taxonomy for assessment purposes (Wilkerson, 2012). This level emerged out of the necessity to describe teachers who are not yet at the *receiving* level. These teachers have not considered a particular skill in any meaningful way or may actually be opposed to the skill.

Participants' responses in describing a teacher at the *unaware* level revealed usage of strong verbs (e.g., opposed, diffident). Table 21 lists phrases used by at least two participants in their descriptions of a secondary mathematics teacher at the *unaware* level.

Table 21

Phrases Used to Describe Teachers at the Unaware Level

Descriptive Phrase	<i>n</i>	Percent
Discourages	6	100
Opposed to	5	83
Lacks self-confidence	4	67
Does not see the need for	3	50
Punishes students	3	50
Belittles students	2	33
Diffident or indifferent	2	33
Does not venture into	2	33
Has limited knowledge or understanding	2	33

In their response to the *unaware* level, participants provided distinctive descriptions of secondary mathematics teachers' dispositions toward problem solving. Table 22 highlights excerpts from participants' descriptions of teachers who are at the *unaware* level.

Table 22

Descriptions of Teachers' Dispositions at the Unaware Level

Participant	Response
Jane	This teacher lacks confidence in her own problem-solving abilities. The teacher might not be aware of the names of different problem-solving strategies like "guess and check" or "look for a pattern." The teacher may be unaware that math can be taught through problem solving.
Cathy	The teacher has not considered student affect and how it impacts performance in class. She only assesses mathematical content and probably in limited ways with problems requiring low cognitive demand or with only one right answer.
Anna	Even if the teacher has a more problem-solving approach textbook, she won't recognize the instructional approach presented in the textbook. The teaching will be teacher-centered all of the time. The teacher is neither asking for student input nor for students to lead the class. The teacher would be in control of doing the thinking rather than encouraging the student to do the thinking.
Beth	There could be a disposition or attitude that it is a waste of time to have students monitor and reflect on the problem-solving process. The teacher may even believe that specific tools are harmful for students.
Andrew	The teacher views the class as a "gateway" where the most capable survive and move on to the next class, and those who really aren't prepared for this level of rigor fail and must retake the class. She may actively seek to discourage some students. The teacher believes her role is to deliver the prescribed curriculum. The teacher may express negative opinions to "touchy-feely" considerations in the classroom. The teacher may even be diffident to the emotional side of adolescence.
Dumaine	This type of teacher does not value mathematics. It is possible that this person demonstrated excellent mathematics skills throughout life. However, they do not show the beauty of mathematics through their teaching. Their students view mathematics as something that they have to learn. This teacher does not recognize the impact of motivating statements on students asking questions after making an error in solving a problem.

Receiving level. In the Affective Domain taxonomy, Krathwohl and Bloom (1956) defined the lowest level as *receiving*. This level refers to a simple awareness and willingness to attend to a particular phenomenon. A teacher at the *receiving* level may have considered or become aware of a particular phenomenon, without taking any actions requiring more than listening and remembering.

Participants' responses in describing a teacher at the *receiving* level revealed verbs indicating uncertainty and basic attempts on the part of the teacher. Table 23 lists phrases that were used by two or more participants in their descriptions of a secondary mathematics teacher at the *receiving* level.

Table 23

Phrases Used to Describe Teachers at the Receiving Level

Descriptive Phrase	<i>n</i>	Percent
Has seen or read about	6	100
Articulates (or is able to tell others about)	5	83
Aware (or considers)	5	83
Listens	5	83
Unsure (or is uncertain/uncomfortable)	5	83
Doesn't know how	4	100
Shows interest in (or is excited about)	4	67
Gets lost	3	50

In their response to the *receiving* level, participants provided distinctive descriptions of secondary mathematics teachers' dispositions toward problem solving. Table 24 highlights excerpts from participants' descriptions of teachers who are at the *receiving* level.

Table 24

Descriptions of Teachers' Dispositions at the Receiving Level

Participant	Response
Jane	This teacher might state the name of specific strategies she uses to solve a problem and is pleased when students use strategies, but may not explicitly require them. This teacher is beginning to regard students' problem-solving skills and dispositions toward math as important, but may not know how to develop these. Minimally this teacher is respectful of and willing to listen to colleagues' ideas about problem solving and is certainly open to discussion, but may not have the skills yet to create a rich environment that promotes teaching through problem solving. This teacher can probably teach directly about problem solving though.
Cathy	If problem solving is in the textbook, then a teacher at the receiving level will teach it, but probably just as it is laid out in print, nothing more nothing less. There would be little, if any, effort put into seeking supplemental materials or resources. Assessment of student growth in problem solving would be minimal, if at all.
Anna	This teacher is aware of the idea of using purposeful open-ended problems but doesn't know of a resource for finding problems for classroom use. At this level, you wouldn't see anything different in their classroom. I think this might be some of the uncertainty of being able to do this. This teacher has read about problem solving or saw it at a conference but isn't comfortable enough to try it. Through professional development (reading, in-services, conference attendance), the teacher may have learned about mathematical dispositions and the role they play in the learning and teaching process. The awareness has not led to action due to either being unsure how to implement ideas in the classroom or due to being given ideas but lacking confidence that the ideas will work with their students.
Beth	The teacher starts asking questions from colleagues who know how to do this or who are "more developed" along the continuum. The teacher starts looking for resources on how to get students to reflect on their process. The teacher asks for responses from students although it might still be at a very low level in terms of cognitive demand. For example, the teacher may have students write the problem in numerical format without writing any of their thinking down. Even if it is a verbal response, there won't be any probing of students' thinking, and the teacher will accept the students' attempts without going deeper.
Andrew	The teacher is aware that the affective domain may play some role in success in mathematics. He is starting to view the teacher's role in the classroom as something more than providing instruction in the curriculum. He may express sympathy for students who are struggling.
Dumaine	I think of a new teacher for this level of the taxonomy. The teacher at this level is aware of importance of problem solving but does not know how to implement it. This teacher might include problem-solving information in lesson plans and begins the lesson by trying to teach content through a problem-solving context. Unfortunately, the teacher "gets lost" in teaching the content in this manner and retreats to a procedural approach.

Responding level. In the Affective Domain taxonomy, Krathwohl and Bloom (1956) defined the second level as *responding*, or actively participating. This level goes beyond simply attending to a particular phenomenon and refers to a teacher's willingness to respond. The teacher at the higher levels of this category is interested in the phenomenon and seeks out opportunities and activities related to the phenomenon.

Participants' responses in describing a teacher at the *responding* level revealed active verbs (e.g., directs, encourages). Table 25 lists phrases that were used by two or more participants in their descriptions of a secondary mathematics teacher at the *responding* level.

Table 25

Phrases Used to Describe Teachers at the Responding Level

Descriptive Phrase	<i>n</i>	Percent
Encourages (through direction and modeling)	5	83
Is comfortable (or more certain)	5	83
Provides (or selects/uses)	5	83
Values (or recognizes as important)	5	83
Devotes (or commits)	4	67
Is aware	4	67
Participates, actively	4	67
Experiments	3	50
Hopes	2	33

In their response to the *responding* level, participants provided distinctive descriptions of secondary mathematics teachers' dispositions toward problem solving. Table 26 highlights excerpts from participants' descriptions of teachers who are at the *responding* level.

The phrases highlighted in bold are discussed in Chapter V in relation to the difficulty of differentiating between the taxonomic levels, particularly neighboring levels in the middle of the continuum (i.e., *responding/valuing* and *valuing/organization*).

Table 26

Descriptions of Teachers' Dispositions at the Responding Level

Participant	Response
Jane	A teacher at this level is different from one at the receiving level by willingly complying and wanting success with teaching problem solving in the classroom with students. This teacher is beginning to recognize that there is more to teaching math than "just the facts." She knows that her role in the classroom goes beyond this, even if she not yet able to do it "right."
Cathy	This teacher actively participates in professional discussions around problem solving. She might take a familiar concept, one that she already knows and understands, and try a problem-solving approach with this topic. She would teach this way, through problem solving, simply because she is interested in the topic and enjoys problem solving .
Anna	With respect to the problem-solving process, the teacher is not as comfortable with letting the students lead the process. They will sometimes do so much scaffolding that the problem-solving process is minimized. The teacher will model problem solving and encourage students to follow their example. Sometimes the teacher may encourage the use of multiple representations only to be sure that the symbolic approach is used. Collectively, the teacher is controlling more of the problem-solving and communication process than they need to.
Beth	The teacher at this level observes students' dispositions while performing tasks and notices positive and negative student responses to these tasks.
Andrew	The teacher recognizes that there is a severe drop-off problem as students progress through levels of mathematics and wishes to contribute to reducing the problem . He decides to be aware of the students' dispositions towards mathematics and actively monitor the students' dispositions . He may believe that there is a linkage between students' disposition towards mathematics and their academic achievement.
Dumaine	The teacher is sufficiently trained in various motivational teaching methods and techniques . However, this is a new method for a teacher, regardless of the amount of teaching experience in years. She could begin a school year with the intent on using a problem-solving teaching method consistently. However, it is difficult and she would probably reduce the frequency of its use. I think she will decide to take a simple concept that she already understand and use inquiry with that topic. She would probably not put forth the effort to learn how to use inquiry with a topic she doesn't already understand well. Problem solving is still not the real deal but she is starting it. If the student asks a really good question or the use of a topic, the teacher might stumble with this and not be able to give an answer.

Valuing level. In the Affective Domain taxonomy, Krathwohl and Bloom (1956) defined the third level as *valuing*, or accepting the worth of a phenomenon. This level goes beyond simply responding to a particular phenomenon and refers to a teacher's commitment to consistently respond. Teachers at the higher levels of this category exhibit behaviors that are stable enough to make their values clearly identifiable.

Participants' responses when describing a teacher at the *valuing* level revealed use of adverbs such as routinely and consistently. Table 27 lists phrases that were used by four or more participants in their descriptions of a secondary mathematics teacher at the *valuing* level. There were no phrases used by less than four participants in describing teaching behavior at this level.

Table 27

Phrases Used to Describe Teachers at the Valuing Level

Descriptive Phrase	<i>n</i>	Percent
Encourages	6	100
Commits or devotes	5	83
Routinely assesses	5	83
Values	5	83
Actively seeks out	4	67
Consistently teaches	4	67
Consistently uses/models/teaches	4	67
Requires	4	67
Routinely plans	4	67
Routinely provides/presents/includes	4	67

In their response to the *valuing* level, participants provided distinctive descriptions of secondary mathematics teachers' dispositions toward problem solving. Table 28 highlights excerpts from participants' descriptions of teachers who are at the *valuing* level. The phrases highlighted in bold are discussed in Chapter V in relation to the difficulty of differentiating between the

taxonomic levels, particularly neighboring levels in the middle of the continuum (i.e., *responding/valuing* and *valuing/organization*).

Table 28

Descriptions of Teachers' Disposition at the Valuing Level

Participant	Response
Jane	The teacher accepts the worth of building new mathematical knowledge through problem solving and even prefers problems that encourage construction of knowledge in the place of routine exercises that do not. If a teacher really values problem solving and accepts its worth, then it is at this point that the teacher begins to wonder if she is reaching all students and whether teaching through problem solving is of value for all. It becomes less mechanical at this stage, and the level of fluency changes for teacher and student.
Cathy	This teacher values problem solving enough to use it consistently , especially when she is comfortable with the content or approach used. Teachers at this level are probably most comfortable with aspects of problem solving they have experience with or have immediate access to, such as technology and tools that are already available in school. They are committed to including problem solving in the classroom but may not take additional time to consistently seek out new methods.
Anna	A teacher at this level will behave similarly to a teacher at the organization level but just less often . I don't see a big difference between these two levels. Teachers at both levels value the problem-solving process and want to see students do this. Although there is some uncertainty at this level. Students will have an opportunity to lead but it is in a little more of a controlled setting than what is at the organization level . The teacher may not see the relationships between all of the parts of the problem-solving process.
Andrew	The teacher accepts his role in the classroom to include engendering more positive dispositions towards mathematics in his students. He recognizes the role small group work can have in providing academic, social-development and emotional support for adolescents. He creates an environment where students are able to talk to one another about mathematics and tolerates their diversions into other topics . He looks for ways to structure small group or whole class discussions that may go beyond symbol manipulation in mathematics.
Dumaine	This teacher has a great time every day at work! She has a passion toward mathematics, teaching, and teaching mathematics. This teacher understands how to create worthwhile lessons using problem solving as a way of teaching mathematics and how to respond to student questions without telling them the process and result. Her questioning skills are good, and she uses clarifying questions to help students develop the necessary mathematics skills to complete tasks . Students are able to help one another in this classroom. However, this teacher has some problems fully implementing problem solving.

Beth's description of teachers' dispositions at the *valuing* level provides a description of teachers' dispositions at the upper echelon of the *valuing* level, one that may be more consistent with a teacher at the *organization* level:

I also see valuing as a real cut-off point between a teacher at the responding level and one who values the process. There is a real change in a teacher and how she approaches the process of monitoring and reflection when she moves from responding to valuing. The monitoring and reflection that is going on in the classroom is part of the class routines. On a certain day if there is some monitoring and reflection going on, it will be revisited and shared in the community. The teacher might say "Remember yesterday when Student A or Student C said or did this . . ." It begins to become more of the larger mathematical community. There is evidence that it is a continual process rather than an isolated event. The teacher goes back and connects what students are currently doing to past experiences in order to move forward on current mathematical endeavors. What they are doing as a group becomes a part of the community's math knowledge. The community creates new resources that can be used in the future.

Beth's description is revisited in Chapter V when discussing the difficulty of differentiating between the taxonomic levels, particularly neighboring levels in the middle of the continuum (e.g., *valuing/organization*).

Organization level. In the Affective Domain taxonomy, Krathwohl and Bloom (1956) defined the fourth level as *organization*, or adapting behavior to build an internally consistent value system. This level goes beyond simply valuing a particular phenomenon and refers to a teacher's commitment to develop an organized plan to implement a value system. Teachers at the higher levels of this category accept professional standards and prioritize time to integrate and enact these standards in the classroom.

Participants' responses when describing a teacher at the *organization* level revealed a combination of strong adverbs and verbs (i.e., routinely encourages, consistently uses). Table 29 lists phrases that were used by four or more participants in their descriptions of a secondary

mathematics teacher at the *organization* level. There were no phrases used by less than four participants in describing teaching behavior at this level.

Table 29

Phrases Used to Describe Teachers at the Organization Level

Descriptive Phrase	<i>n</i>	Percent
Consistently uses/models/provides	6	100
Routinely encourages all students	6	100
Commits or devotes	5	83
Creates/establishes	5	83
Expects all students	5	83
Routinely plans	5	83
Routinely questions/solicits	5	83
Adapts	4	67
Consistently teaches/introduces	4	67
Expects most (or all) students	4	67
Formally assesses	4	67
Purposefully (or deliberately) selects	4	67
Seeks out	4	67

In their response to the *organization* level, participants provided distinctive descriptions of secondary mathematics teachers' dispositions toward problem solving. Table 30 highlights excerpts from participants' descriptions of teachers who are at the *organization* level.

Table 30

Descriptions of Teachers' Dispositions at the Organization Level

Participant	Response
Jane	This teacher plans lessons and organizes class time to ensure students have an opportunity to learn through problem solving. She would be seen as a leader in the school, and maybe even at the state level, presenting at conferences to promote a problem-solving approach. She would work collaboratively with other math teachers through lesson study, professional development or co-planning.

Cathy	This teacher would begin to advocate for problem solving and might even plan problem-solving tasks and assessments with colleagues. I think this teacher would be keenly aware that disposition matters and would take the time to examine disposition in students. Students would be expected to reflect on their work, their dispositions and provide feedback to the teacher on which tasks were challenging and how a particular task might be improved.
Anna	The teacher has established a mathematically-rich, risk-free environment, as described in the characterization level, but it is not as pervasive. The teacher more naturally focuses on the mathematics content in the teaching and learning process (instruction and assessment), but with intense planning, can incorporate mathematical dispositions. As part of this process, the teacher focuses on determining how a task effects students' mathematical disposition. At this level, the teacher would only focus on <i>certain</i> tasks; at the characterization level, the teacher would focus on <i>all</i> tasks.
Beth	I think that there would be classroom routines where the students would monitor and reflect daily. The classroom routine might include an "opening pass" that requires students to reflect on what they did the day before. Students would work in math journals where they would respond to questions. The routines are so well known to both teacher and students that the students would automatically do reflection without being prompted. There is less control exerted from the teacher, and the class is student driven. This can be seen in all aspects whether the students are working individually, in pairs or in groups. The students are questioning each other about how they are approaching the problem. I think that the task the teacher gives students, whether an engagement or assessment task, will consistently include monitoring and reflecting.
Andrew	The teacher considers developing confidence with mathematics as a major function of his instruction. The teacher plans for activities that address a variety of learning styles and can be approached using a variety of skills and strategies. The teacher organizes problems in a logical fashion in order to demonstrate the underlying methods of representation. He puts effort into finding problems that fit a multiple-representation format and may also write and design such problems. Student work showing translations of representations is encouraged.
Dumaine	The teacher not only uses the techniques necessary to encourage students to use problem solving to complete worthwhile tasks, but the teacher has become a leader in the school to promote this type of teaching. The students are achieving beyond all expectations and, more importantly, the students are talking about using their problem-solving skills outside the classroom. They find that problem solving helps them think more efficiently when completing worthwhile mathematics tasks. The teacher really has to go through receiving, responding and valuing to get here. Both the teacher and the students have to have gone through the stages. The teacher will finish the lesson when everyone understands the purpose of the lesson, making it relevant to students so the lesson just flows. The teacher uses a "run and gun" approach where, if you start it, you have to finish it, rather than begin again the next day.

Characterization level. In the Affective Domain taxonomy, Krathwohl and Bloom (1956) defined the highest level as *characterization*, or behaving according to a value system in a consistent and predictable manner. A teacher at this level is entirely self-reliant and independent and displays a commitment to professional standards on a daily basis.

Participants' responses when describing a teacher at the *characterization* level also revealed a combination of strong adverbs and verbs (i.e., explicitly requires, intentionally uses). Table 31 lists phrases that were used by four or more participants in their descriptions of a secondary mathematics teacher at the *characterization* level. There were no phrases used by less than four participants in describing teaching behavior at this level.

Table 31

Phrases Used to Describe Teachers at the Characterization Level

Descriptive Phrase	<i>n</i>	Percent
Expects	6	100
Explicitly encourages all students	6	100
Consistently teaches/introduces	5	83
Ensures	5	83
Explicitly requires	5	83
Designs	4	83
Devotes or commits	4	67
Intentionally uses/models/provides	4	67
Naturally thinks about	4	67
Prioritizes	4	67
Seeks out or selects	4	67

In their response to the *characterization* level, participants provided distinctive descriptions of secondary mathematics teachers' dispositions toward problem solving. Table 32 highlights excerpts from participants' descriptions of teachers who are at the *characterization* level.

Table 32

Descriptions of Teacher Dispositions at the Characterization Level

Participant	Response
Jane	A teacher at this level teaches more than using problem-solving strategies. Students are encouraged to share ideas, explain their reasoning and evaluate the mathematical arguments of others. The teacher may still need to model the problem-solving process, but this will come across more fluid and natural to students. Students will see themselves as being able to do this naturally.
Cathy	This classroom would have students asking for things they need to solve a problem or accomplish the task at hand. And the teacher would encourage the students to ask for and use mathematical tools and resources. The teacher might also be a bit pushy, in the sense that she would challenge students to go beyond their skills, even if students are uncomfortable. She would be at ease with this since stretching students is what has to happen.
Anna	I would see a classroom in which the teacher has established a risk-free environment where students are encouraged to try and share and build off each other. The teacher is a facilitator and would be comfortable with lots of different ideas thrown around. As the class comes up with new knowledge, we might call it "Tara's Theorem" or "Jon's theorem." It's displaying the attitude that all students can do this. If it doesn't work then we learn from it. This indicator means that the student sharing of ideas goes beyond uses of strategies. The teacher encourages and expects students to explain their reasoning, construct arguments that can be presented to others, and in the process students will evaluate each other's arguments.
Beth	The cognitive demand will be more rigorous because the teacher is more comfortable with monitoring and reflection. I think that at this level in the classroom you are going to have the teacher reflecting personally on the math problem solving that is going on in the classroom. The teacher might be journaling and setting goals around the students and their reflection process. You might see portfolios where the students have to show their reflection process and growth in problem solving. I think, as a teacher introduces a concept, it would be through a problem-solving approach where students are thrown into a situation that is new and they would struggle and realize that they needed a "piece" of math that they don't yet have. The teacher would help them realize that they need a "piece" they don't have to solve the problem and be ready to teach the missing "piece" to help students progress.
Andrew	This teacher incorporates positive aspects of the previous taxonomic levels. He advocates for problem-solving instruction to an extreme. He displaces adopted curriculum in favor of problem-solving instruction. The teacher knows the holy grail is actually problem solving.

Dumaine	Let's take it from the students' point of view of how they see the teacher. At this point the students understand why a teacher is enthusiastic about a particular topic. Both the teachers and students know what we are studying and what it could be used for. The teacher has brought kids to a stage where they automatically see a use for the math they are learning. It makes no difference what topic is being taught because the students have been won over through problem-solving methods that make sense to them. I almost look at this as students going from extrinsic to intrinsic. No one has to be told what the use is or why it should be valued. The teacher is teaching mathematics through problem solving and doesn't have to think about this. It's innate.
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Extremes along the continuum. As in any continuum, participant descriptions of teachers at the extreme levels in the Affective Domain taxonomy were entirely distinct. Descriptions of teachers at the *unaware*, *receiving*, and *characterization* levels were strikingly different, as evidenced in participants' selection of verbs and adverbs used to describe teachers at these two extremes. In contrast, adjacent elements in the middle of the continuum (e.g., *valuing/organizing*) were not as noticeably different from each other. For example, Anna described the subtle difference between a teacher at the *valuing* and *organization* level:

A teacher at this level will behave similarly to a teacher at the organization level but just less often. I don't see a big difference between these two levels. Teachers at both levels value the problem-solving process and want to see students do this – although there is some uncertainty at this level. Students will have an opportunity to lead but it is in a little more of a controlled setting than what is at the organization level. The teacher may not see the relationships between all of the parts of the problem-solving process.

When describing teachers' dispositions at the *characterization* level, Jane described a teacher who advocates for problem-solving instruction and helps others to view problem solving as an important method for helping students build new mathematics knowledge. Andrew also described a teacher who advocates for problem-solving instruction, but to an extreme. Beth described a teacher who would advocate for all students on a school-wide basis. According to her, this teacher would advocate for and develop in colleagues a variety of behaviors (e.g., regular use of a problem-solving approach, use of a variety of tools to solve problems, creation

of inventories to assess students' dispositions toward mathematics). Cathy, Jane and Beth described a teacher who journals, sets goals, and personally reflects on the problem solving that is happening in the classroom.

During the coding of participants' responses to the Affective Domain taxonomy worksheets, a fifth category of teacher behavior emerged at the *receiving* and *responding* levels, with more detailed examples of teacher behavior at the upper levels of the taxonomy (i.e., *valuing*, *organization*, and *characterization*). This category of teacher behavior was coded as professionalism. When responding to the bottom level, *unaware*, not a single participant described a teacher behavior that fell within the professionalism category. However, in response to the bottom levels of the original taxonomy, *receiving* and *responding*, participants began to describe behaviors related to professionalism. Beth and Cathy described a teacher at the *receiving* level as one who listens to and is open to colleagues' ideas and strategies about problem solving and how to engage students in problem solving. Jane attributed these behaviors to both a teacher at the *receiving* and *responding* levels.

When describing teachers at the *receiving* and *responding* levels, Anna and Dumaine both described a beginning teacher who may have read about the problem-solving process or heard about it at a conference. They were unsure whether to place this beginning teacher at the *receiving* or *responding* level. According to Dumaine, a teacher at the *receiving* and *responding* levels may have attended a workshop where problem solving was the theme or attended sessions where they saw the benefit of problem solving in the classroom, but would still be unsure of her teaching skills. Anna asserted that the teachers' perceived abilities about themselves or their students would ultimately keep them from including problem solving in the classroom. If the beginning teacher did not attempt inclusion of problem solving in the classroom, Jane asserted that the teacher would be at the *receiving* (as opposed to the

responding) level. Andrew described a teacher at the *receiving* level as someone who is starting to view his role in the classroom as “something more than providing instruction in the curriculum.” Jane viewed this same teacher as putting little, if any, effort into seeking out supplemental materials and resources.

Typical Teaching Behaviors at Each Taxonomic Level

The researcher applied the Wilkerson and Lang (2011) adaptation of the Krathwohl and Bloom (1956) taxonomy to generate descriptions of typical teaching behaviors at each taxonomic level for each of the five general indicators of secondary mathematics teachers’ positive dispositions toward problem solving. The results that follow were generated from data presented in Table 19, Appendix D and the participants’ descriptions of typical teaching behaviors at each of the six affective taxonomic levels (see Tables 21 to 32).

Figure 4 provides a list of typical teaching behaviors at each taxonomic level describing the extent to which a teacher values worthwhile mathematically rigorous problem solving. Figure 5 provides a list of typical teaching behaviors at each taxonomic level describing the extent to which a teacher values diversity of students’ explanations, ideas and observations about mathematical problems. Figure 6 provides a list of typical teaching behaviors at each taxonomic level describing the extent to which a teacher values a risk-free problem-solving environment that encourages all students. Figure 7 provides a list of typical teaching behaviors at each taxonomic level describing the extent to which a teacher values a variety of tools, including technology, to solve problems. Figure 8 provides a list of typical teaching behaviors at each taxonomic level describing the extent to which a teacher believes that all students must develop productive dispositions toward problem solving (i.e., confidence, interest, appreciation, enjoyment, and perseverance).

Figure 4. Typical Teaching Behaviors Using the Affective Taxonomy for General Indicator 1:
The teacher values worthwhile mathematically rigorous problem solving.

Taxonomic Levels	Typical Teaching Behaviors at Each Taxonomic Level
Unaware	<ul style="list-style-type: none"> • Has not considered or may be opposed to teaching mathematics through problem solving. • Has not considered the cognitive demand of tasks. • Avoids non-standard problems with multiple solution paths. • Believes there is one, best way to solve problems. • Does not recognize problem-solving situations that arise in other contexts. • Presents math as being little more than mechanical in nature.
Receiving	<ul style="list-style-type: none"> • Understands the importance of problem solving but is uncertain how to implement it. • Interested in problem solving and may provide a promise to teach through it. • Interested in problems that can be solved using a variety of strategies and representations. • Differentiates between tasks with varying levels of cognitive demand. • Has attended workshops or read about teaching mathematics through problem solving. • Listens to colleagues' approached to problem-solving instruction.
Responding	<ul style="list-style-type: none"> • Teaches just as problem solving is laid out in the adopted curriculum. • Begins to see opportunities for problem solving in daily instruction, but may not include them. • Puts some effort into seeking out resources on teaching mathematics through problem solving. • Provides an extra credit problem oriented towards problem solving if time permits. • Attempts to teach through problem solving until it becomes too difficult. • Focuses instruction on students learning specific strategies with little time for discussion. • Eliminates problem solving as part of a lesson if time is a factor.
Valuing	<ul style="list-style-type: none"> • Values and enjoys the problem-solving process. • Consistently uses uncommitted time to provide students with problem-solving opportunities. • Prefers tasks with real-world contexts, multiple solution paths and higher cognitive demands. • Routinely models and encourages mathematical reasoning about problems and their solutions. • Commits enough time to problem solving that students are aware it is important. • Devotes time in class to review, discuss, expand and extend familiar problems. • Consistently teaches familiar mathematical content through problem solving.
Organization	<ul style="list-style-type: none"> • Has a clear vision for how problem solving will work in daily lessons. • Organizes class time to ensure student engagement in and learning through problem solving. • Establishes a mathematically-rich problem-solving environment for nearly all students. • Consistently introduces mathematical concepts through a variety of problem-solving strategies. • Prioritizes worthwhile, authentic problems with high cognitive demand in daily lessons. • Routinely searches for real-world problems that can serve as a focal point of lessons.
Characterization	<ul style="list-style-type: none"> • Explicitly requires all students to extend problem solving to other content areas and contexts. • Provides direct instruction only if required or requested by students while solving a problem. • Devotes substantial personal time to seek out purposeful, open-ended problems. • Insists that every problem have a context that is authentic and interesting to students. • Displaces adopted curriculum in favor of problem-solving instruction. • Lobbies for more problem solving throughout the school's curriculum.

Figure 4. Adapted from the DAATS model by Wilkerson, J. R., and Lang, W. S., 2007, and the Affective Domain by Krathwohl, D. R., and Bloom, B. S., and Masia, B. B., 1956; 1973.

Figure 5. Typical Teaching Behaviors Using the Affective Taxonomy for General Indicator 2:
The teacher values diversity of students' explanations, ideas and observation about mathematical problems.

Taxonomic Levels	Typical Teaching Behaviors at Each Taxonomic Level
Unaware	<ul style="list-style-type: none"> • Has not considered the value of students' input. • May be opposed to students doing the thinking. • Unaware of various problem-solving strategies. • Does not elicit students' responses. • Has not considered students solving problems using specific strategies or representations.
Receiving	<ul style="list-style-type: none"> • Has some exposure to problem solving strategies and can name some specific strategies. • Recognizes student thinking is an important part of the problem-solving process. • Accepts students' responses but without probing their thinking. • Considers using problem solving assessment and feedback as part of the class. • Listens to colleagues' approaches to generating students' explanations and observations.
Responding	<ul style="list-style-type: none"> • Allows students to use a variety of strategies. • Allows students to use a variety of representations when solving problems. • Practices questioning students about their problem-solving processes. • Includes written assessments of students' problem-solving processes, if time permits. • Directs students to try specific strategies or representations. • Devotes some class time to discussion, but is uncomfortable with students taking the lead.
Valuing	<ul style="list-style-type: none"> • Is pleased when students use of a variety of familiar strategies and representations. • Fosters a problem-solving community through discussion. • Welcomes diversions into other mathematical topics. • Provides opportunities for students to lead the discussion and create problems. • Questions students about their discoveries, observations, conclusions and reflections. • Expects students to explain their mathematical reasoning in verbal and written forms.
Organization	<ul style="list-style-type: none"> • Organizes class time to ensure students have opportunities to justify (and share) their reasoning. • Consistently includes in lessons effective questioning strategies that probe students' thinking. • Routinely encourages discussion where students compare and contrast their thinking. • Regularly designs lessons that encourage student choice of strategies and representations. • Intentionally sets aside class time for students to generate their own problems. • Intentionally highlights various explanations, strategies, and representations.
Characterization	<ul style="list-style-type: none"> • Insists every student's explanation, ideas and observations are shared before moving on. • Advocates for diversity of students' explanations, ideas and observations in every classroom. • Insists students provide both written and verbal explanations of reasoning for all problems. • Views students' sharing their reasoning as the focal point of the problem-solving experience.

Figure 5. Adapted from the DAATS model by Wilkerson, J. R., and Lang, W. S., 2007, and the Affective Domain by Krathwohl, D. R., and Bloom, B. S., and Masia, B. B., 1956; 1973.

Figure 6. Typical Teaching Behaviors Using the Affective Taxonomy for General Indicator 3:
The teacher values a risk-free problem-solving environment that encourages all students.

Taxonomic Levels	Typical Teaching Behaviors at Each Taxonomic Level
Unaware	<ul style="list-style-type: none"> • May actively seek to discourage or belittle some students. • Opposes the idea that all students are capable of engaging in rigorous mathematical tasks. • Is uncomfortable with inclusion of student-created problems.
Receiving	<ul style="list-style-type: none"> • Recognizes the importance of motivational techniques to encourage problem solving. • Is beginning to believe every student is capable of solving rigorous mathematical problems. • Listens to colleagues' approaches to individualizing instruction to ensure student success.
Responding	<ul style="list-style-type: none"> • Encourages students to learn through problem solving in a controlled setting, if time permits. • Attempts to use motivational techniques with students. • May abandon problem solving when students become discouraged.
Valuing	<ul style="list-style-type: none"> • Routinely adapts problems and problem solving instruction to students' abilities and needs. • Encourages most students to engage in and internalize the problem-solving process. • Is comfortable with inclusion of student-created problems. • Commits to establishing a risk-free problem-solving environment for nearly all students.
Organization	<ul style="list-style-type: none"> • Adapts approaches (i.e., tools, representations, technology, strategies) for individual students. • Displays an encouraging attitude that all students will learn through problem solving. • Expects most students to extend and/or design problems. • Works systematically to reach all students. • Establishes a risk-free problem-solving environment for all students. • Organizes class time to ensure all students are successful in the problem-solving process.
Characterization	<ul style="list-style-type: none"> • Advocates for a risk-free problem-solving environment in every classroom in every discipline. • Views the needs of adolescents as the center of the problem-solving environment. • Insists all students' ideas are valued by everyone. • Insists students correct and explain all mistakes.

Figure 6. Adapted from the DAATS model by Wilkerson, J. R., and Lang, W. S., 2007, and the Affective Domain by Krathwohl, D. R., and Bloom, B. S., and Masia, B. B., 1956; 1973.

Figure 7. Typical Teaching Behaviors Using the Affective Taxonomy for General Indicator 4:
The teacher values a variety of tools, including technology, to solve problems.

Taxonomic Levels	Typical Teaching Behaviors at Each Taxonomic Level
Unaware	<ul style="list-style-type: none"> • Unaware of what is possible with different technology/tools. • May be opposed to the use of technology/tools in problem solving.
Receiving	<ul style="list-style-type: none"> • Shows interest in using different technology/tools to teach problem solving. • May have attended workshops or read about the use of tools/technology to solve problems. • Begins to look for tools/technology to teach problem solving. • Listens to colleagues' approaches to using tools/technology to teach problem solving. • Unsure of how to use tools/technology to solve problems.
Responding	<ul style="list-style-type: none"> • Is comfortable with and models the use of some tools/technology to solve problems. • Allows, and is pleased when, students use technology/tools. • Uses tools as prescribed in a lesson. • Uses readily available tools/technology to occasionally engage students in problem solving.
Valuing	<ul style="list-style-type: none"> • Enjoys using tools/technology with students to solve problems. • Integrates a variety of appropriate tools and technology to support problem solving instruction. • Encourages student choice of tools and technology to solve problems. • Selects tasks that require students to use a variety of tools and/or technology. • Expects students to justify their choice of tool/technology.
Organization	<ul style="list-style-type: none"> • Sets aside time to design tasks that require students to use a variety of tools/technology. • Routinely includes a variety of familiar tools/technology for student use. • Routinely commits class time to explore using tools/technology to solve problems. • Formally assesses students' fluency with tools/technology to solve problems. • Adapts problems and lessons to require student use of tools/technology.
Characterization	<ul style="list-style-type: none"> • Intentionally uses a variety of tools whenever possible. • Encourages a technology/tool rich environment in every classroom in every discipline. • Explicitly requires students to be fluent with all tools available. • Advocates for meaningful use of technology/tools that ensures students access to the math. • May avoid problems or solutions that do not require tools/technology.

Figure 7. Adapted from the DAATS model by Wilkerson, J. R., and Lang, W. S., 2007, and the Affective Domain by Krathwohl, D. R., and Bloom, B. S., and Masia, B. B., 1956; 1973.

Figure 8. Typical Teaching Behaviors Using the Affective Taxonomy for General Indicator 5: *The teacher believes that all students must develop productive dispositions toward problem solving (i.e., confidence, interest, appreciation, enjoyment, and perseverance).*

Taxonomic Levels	Typical Teaching Behaviors at Each Taxonomic Level
Unaware	<ul style="list-style-type: none"> • Unaware that a student's disposition impacts performance. • Has not considered the impact of worthwhile tasks on students' mathematical dispositions. • Only uses assessments that address mathematical content.
Receiving	<ul style="list-style-type: none"> • Accepts that students' dispositions play a valuable role in their success in mathematics. • Accepts the importance of the teacher's role in developing disposition. • Is interested in developing, analyzing and assessing student disposition. • Listens to colleagues' ideas about student disposition. • Unsure of how to assess students' dispositions.
Responding	<ul style="list-style-type: none"> • Occasionally discusses students' dispositions with them. • Attempts to model positive dispositions toward mathematical problem solving. • Assesses students' dispositions toward problem solving if time permits. • Begins to differentiate between positive and negative student responses to a task.
Valuing	<ul style="list-style-type: none"> • Seeks out problems that have a positive impact on students' mathematical dispositions. • Designs instruction that engenders a productive disposition toward math. • Solicits feedback from students about their dispositions. • Sets aside class time to assess students' mathematical dispositions. • Models positive dispositions toward mathematical problem solving.
Organization	<ul style="list-style-type: none"> • Prioritizes the development of students' confidence with mathematical problem solving. • Formally assesses students' dispositions in a variety of ways (e.g., projects, discussion). • Expects and encourages all students to persevere. • Prioritizes encouraging feedback as a major part of problem-solving instruction. • Makes daily instructional decisions based on the analysis of dispositional assessments.
Characterization	<ul style="list-style-type: none"> • Designs instruction that focuses more on students' dispositions than content. • Views students' desire for challenging problems as the driving force of learning mathematics. • Insists all students display confidence, interest, enjoyment, and perseverance at all times. • May avoid a lesson because it could negatively impact students' dispositions. • Plans tasks with colleagues to examine the disposition of students.

Figure 8. Adapted from the DAATS model by Wilkerson, J. R., and Lang, W. S., 2007, and the Affective Domain by Krathwohl, D. R., and Bloom, B. S., and Masia, B. B., 1956; 1973.

Worksheet 2.3

The behaviors indicating teachers' positive dispositions toward problem solving, as listed in Table 19, served as the content for Worksheet 2.3. Participants selected assessment methods for each indicator to ensure varying levels of inference. Using the descriptions of known measures of affective in the literature review in Chapter II, participants correlated indicators with the following assessment methods: scales (SC), questionnaires (QU), focus groups (FG), observations (OB), event reports (ER), and situational analysis tests (SA). Participants identified which assessment methods must (or should) be used, could be used, or would not at all be useful in assessing each indicator in teachers. Participants also suggested additional methods that they believed could be used for assessing particular indicators. However, with the exception of event reporting, the Wilkerson and Lang (2007) DAATS model includes only the assessment methods that are known measures of affect (Hopkins, 1998).

The analysis for this worksheet began with reviewing the responses of all six participants to obtain a general sense of those assessment methods that the participants identified as useful in assessing particular indicators. Following an initial review, the researcher tallied the number of participants who identified the assessment methods as not useful (coded as *no*), possibly being useful (coded as *possibly*) and absolutely necessary (coded as *yes*) in assessing the individual indicators. The tables in Appendix E list the tallies for each indicator.

The researcher reviewed for consistency participants' selections of assessment methods with particular attention to the indicators where responses were spread across the three categories (i.e., yes, possibly, no). For example, two participants believed that a belief scale should be used to assess whether a teacher values respectful discourse (*Indicator 3.6*), two participants believed it was possible to assess this indicator using a belief scale, and two participants believed that a belief scale would not be useful in assessing this value in teachers.

To make a determination of assigning a “yes” in the assessment framework for assessing *Indicator 3.6* using a belief scale, the researcher analyzed individual participants’ responses horizontally (i.e., participants’ responses to the utility of the other assessment methods for *Indicator 3.6*) to ensure consistency. In reviewing *Indicator 3.6*, the researcher determined that the two participants who classified a belief scale as “not useful” did so because they believed the best way to ensure that a teacher valued respectful discourse was through observation. All indicators with their corresponding assessment methods were reviewed for consistency in order to generate the assessment frameworks (see Tables 33 to 37). However, the consistency of the assessment frameworks was impacted by the small number of participants in this study. Although the researcher reviewed for consistency participants’ selections of assessment methods where the responses were spread across the three categories (yes, possibly, no), the decision about *yes*, *possibly*, or *no* could be significantly impacted by a single participant’s vote. Assessment developers should use the assessment framework as guide only, to be confirmed and adjusted locally. If developers are able to identify good items for an indicator with a corresponding assessment method classified as a *no*, they should be comfortable in using the items, since as many as four of the six respondents may have indicated that such items could be developed.

Participants were given the opportunity to reflect on the process of completing Worksheet 2.3 and provide additional assessment methods for any of the indicators. Jane, Cathy, Anna and Andrew all felt that the event reports would not always yield useful results. As Anna completed Worksheet 2.3, she found herself not using the event report very often. Since event reports documented incidents where the teacher behavior was in opposition to the desired behavior, Jane believed event reports should mainly be reserved for “ferreting out teachers who have negative dispositions toward problem solving and should be counseled out

of the profession, if multiple reports surface.” Andrew believed that lots of teacher, including him, do “stupid things that [they] don’t really value.” Cathy thought that the event reports could be useful if they were used in a way that might indicate positive dispositions such as a “caught being good” slip completed by teachers serving in a mentoring capacity or by university faculty serving in an evaluative capacity.

All participants suggested additional assessment methods that might be useful in identifying teachers’ dispositions toward problem solving although these methods were not all known measures of affect (Hopkins, 1998). Jane thought that lesson plan analysis would be a valuable assessment method for many of the indicators. She thought that a scoring guide would be a useful assessment because it would give teacher candidates an opportunity to evaluate their own lesson plans in terms of their own and students’ dispositions toward problem solving. At first Cathy thought that it would be valuable to evaluate lesson plans as one of the assessment methods, but ultimately felt the best method for assessing the teachers’ actual dispositions would be through an observation of the teachers actually implementing the lesson in the classroom with students. Dumaine asserted that assessment methods designed to help students develop productive views of problem solving would produce the most valuable results for the teacher. Andrew emphasized the value of including student questionnaires and individual student interviews along with student focus groups. While Anna acknowledged that it is not always practical to ask teachers to do more work, she also wondered whether an annotated journal would be a valuable assessment. She added that teachers could also benefit from analyzing a video of themselves teaching so that they would be able to “provide evidence that they were valuing a variety of tools or that they were attending to students’ dispositions as they implement lessons.” Finally, Beth commented on the power of student work samples, alongside a teacher’s written or verbal descriptions of the work, in allowing teachers to show

evidence of the first and second general indicators in addition to the specific indicators 1.1, 1.2, 1.3, 1.4, 1.5, 2.1, 2.2, 2.3, 2.4, 2.5, 3.5, 3.6, 5.3, and 5.4.

Worksheet 2.4

Worksheet 2.4 was designed to establish an assessment framework to serve as a starting point to create instruments, and items within instruments, for use in assessing secondary mathematics teachers' dispositions toward problem solving. Creating an assessment framework, or blueprint, ensured that all indicators were sufficiently covered. Tables 33-37 resulted from a compilation and analysis of the six participants' responses to Worksheet 2.3 (see Appendix E). For each indicator and each assessment method, data in the tables in Appendix E were used to determine whether a particular assessment method must be used (yes), could be used (possibly) or would not be useful at all (no) in measuring a particular indicator of positive disposition toward problem solving. All indicators with their corresponding assessment methods were reviewed for consistency in order to generate the assessment frameworks (see Tables 33 to 37). However, the consistency of the assessment frameworks was impacted by the small number of participants in this study. Although the researcher reviewed for consistency participants' selections of assessment methods where the responses were spread across the three categories (yes, possibly, no), the decision about *yes*, *possibly*, or *no* could be significantly impacted by a single participant's vote.

Table 33

Assessment Framework for Indicators 1.1 to 1.6

General and Specific Indicator(s)		SC	QU	FG	OB	ER	SA
<i>The teacher values worthwhile mathematically rigorous problem solving.</i>		P	P	No	Yes	No	P
As part of teaching through problem solving, the teacher:							
1.1	Values open-ended problems that have multiple and/or unclear paths to a solution.	P	P	No	Yes	No	Yes
1.2	Values purposeful problems that encourage students to apply specific mathematical content and processes to other subjects and in real-world contexts.	Yes	Yes	P	Yes	No	P
1.3	Values problems that highlight a variety of problem solving strategies.	P	P	P	Yes	No	Yes
1.4	Values problems that require students to build new mathematics knowledge through problem solving.	P	P	P	Yes	No	P
1.5	Values cognitively demanding tasks that stretch students.	Yes	P	Yes	Yes	No	P
1.6	Believes that ample class time must be dedicated to student solution and discussion of problems.	Yes	P	P	Yes	No	P

Note. SC = scales; QU = questionnaires; FG = focus group; OB = Observation; ER = Event Report; SA = Situational Analysis Test; P = possibly

Table 34

Assessment Framework for Indicators 2.1 to 2.5

General and Specific Indicator(s)		SC	QU	FG	OB	ER	SA
<i>The teacher values diversity of students' explanations, ideas and observations about mathematical problems.</i>		P	P	Yes	Yes	No	P
As part of teaching through problem solving, the teacher:							
2.1	Believes all students have unique ways of expressing their mathematical thinking and reasoning.	P	P	P	Yes	No	P
2.2	Values both written and verbal explanations of reasoning.	P	P	Yes	Yes	No	P
2.3	Values a variety of problem-solving strategies, including solution paths that vary from what was taught in class.	No	P	Yes	Yes	No	P
2.4	Values use of various representations, highlighting them whenever possible.	Yes	P	Yes	Yes	No	P
2.5	Values varying opinions and different ways of thinking.	P	Yes	Yes	Yes	P	P

Note. SC = scales; QU = questionnaires; FG = focus group; OB = Observation; ER = Event Report; SA = Situational Analysis Test; P = possibly

Table 35

Assessment Framework for Indicators 3.1 to 3.6

General and Specific Indicator(s)		SC	QU	FG	OB	ER	SA
<i>The teacher values a risk-free problem-solving environment that encourages all students.</i>		Yes	P	Yes	Yes	P	P
As part of teaching through problem solving, the teacher:							
3.1	Values respectful discourse.	Yes	P	P	Yes	P	No
3.2	Values an environment where students are problem-solving authorities.	P	P	Yes	Yes	P	P
3.3	Believes all students' comments are valuable.	P	P	P	Yes	P	P
3.4	Believes students learn through their mistakes.	Yes	P	P	Yes	No	P
3.5	Is committed to individualized instructional support to ensure success of all students.	P	P	Yes	Yes	No	No
3.6	Believes every student is capable of solving rigorous mathematical problems.	P	P	P	Yes	No	P

Note. SC = scales; QU = questionnaires; FG = focus group; OB = Observation; ER = Event Report; SA = Situational Analysis Test; P = possibly

Table 36

Assessment Framework for Indicators 4.1 to 4.3

General and Specific Indicator(s)		SC	QU	FG	OB	ER	SA
<i>The teacher values a variety of tools, including technology, to solve problems.</i>		P	P	Yes	Yes	No	P
As part of teaching through problem solving, the teacher:							
4.1	Values using a variety of tools to solve problems.	P	P	P	Yes	No	P
4.2	Is committed to providing tools to students at all times.	P	P	P	Yes	No	P
4.3	Is committed to discovering new tools (or novel uses of traditional tools) to solve problems.	P	Yes	P	Yes	No	No
<i>Note.</i> SC = scales; QU = questionnaires; FG = focus group; OB = Observation; ER = Event Report; SA = Situational Analysis Test; P = possibly							

Table 37

Assessment Framework for Indicators 5.1 to 5.5

General and Specific Indicator(s)		SC	QU	FG	OB	ER	SA
<i>The teacher believes that all students must develop productive dispositions toward problem solving (i.e., confidence, interest, appreciation, enjoyment, and perseverance).</i>		Yes	Yes	P	Yes	No	P
As part of teaching through problem solving, the teacher:							
5.1	Values problem-solving experiences that support the development of positive dispositions in students.	Yes	P	Yes	Yes	No	P
5.2	Attends to students' dispositions in the planning and delivery of instruction.	P	Yes	P	Yes	No	No
5.3	Values feedback given to students that fosters a productive disposition (i.e., commitment, perseverance, confidence).	P	Yes	Yes	Yes	No	P
5.4	Values a variety of assessments to measure students' dispositions (e.g., observations, interviews, exit slips, journal writing, self-assessments).	P	Yes	P	Yes	No	P
5.5	Believes challenging tasks motivate students.	P	P	No	Yes	No	P

Note. SC = scales; QU = questionnaires; FG = focus group; OB = Observation; ER = Event Report; SA = Situational Analysis Test; P = possibly

Summary of Results

This study began with a single focus (i.e., secondary mathematics teachers' dispositions toward problem solving) to explore deeply. Chapter IV concludes with an examination of the three central research questions that were motivated by the researcher's interest in applying Wilkerson and Lang's (2007) DAATS model to measure secondary mathematics teachers' dispositions toward problem solving. As the study progressed, the researcher reviewed and reformulated the original research questions as they evolved in a manner consistent with the research design (Creswell, 2009; Maxwell, 2009). Four refined questions emerged through this reflexive process:

1. What are the purposes, uses, content, propositions and context of an assessment system to measure secondary mathematics teachers' dispositions toward problem solving?
2. What are the standards-based observable (verbal and nonverbal) behaviors, attitudes, or practices (indicators) that define the construct of secondary mathematics teachers' commitment to problem solving?
3. How can the Krathwohl and Bloom (1956; 1973) Affective Domain taxonomy be used to differentiate levels of secondary mathematics teachers' commitment to problem solving?
4. What assessment methods can be used to measure the construct of secondary mathematics teachers' dispositions toward problem solving, at varying levels of inference, leading to a valid assessment of the indicators of secondary mathematics teachers' positive dispositions toward problem solving?

Table 38 summarizes the data sources and indicates the alignment between sources and the refined research questions.

Table 38

Alignment of Data Sources to Refined Research Questions

Data Source	Refined RQ1	Refined RQ2	Refined RQ3	Refined RQ4
Participant Information Sheet	x			x
National Standards	x	x		x
Worksheet 1.1	x	x		
Worksheet 1.2	x	x		
Worksheet 1.3	x			
Worksheet 1.4	x			
Steps 1A-1D Interview Protocol	x			
Worksheet 2.2		x	x	x
Affective Domain Worksheets		x	x	x
Worksheet 2.3				x
Worksheet 2.4				x
Step 2B Interview Protocol		x	x	
Steps 2C-2D Interview Protocol				x

Note. This table provides an alignment of data sources to refined research questions that emerged from the central research questions in this study. RQ1 = What are the purposes, uses, content, propositions and context of an assessment system to measure secondary mathematics teachers' dispositions toward problem solving?; RQ2 = What are the standards-based observable (verbal and nonverbal) behaviors, attitudes, or practices (indicators) that define the construct of secondary mathematics teachers' commitment to problem solving?; RQ3 = How can the Krathwohl and Bloom (1956) Affective Domain taxonomy be used to differentiate levels of secondary mathematics teachers' commitment to problem solving?; RQ4 = What assessment methods can be used to measure the construct of secondary mathematics teachers' dispositions toward problem solving, at varying levels of inference, leading to a valid assessment of the indicators of secondary mathematics teachers' positive dispositions toward problem solving?

This study produced four major results. First, participants reached consensus on the purpose, use and content of an assessment framework designed to measure secondary mathematics teachers' dispositions toward problem solving (see Figure 3). Second, participants assisted in the development of indicators of secondary mathematics teachers' positive dispositions toward problem solving (see Table 19). Third, participants' responses generated a list of typical teaching behaviors for each general indicator and for each taxonomic level of the Affective Domain (see Figures 4 through 8). Fourth, participants assisted in the development of an assessment framework that correlated indicators with methods for assessing affect at varying levels of inference (see Tables 33-37).

Refined Research Question One

The primary purpose of this study was to apply the first two steps of the Wilkerson and Lang's (2007) Disposition Assessment Aligned with Teacher Standards (DAATS) model to develop an assessment framework for selecting existing instruments or designing future instruments to assess secondary mathematics teachers' dispositions toward problem solving. DAATS Step 1 identified and defined the broader purpose, use, propositions, content and context of the assessment framework. To answer this question, data were analyzed from participants' responses to Worksheets 1.1, 1.2, 1.3 and 1.4 used in DAATS Steps 1A, 1B, 1C and 1D. Participants achieved consensus on the purposes, uses, content, propositions, and context of an assessment system designed to measure secondary mathematics teachers' positive dispositions toward problem solving (see Figure 3). They agreed that the purposes of the assessment system should be to ensure a common set of values in secondary mathematics teachers, improve performance of individual secondary mathematics teachers, improve pre-service teacher preparation programs, impact the value systems of children (e.g., motivation to learn), and conduct research on teaching (see Table 11). Participants affirmed that the assessment system

should be focused on low-stakes uses such as advising, remediation and program improvement (see Table 12). Participants agreed on the content of the assessment system: national professional association standards, i.e., CCSS-M, NCTM and CAEP/NCTM (see Table 13). Participants approved the following propositions: a positive disposition toward problem solving is critical to effective mathematics teaching; this disposition can be identified and measured; national standards contribute to the identification of this standard and using appropriate theories of affective measurement; and measures of this disposition can be developed based on the standards and values identified (see Table 14). Finally, participants agreed that faculty support level, availability of fiscal resources, availability of personnel and time, were contextual factors that could either support or undermine the assessment of secondary mathematics teachers' dispositions toward problem solving (see Table 15).

Refined Research Question Two

DAATS Steps 2A and 2B built upon participants' broad planning of an assessment system through an analysis and visualization of the standards and indicators that were identified during DAATS Step 1. To answer this research question, data were taken from participants' responses to Worksheet 2.2, used in DAATS Steps 2A and 2B, along with participants' responses to the Affective Domain taxonomic levels worksheets.

Education is increasingly driven by expectations set by a standards-based system for programs, teachers and students. The researcher conducted an initial review and alignment of the sets of national standards that address dispositions toward problem solving. The review provided a domain from which participants could sample as they visualized secondary mathematics teachers demonstrating the affective target: positive dispositions toward problem solving. The review revealed a broad set of observable (verbal and nonverbal) behaviors, attitudes, and practices that were likely to be consistent with secondary mathematics teachers'

positive dispositions toward problem solving (see Appendix B). As noted in the literature review, a comparison of eight sets of national standards revealed expectations, at varying levels of specificity, for teachers' behaviors, attitudes and practices with respect to problem solving. In order to use the standards and indicators identified during the review in a meaningful way, commonalities were drawn from the eight sets of standards with a primary focus on the three sets of national standards identified by participants in the content section of Worksheet 1.1 (see Appendix A for the worksheet and Appendix B for the list of commonalities). The list in Appendix A served as the foundation for Worksheet 2.2 and the participants' work in identifying indicators of secondary mathematics teachers' positive dispositions toward problem solving.

Participants' responses to Worksheet 2.2 elicited a set of indicators describing teachers' positive dispositions toward problem solving to sample from when assessing the construct (see Table 19). The five general indicators are minimal measures that were taken from at least five of the six participants when describing behaviors that are likely to be consistent with secondary mathematics teachers exhibiting positive dispositions toward problem solving (see Table 18). The specific indicators in Table 19 provided a set of behaviors that expanded upon the intent (i.e., breadth and depth) of each general indicator. The set of indicators of secondary mathematics teachers' positive dispositions toward problem solving would ultimately serve as the foundation for the assessment framework.

Finally, the analysis of participants' descriptions of typical teaching behaviors, attitudes or practices at each taxonomic level of Krathwohl and Bloom's (1956) Affective Domain, along with the *unaware* level added for assessment purposes (Wilkerson, 2012), provided a rich set of observable behaviors, attitudes and practices that describe teachers' levels of awareness and commitment to teaching through problem solving (see Appendix D and Figures 4 through 8). The

descriptions of typical teaching behaviors provide additional definition to the construct of secondary mathematics teachers' commitment to problem solving.

Refined Research Question Three

The Krathwohl and Bloom (1956) Affective Domain taxonomy provided the foundation for describing and measuring affective targets in this study. The DAATS model is based on the five levels of the Krathwohl and Bloom (1956) Affective Domain taxonomy (*receiving, responding, valuing, organization, and characterization*) and includes an additional level (*unaware*) for assessment purposes. Participants' descriptions of teachers at the six affective taxonomic levels are aggregated in Appendix D. The researcher reviewed the indicators of positive dispositions (see Tables 19) in conjunction with participants' descriptions of typical teaching behaviors at the six affective taxonomic levels (see Tables 21-32 and Appendix D) to generate Figures 4 through 8. The typical teaching behaviors for each taxonomic level for each of the five general indicators of positive dispositions toward problem solving can be used in an assessment system to differentiate levels of secondary mathematics teachers' commitment to problem solving.

Refined Research Question Four

The purpose of the first two steps of Wilkerson and Lang's (2007) Disposition Assessment Aligned with Teacher Standards (DAATS) model in this study was to determine design inputs for assessing secondary mathematics teachers' dispositions toward problem solving (DAATS Step 1) and align these inputs in order to create an assessment framework that correlates indicators and assessment methods (DAATS Step 2). The data obtained during DAATS Step 1 provided the design inputs and assisted in defining the propositions and principles underlying an assessment system that would result in valid assessment of indicators of secondary mathematics teachers' dispositions toward problem solving. The foundational work

in DAATS Step 1, combined with a review and analysis of related standards and indicators, set the stage for participants to visualize teachers demonstrating the affective target of positive dispositions toward problem solving. The visualization process was documented using Worksheet 2.2 (see Table 19 and 20 for results), through the Affective Domain Taxonomy worksheets (see Tables 21-32), and in the comprehensive lists of participant descriptions' of typical teaching behaviors for each of the six affective taxonomic levels (see Appendix D). Data from Worksheet 2.2 provided indicators of secondary mathematics teachers' positive dispositions toward problem solving. These indicators provided the foundation for the assessment framework. Indicators and assessment methods were combined to create Worksheet 2.3 which allowed participants to suggest assessment methods at different levels of inference and an assessment framework correlating indicators and affective measurement methods. Participants' tallies for each indicator and each affective measurement method are provided in Appendix E. DAATS Step 2 of the study culminated with an assessment framework that correlated indicators and affective assessments methods, at varying levels of inference, as summarized in Tables 34-38.

The consistency of the assessment frameworks (see Tables 33-37) was impacted by the small number of participants in this study. Although the researcher reviewed for consistency participants' selections of assessment methods where the responses were spread across the three categories (yes, possibly, no), the decision about *yes*, *possibly*, or *no* could be significantly impacted by a single participant's vote. Assessment developers should use the assessment framework as guide only, to be confirmed and adjusted locally. If developers are able to identify good items for an indicator with a corresponding assessment method classified as a *no*, they should be comfortable in using the items, since as many as four of the six respondents may have indicated that such items could be developed.

Concluding Remarks on the Relationship of Validity to the Major Findings

The Wilkerson and Lang's (2007) Disposition Assessment Aligned with Teacher Standards (DAATS) model outlines five steps to develop valid assessments: address design inputs (DAATS Step 1), plan with a continuing eye on valid assessment decisions (DAATS Step 2), develop instruments (DAATS Step 3), make decisions and manage data (DAATS Step 4), and ensure credible data (DAATS Step 5). Completing the five steps has the potential to yield assessment decisions and inferences about secondary mathematics teachers' dispositions toward problem solving.

During DAATS Step 1, participants' responses to the purpose, use and content of the assessment system (see Worksheet 1.2) provided the beginning work for valid inferences, since these concepts are central in most definitions of validity. Participants' responses to the propositions helped to ensure that they were receptive to the assessment of dispositions and philosophically prepared for work. During DAATS Step 2, the researcher began developing the construct definition of "secondary mathematics teachers' dispositions toward problem solving," by reviewing and aligning all sets of relevant national standards (see Appendix B). The construct was further articulated by having participants visualize the affective, or dispositional, targets (see Worksheet 2.2 in Appendix A). The assessment framework provided a representative and proportional coverage of the construct indicators, which, if used or updated, can demonstrate content validity in the instruments developed. Finally, participants identified dispositional statements that were job-related, another requirement for content validity in the instruments to be developed. Consequently, users of these products can have confidence that they are working with a well-defined construct and can build a content valid set of instruments if they follow or adapt the assessment framework proposed. Statistical testing of the instruments will further confirm validity at a later date. Since the framework reflects the varying opinions of six

participants, users can use it in tact or modify it, as long as they ensure that their instruments cover the indicators in a way that is representative and proportional.

In order to ensure that the assessment system allows assessors to make valid, reliable and fair decisions about secondary mathematics teachers' disposition toward problem solving, all five steps of the DAATS model must be faithfully implemented in a systematic manner.

Wilkerson and Lang (2007) put it thusly:

We teach our students day after day that they should never enter a classroom without a lesson plan, a unit plan, and a classroom management plan. There's always a plan . . . Yet somehow, many of us have deluded ourselves into thinking that planning is less important in our world of teacher assessment – and worse, that we don't have to practice what we preach (p. 245).

The DAATS model provides a model that demonstrates how “solid planning for the assessment of dispositions not only gives us the data we need in a systematic way, but it gets us their safely” (p. 245). This study applied the first two of five steps in the DAATS model. Additional work remains in order to create instruments aligned with standards and consistent with the assessment framework (DAATS Step 3), design and implement data aggregation, tracking, and management systems (DAATS Step 4), and ensure credibility and utility of data (DAATS Step 5).

Chapter Summary

This chapter presented the results for each step of the study, organized by worksheet, in chronological order. The chapter concluded with an examination of four refined research questions that emerged from the data collected during each phase of the study.

The results of DAATS Step 1 established likely purposes and uses for an assessment system targeting secondary mathematics teachers' dispositions toward problem solving. During DAATS Step 2, the researcher began developing the construct definition of “secondary mathematics teachers' dispositions toward problem solving,” by reviewing and aligning all sets of relevant national standards. The results of DAATS Step 2 provided measurable, standards-based

indicators of secondary mathematics teachers' positive dispositions toward problem solving. The application of the Krathwohl and Bloom (1956) Affective Taxonomy to the results in this study established a range of typical teaching behaviors for the standards-based indicators. The final steps of DAATS Step 2 resulted in an assessment framework for measuring secondary mathematics teachers' dispositions toward problem solving. Ultimately this assessment framework is designed to assist in the development of items and instruments that could be used, modified, or expanded for a variety of purposes, such as demonstrating expectations related to teaching problem solving to secondary mathematics teacher candidates.

CHAPTER V

CONCLUSIONS

“It is often easier to fight for principles than to live up to them” (Stevenson, 1952).

Introduction

This chapter presents a summary of the study and significant conclusions drawn from the data presented in Chapter IV. It presents the major findings and how they relate to the professional and research literature on teachers’ dispositions. Finally, it provides a discussion of the implications for action and recommendations for further research on secondary mathematics teachers’ dispositions toward problem solving.

Summary of Study

Dispositions, or affect, play a role in the teaching and learning of mathematics. Studying teachers’ dispositions is an area of interest in the teacher education community. Teachers’ affect is *critically* important even though it has not been as widely studied as other concepts such as teachers’ beliefs (Philipp, 2007). Dispositions represent individuals’ habits of mind that translate knowledge, skills and beliefs into actions in a classroom. The focus of this study was developing indicators of secondary mathematics teachers’ positive dispositions toward problem solving as evidenced through teaching behavior. Teachers’ positive dispositions toward mathematical processes, such as problem solving, may play a role in supporting students’ productive dispositions toward mathematics. While the relationship between teachers’ positive dispositions toward the mathematical process of problem solving and the development of students’ productive dispositions toward making sense of problems and persevering in solving

them, has not been studied, a relationship is believed to exist, as evident in the *Program Standards for Initial Preparation of Mathematics Teachers: Standards for Secondary Mathematics Teachers* (NCTM, 2003; NCTM, 2012). Assessing teachers' dispositions toward problem solving as they pertain to and influence the teaching and learning of problem solving in the classroom may provide critical evidence in examining this relationship. Furthermore, developing valid and reliable methods for assessing teachers' dispositions toward problem solving may contribute to improving the preparation of pre-service mathematics teachers and the professional development of in-service mathematics teachers. The research community needs to better understand and assess teachers' dispositions toward mathematical processes and practices. Finally, there is a need to examine the extent to which teachers' dispositions toward problem solving impact their instructional choices and ultimately the development of students' productive dispositions toward mathematics.

Purpose of the Study and Research Questions

The primary purpose of this study was to apply Wilkerson and Lang's (2007) Disposition Assessment Aligned with Teacher Standards (DAATS) model to develop an assessment framework for selecting existing instruments or designing future instruments to assess secondary mathematics teachers' dispositions toward the mathematical process of problem solving. The assessment framework provides a blueprint for ensuring valid assessment decisions and inferences about secondary mathematics teachers' dispositions toward problem solving. Once an assessment framework is developed for measuring secondary mathematics teachers' dispositions toward problem solving, researchers will be better equipped to design future studies to investigate the relationship between a secondary mathematics teachers' positive dispositions and the development of students' productive dispositions. An assessment

framework of this type could serve the accreditation, certification, professional-development and research goals of individuals working in the field of mathematics education.

The three central research questions addressed by this study were motivated by the researcher's interest in applying Wilkerson and Lang's (2007) DAATS model to measure secondary mathematics teachers' dispositions toward problem solving. The original, central research questions of this study were:

1. Based on the standards, what are observable (verbal and nonverbal) behaviors, attitudes, or practices that are likely to be consistent with secondary mathematics teachers exhibiting positive dispositions toward problem solving
2. Using Wilkerson and Lang's (2007) Disposition Assessment Aligned with Teacher Standards (DAATS) model, to what extent can an assessment framework, with assessment methods at different levels of inference, be developed to assess secondary mathematics teachers' dispositions toward problem solving?
3. To what extent will the assessment framework provide a valid framework for selecting existing instruments (or designing future instruments) to measure secondary mathematics teachers' dispositions toward problem solving?

As the study progressed, the researcher reviewed and reformulated the original research questions as they evolved in a manner consistent with the research design (Creswell, 2009; Maxwell, 2009). Four refined questions emerged through this reflexive process:

1. What are the purposes, uses, content, propositions and context of an assessment system to measure secondary mathematics teachers' dispositions toward problem solving?

2. What are the standards-based observable (verbal and nonverbal) behaviors, attitudes, or practices (indicators) that define the construct of secondary mathematics teachers' commitment to problem solving?
3. How can the Krathwohl and Bloom (1956) Affective Domain taxonomy be used to differentiate levels of secondary mathematics teachers' commitment to problem solving?
4. What assessment methods can be used to measure the construct of secondary mathematics teachers' dispositions toward problem solving, at varying levels of inference, leading to a valid assessment of the indicators of secondary mathematics teachers' positive dispositions toward problem solving?

This study produced four major results. First, participants reached consensus on the purpose, use and content of an assessment framework designed to measure secondary mathematics teachers' dispositions toward problem solving (see Figure 3). Second, participants assisted in the development of indicators of secondary mathematics teachers' positive dispositions toward problem solving (see Table 19). Third, participants' responses generated a list of typical teaching behaviors for each general indicator and for each taxonomic level of the Affective Domain (see Figures 4 through 8). Fourth, participants assisted in the development of an assessment framework that correlated indicators with methods for assessing affect at varying levels of inference (see Tables 33-37). The four major results correspond directly to the four refined research questions that emerged from the central research questions that motivated the study.

This study did not attempt to develop and validate instruments (i.e., scales, interviews, focus groups, etc.) designed to accurately and fairly assess secondary mathematics teachers' dispositions toward problem solving. Instead, this study attempted a more global task of developing indicators of secondary mathematics teachers' positive dispositions toward problem

solving within an assessment framework to distinguish among teachers who exhibit more positive (or negative) dispositions toward problem solving and suggest items and instrumentation for assessing teachers' dispositions toward problem solving at varying levels of inference.

Review of Methodology

This study used a mixed-methods design with two steps corresponding to the first two steps of Wilkerson and Lang's (2007) five-step DAATS model and informed by the foundations of psychological testing (i.e., *APA Standards for Educational and Psychological Testing*) outlined by Miller, McIntire and Lovler (2011). The study began with an analysis of the standards on secondary mathematics teachers' dispositions toward problem solving and culminated with an assessment framework correlating indicators of secondary mathematics teachers' positive dispositions toward problem solving with methods for assessing disposition. An abbreviated description of the steps in this study, adapted from the first two steps of Wilkerson and Lang's (2007) five-step DAATS model, is given below:

DAATS Step 1: Assessment Design Inputs

Define purpose, use, propositions, principles, content and other contextual factors that will define the conceptual framework for an assessment system designed to measure secondary mathematics teachers' dispositions toward problem solving and ultimately guide the development and validation of indicators of secondary mathematics teachers' positive dispositions toward problem solving (p. 42).

DAATS Step 2: Planning with a continuing eye on valid assessment decisions

Identify and analyze standards and indicators of secondary mathematics teachers' positive dispositions toward problem solving. Visualize secondary mathematics teacher demonstrating the affective targets that indicate a positive disposition toward problem solving. Establish content validity of the indicators through an examination of agreement of experts on the applicability of values, domain coverage, and relevancy to the work of secondary mathematics teachers. Build an assessment framework that correlates standards and assessment methods (p. 62).

The researcher selected a mixed-methods, concurrent triangulation strategy to analyze the quantitative and qualitative data sources because it was best suited to compare and substantiate the findings of the study (Creswell, 2009). Each step in this study included interview data. Each interview was recorded and transcribed. The researcher reviewed the interview data a minimum of two times before developing a preliminary list of categories based on prominent themes that emerged from participants' responses. After each theme was assigned an initial coding, the researcher read all of the responses for each question in order to develop a master code list of response categories. Using the master code list, the researcher coded the full transcript of each participant for each worksheet or interview. The researcher noted when more than a single reference was made in a response category. Conducting a thorough analysis of each response for each worksheet or interview allowed themes and patterns to emerge during every step of this study. The researcher reviewed all interview transcripts to verify the findings (i.e., main themes and patterns) were consistent with the qualitative data. Where applicable, the findings from the worksheets and interviews were analyzed to determine consistency with the national standards on teachers' dispositions toward problem solving.

Major Findings Related to the Literature

This study applied Wilkerson and Lang's (2007) five-step DAATS model and principles of affective measurement to an exploration of secondary mathematics teachers' dispositions toward problem solving. This section reports the major findings for each central research question and implications for current theory on teachers' dispositions.

Central Research Question One

This study sought to generate observable behaviors, attitudes, and practices that are likely to be consistent with secondary mathematics teachers exhibiting positive dispositions toward problem solving. Not surprisingly, since affective measurement, along with Wilkerson

and Lang's (2007) DAATS model, is grounded in the Krathwohl and Bloom's (1956) Affective Domain, the findings in this study align closely with the literature on affective measurement and the hierarchical levels of the Affective Domain. The findings that align with the research literature include (a) the significance of framing teachers' dispositions along a continuum, (b) dispositions as a juxtaposition of attitudes, values and beliefs, and (c) significance of and overlap between the normative and behavioral science approaches toward dispositions.

Teachers' dispositions along a continuum. In the original Affective Domain taxonomy, Krathwohl and Bloom (1956) defined five categories useful in describing affective characteristics of individuals: *receiving*, *responding*, *valuing*, *organizing*, and *characterizing*. As a result of more recent research on measurement and evaluation of teachers' dispositions, a sixth category *unaware* was added at the base of the taxonomy for assessment purposes (Wilkerson, 2012). The *unaware* level emerged out of the necessity to describe teachers who are not yet at the *receiving* level. These teachers have not considered a particular skill in any meaningful way or may actually be opposed to the skill. As part of this study, participants were prompted to describe teachers at the *unaware* level and at each of the original five levels of the Affective Domain.

The findings of this study confirm that distinct beliefs, attitudes and practices that are helpful in distinguishing between teachers at the various levels exist. For example, participants' descriptions of teachers' dispositions toward problem solving at the *unaware* and *receiving* levels were noticeably distinct. Participants described teachers at the *unaware* level as discouraging, oppositional, and lacking in confidence. Participants described teachers at the *receiving* level as aware, able to articulate, and showing interest in problem solving, even if they may be uncertain about or get lost in the problem-solving process. This study confirmed the necessity of the *unaware* level within the Affective Domain for the purpose of assessing

teachers' dispositions. Similarly, participants described teachers at the *organization* level as consistently and routinely encouraging students throughout the problem-solving process, questioning and soliciting responses from students, and expecting *nearly all* students to solve problems. Participants described a teacher at the *characterization* level as equivalent to a teacher at the *organization* level but with more intention and explicitness in their expectations for *all* students. However, participants' responses did not reveal the full spectrum of the *characterization* level in the Krathwohl and Bloom (1956) taxonomy, i.e., the compulsive and pervasive nature of teachers' behaviors at this level.

As in any continuum, participants' descriptions of teachers at the extreme levels in the Affective Domain taxonomy were entirely distinct. Descriptions of teachers at the lowest levels (i.e., *unaware* and *receiving*), when compared to descriptions of teachers at the highest levels (i.e., *organization* and *characterization*), were strikingly different, as evidenced in participants' selections of verbs and adverbs used to describe teachers at these two extremes. In contrast, teaching behaviors at adjacent levels in the middle of the taxonomy (e.g., *valuing* and *organizing*) were not as noticeably different from each other. The difficulty of differentiating between the taxonomic levels was evident, at times, in participants' responses. For example, when describing teachers' dispositions toward problem solving at the *responding* level, participants used phrases such as "willingly complies", "wants success", "actively participates", "shows interest in", "enjoys problem solving", "wishes to contribute", "actively monitors", and "sufficiently trained" (see bold type in Table 26). These phrases, while indicating responsiveness, are more consistent with the *valuing* level of the original Affective Domain. Similarly, when describing teachers' dispositions toward problem solving at the *valuing* level, participants used phrases such as "uses consistently", "creates an environment", "tolerates diversions", "looks for ways", and "understands how" (see bold type in Table 28). Again, these phrases, while

indicating teachers who *value* problem solving, are more consistent with the *organization* level of the original Affective Domain. In particular, Beth's descriptions of teachers' dispositions at the *valuing* level might cross the boundary between *valuing* and *organization* when she stated that monitoring and reflection are "part of the class routines" and described a community that "creates new resources that can be used in the future." The difficulty of differentiating between adjacent taxonomic levels will be revisited in the implications for action and recommendations for further research.

This study generated an affective continuum that provided additional insight into Beyers' framing of dispositions in terms of dispositional cognitive, affective and conative mental components and emphasizes the equal footing and interplay between thoughts, feelings and actions (2011). Participants' descriptions of teachers at the lower levels of the Affective Domain emphasized thought as a foundational piece, with feeling and action becoming increasingly noticeable when proceeding up the continuum from *unaware* to *characterization*. The findings of this study, particularly in relation to behavioral and affective tendencies of teachers at the extreme levels of the Affective Domain continuum, aligned with the conceptualization of dispositions as recurrent tendencies that distinguish an individual from others (APA, 2007).

Defining dispositions. Participants in this study generated a set of observable behaviors that are likely to be consistent with secondary mathematics teacher exhibiting positive dispositions toward problem solving (see Table 19). Not surprisingly and primarily a result of the design of the study, the findings confirmed that dispositions are a combination of "attitudes, values, and beliefs that influence the application and use of knowledge and skills" (Wilkerson & Lang, 2007, p. 2). This study generated indicators that confirmed dispositions as a combination of values, attitudes and beliefs (Wasicsko, 2006). Furthermore, participants described teachers'

habits of mind and behavioral tendencies in manners consistent with dispositions as framed by Jung (2004) and Thornton (2006).

Participants in this study generated descriptors for teachers' thoughts, feelings and actions at the five levels of Krathwohl and Bloom's (1956) Affective Domain along with descriptors for teachers at the sixth level (i.e., *unaware*) added for assessment purposes (Wilkerson, 2012). The descriptors confirmed dispositions as a composition of cognitive, affective and conative patterns of behaviors (Beyers, 2011; NCMT, 1989). Participants' variety of descriptors was consistent with Beyers' inference of dispositional cognitive, affective and conative mental functions (2011). Participants' descriptions of teachers at the six levels were consistent, particularly at the higher levels, with the definition of conation rooted in the historical, tripartite view of mental processes as a combination of cognition, affection and conation, where conation connects knowledge and affect and represents the mental and behavioral tendencies of teachers to act or strive to act in the classroom (Snow & Jackson, 1994). The participants consistently described a variety of thought processes, feelings, attitudes and inclinations to act purposefully at each level with a greater emphasis on *inclinations to act* when describing teachers at the highest levels of *organization* and *characterization*. According to participants' descriptions, teachers' efforts in the classroom, along with teachers' levels of professional commitment, increased from nothing at the *unaware* level to intentionality and devotion at the *characterization* level. This affirmed that dispositions manifest as a "pattern of behavior that is exhibited frequently and in the absence of coercion and constituting a habit of mind under some conscious and voluntary control, and that is intentional and oriented to broad goals" (Katz as cited in Wilkerson & Lang, 2007, p. 9). Similarly, this finding supported the perception that teacher candidates' dispositions should theoretically "deepen as [they] develop

the understanding and skill that support, for example, a disposition to work to meet the needs of all learners in a class” (Diez, 2007, p. 198).

Finally, the descriptions of teachers at the higher levels of the taxonomy were consistent with the NCTM expectation that positive dispositions would not only manifest as constant positive attitudes toward the expectation, but would also actualize in the classroom as a pattern of behavior that is exhibited frequently, consciously, intentionally and voluntarily. Snow (1980) suggested that researchers would need to synthesize cognition, affect and conation in order to define a theoretical framework for examining intelligent behavior in the real world. This study examined secondary mathematics teaching behaviors in the classroom setting as a composition of these three mental functions. Participants’ descriptions of teachers’ dispositions at the various levels of the Affective Domain (see Appendix D) produced an operational synthesis of cognition, affect and conation that has the potential to assist in closing the often-noticed gap between teachers’ abilities and their actions (Ritchart as cited in Thornton, 2006).

Normative approach toward dispositions. This research study was an examination of dispositions toward problem solving from a normative theoretical perspective (Burant, Chubbuck, & Whipp, 2007; Noddings, 1992; Van Manen, 2000; Osguthorpe, 2008; Birmingham, 2009). Therefore, participants naturally confirmed that secondary mathematics teachers should demonstrate positive dispositions toward problem solving simply because of the inherent value of problem solving in the study of mathematics (i.e., normative approach to dispositions). Furthermore, the participants confirmed the necessity of aligning values to national standards and expectations in order to assess teachers’ dispositions toward problem solving (Wilkerson & Lang, 2007).

Participants’ descriptions of teachers at the higher taxonomic levels of the Affective Domain (i.e., *valuing, organization, characterization*) also confirmed that students of these

teachers would be expected to have more productive dispositions toward problem solving in comparison to students of teachers at the lowest levels (i.e., *unaware* and *receiving*).

Participants' descriptions of teachers at each level revealed that teachers' approaches to problem solving instruction, problem selection, students and problem solving assessment at the *unaware* and *receiving* levels differed significantly in comparison with teachers' approaches at the *organization* and *characterization* levels. Similarly, participants' descriptions of what students would be doing (or would not be doing) at the *unaware* and *receiving* levels differed significantly in comparison with what students would be expected to do by their teachers at the higher levels of the Affective Domain. The findings are consistent with examining dispositions from both a normative approach (i.e., intrinsic value) and behavioral science approach (i.e., instrumental value). After all, teachers exhibiting positive dispositions toward problem solving would be expected to value students' productive dispositions toward problem solving. Assuming teachers at the higher levels of the taxonomy (i.e., *organization* and *characterization*) would be deemed accomplished teachers of problem solving by the NBPTS, the observable actions of teachers at these levels imply an impact on students that is consistent with the behavioral science and normative theoretical framework underlying the NBPTS expectations of teachers of mathematics (2001).

Central Research Question Two

This study sought to develop an assessment framework to assess secondary mathematics teachers' dispositions toward problem solving using affective measurement methods at varying levels of inference. In order for an assessment framework to be considered valid, assessors must be confident that they are able to abstract from observable behaviors the identified construct, i.e., secondary mathematics teachers' positive dispositions toward problem solving. Two findings that aligned with the related literature were the significance of (a)

assessing dispositions at varying levels of inference and (b) using dispositions assessment as a tool for teacher development.

Assessing dispositions at varying levels of inference. Wilkerson and Lang (2007) emphasized the importance of being able to “move up the confidence ladder” when assessing teachers’ dispositions using affective measurement techniques (p. 32). Advantages and disadvantages are apparent for each rung on this ladder. For example, while a belief scale might be easy to score, this measure provides limited confidence since the teacher may be able to fake responses. An observation, on the other hand, is more challenging to score, yet provides the most confidence since the teacher is not able to fake performance.

As a result of this study, indicators of secondary mathematics teachers’ positive dispositions toward problem solving were generated (see Table 19) from participants’ responses along with corresponding methods of assessment (see Tables 33-38). For example, the third general indicator described teachers with positive dispositions toward problem solving as valuing a risk-free problem-solving environment that encourages all students. Indicator 3.6 described teachers who believed every student was capable of solving rigorous mathematical problems. Participants’ responses indicated that scales, teacher questionnaires (or interviews), student focus groups, performance observations and situational analysis tests could be useful in assessing this indicator. Participants’ responses also revealed that performance observation would be an essential method for measuring the indicator. Table 39, adapted from Wilkerson and Lang’s (2007) descriptions of methods for assessing dispositions, provides a summary of methodologies, sample items, scoring ease and confidence levels for assessing *Indicator 3.6* that could be developed from the assessment framework that resulted from this study.

Table 39

Summary of Methodologies, Sample Items, Scoring Ease and Confidence Levels for Indicator 3.6

Methodology	Sample Items	Scoring Ease	Confidence Level
Scale	Agree/Disagree: “Every student is capable of solving mathematical problems.”	Easy to score	Limited confidence as the teacher could have guessed
Questionnaire	Describe a teaching and learning situation where students were given a rigorous mathematical problem. What happened?	Medium difficulty in scoring	Increased confidence as the teacher could have copied
Interview	How do you typically select mathematical problems for different students or groups of students?	Medium difficulty in scoring	Increased confidence even though the response could still be faked
Focus Group	Tell me about the problems your teacher asks you solve. What does your teacher do to encourage you to solve problems? What does your teacher do when you get “stuck” while solving a problem?	Difficult to score with much happening concurrently	Most confidence as the students’ responses cannot be faked
Observation	Frequency count of teacher providing students with rigorous mathematical problems or teacher recognition of students’ capacity to solve problems.	Difficult to score with much happening concurrently	Most confidence as the teacher cannot fake performance
Situational Analysis Test	Teacher is asked to respond to a hypothetical scenario where a student is struggling to solve a rigorous math problem.	Difficult to score due to wide range of possible responses	Most confidence provided teaching values surface in response

Participants’ responses consistently specified the necessity to employ a variety of assessment methods in order to have increased levels of inference and confidence when measuring each indicator of teachers’ dispositions toward problem solving. Participants’ responses also revealed performance observation as the top rung of the confidence ladder

when assessing teachers' dispositions. They identified other methods (i.e., student focus groups, scales, teacher questionnaires and interviews, situational analysis tests) as valuable means in assessing teachers' dispositions toward problem solving.

Participants did not view event reports as a particularly useful method in assessing teachers' dispositions toward problem solving. Andrew viewed an event report as indicative of an incident where the teacher's behavior would be in opposition to the desired behavior. He did not believe an event report would yield useful results since lots of people, including him, do "stupid things that they do not really value." Similarly, Cathy felt the event report should mainly be "reserved for ferreting out teachers who have negative disposition toward problem solving." She believed that a teacher should be counseled out of the profession only if multiple reports surface. Participants' lackluster responses to relying on event reporting in assessing teachers' dispositions were consistent with the literature on affective measures, of which event reporting is not a formal method for measuring affect (Wilkerson and Lang, 2007; Hopkins, 1998).

Participants suggested five additional assessment methods for inclusion in the assessment framework: student work samples, student questionnaires, lesson plan samples, annotated teacher journals and video analyses. Additionally, Anna found herself not using the event report option very often when responding to Worksheet 2.3. She wondered if there was an assessment using both examples and non-examples of the indicator that would be a better means than event reporting when assessing teachers' dispositions toward problem solving. These methods could provide increasing levels of inference and confidence and are discussed in the recommendations for further research.

Using dispositions assessment for teacher development. Five of the six participants currently work in the field of mathematics teacher education. Therefore, it is not surprising that participants concurred that methods for assessing dispositions would be meaningful as tools for

professional development (Murrell, et al., 2010). Wilkerson and Lang (2007) identify several reasons to assess teachers' dispositions (pp. 43-44). These purposes include certification and licensure of a teacher, ensuring a common set of values, improving the performance of individual teachers, and receiving national accreditation or recognition. When looking to make decisions about individual teachers, teacher educators hope for the opportunity to diagnose and remediate dispositional problems that could ultimately impact children (p. 43-44). Severe dispositional problems can lead to the denial or revocation of a teacher's certificate. "If the usage decision includes the possibility of denying graduation or rehire (high stakes), then the assessment developers need to spend much more time on designing the system to ensure that has psychometric integrity" (p. 45). Step 5 of the DAATS model (2007) addresses this usage.

Jane, Andrew and Beth talked at length about the potential of the system to have a variety of purposes depending upon whether teachers are in pre-service selection, preparation, graduation, or in-service/professional development phases of their careers. According to Beth, professional development could provide experiences for individual teachers to see their scores as this might assist teachers in setting professional development goals based on their individual strengths and challenges. Andrew added that the system could identify teachers who have positive dispositions toward developing themselves in the future. These findings are consistent with the call for teacher educators to share their wisdom and make their methods of using assessments for purposes of development more visible in order to benefit prospective teachers in forging their professional identities and serve as a resource to the field (Murrell et al., 2010, p. 199). Additional findings consistent with using methods for assessing dispositions for teacher development are provided during a discussion of the relationship of the findings to current theoretical perspectives on dispositions.

Central Research Question Three

This study sought to develop an assessment framework for selecting existing instruments (or designing future instruments) to measure secondary mathematics teachers' dispositions toward problem solving. In order to answer this research question, DAATS Step 3 would need to be undertaken. Therefore, the results of this study did not adequately answer the third central research question. However, the results of the study put forward for consideration implications for practice in terms of creating instruments aligned with the standards and consistent with the assessment framework. Table 39 suggested possible methodologies, sample items, scoring ease and confidence levels for assessing the extent to which teachers believe that every student is capable of solving rigorous mathematical problems. Similarly, this process could be repeated for other indicators and for various methodologies. Participants' responses to the sample items would allow assessors to infer the affective taxonomic level where teachers' commitment to problem solving resides. Suggested by the findings of this study, Table 40 suggests possible methodologies and sample items for assessing the extent to which a teacher is committed to providing tools to students at all times (indicator 4.2). It is left as an exercise to the reader to surmise secondary mathematics teachers' possible responses to the sample items and align them with the six affective domain levels (i.e., *unaware*, *receiving*, *responding*, *valuing*, *organization*, and *characterization*) as proposed in Figures 4 through 8. Like the proof of Fermat's last theorem, this exercise is too large to fit in the margins of the pages of this dissertation!

Even though participants' responses to *Indicator 4.2* on Worksheet 2.3 specified that event reports would not be as useful as other affective measurement techniques in assessing this indicator, a sample event report is included in Table 40 to illustrate Cathy's affirmation that event reports could be used to "ferret out" teachers with negative dispositions toward the use

of tools, including technology, in problem solving, particularly as this indicator applies to *all* students. Based on the findings of this study, assessment methodologies at varying levels of inference and sample items could be generated for every indicator of secondary mathematics teachers' positive dispositions toward problem solving.

Table 40

Summary of Affective Domain Levels, Methodologies and Sample Items for Indicator 4.2

Methodology	Sample Item
Event Report	Verbal remark or written reflection indicating a negative attitude toward technology, or a belief that tools, in general, are a "crutch" for students, when solving problems.
Scale	Agree/Disagree: "In general students should solve problems by hand, without the use of calculators."
Scale	Agree/Disagree: "The best teachers provide students with a variety of tools, including technology, to solve problems."
Questionnaire	Describe tools you have used or witnessed others use to solve problems. To what extent were the tools helpful?
Questionnaire	Describe a recent classroom experience where students used tools to solve problems.
Interview	How often, and under what circumstances, do you allow students to use tools, including technology, to solve problems? How do you decide which tools will be available for different students or groups of students when solving mathematical problems?
Focus Group	Tell me about the tools your teacher allows you to use to solve problems. Does your teacher encourage you to use technology to solve problems? Do you have choice in selecting tools for solving problems?
Observation	Frequency count of teacher providing students with a variety of appropriate tools to solve problems or remarks toward students to use tools
Situational Analysis Test	Teacher is shown a picture of a student using a particular tool to solve a math problem and asked what she sees.

Relationship of Findings to Current Theoretical Perspectives on Dispositions

The findings of this study align with aspects of current theoretical approaches to teachers' dispositions and their respective approaches to assessing teachers' dispositions toward problem solving. Current theoretical approaches to teachers' dispositions include the social cognitive (Breese & Nawrocki-Chabin, 2007), perceptual (Wasicsko, 2007), constructivist-developmental (Oja & Reiman, 2007), teachers' dispositions in context (Freeman, 2007), and teacher formation (Hare, 2007) perspectives. What follows are implications for practice that align with the five theoretical perspectives on dispositions along with a discussion of the relationships between the findings of this study and the expectations set forth by national organizations (e.g., NCTM, NBPTS).

The social cognitive perspective toward dispositions emphasizes the significance of teacher candidates' self-awareness and reflection. According to Breese and Nawrocki-Chabin (2007), prospective teachers must be nurtured, observed and provided feedback so that they are consciously aware of positive teaching behaviors and can reflect and grow from them (p. 35). The indicators of secondary mathematics teachers' positive dispositions toward problem solving (see Table 19) along with the descriptions of teachers at the highest levels of the Affective Domain (see *organization* and *characterization* levels in Figures 7 and 8) provide a rich set of teaching behaviors that mathematics teacher educators might use to assist prospective teachers in recognizing dispositions in others as well as in themselves. Furthermore, the descriptions of teachers' dispositions at all levels of the original Affective Domain, along with the sixth level added for assessment purposes (i.e., *unaware*), provide an opportunity for teacher educators to nurture, observe and provide feedback to teacher candidates at all levels of the Affective Domain taxonomy.

Foundational to the perceptual approach toward dispositions is the significance placed on an individual teacher's perception of self, others, the world and the nature and purpose of teaching. According to Wasicsko (2007), the identification, development and assessment of teachers' dispositions should be based to a great degree on teacher reflection and self-assessment. The indicators of secondary mathematics teachers' positive dispositions toward problem solving (see Table 19) along with the descriptions of teachers at the highest levels of the Affective Domain (see *organization* and *characterization* levels in Appendix D), provide a rich set of positive teaching behaviors that prospective teachers might use to ensure that self-assessments match assessments made by peers, professors, mentors and clinical faculty. This study sought to develop an assessment framework for selecting existing instruments (or designing future instruments) to measure secondary mathematics teachers' dispositions toward problem solving. The instruments and sample items that could be generated using the assessment framework could be employed as a "reality check" for prospective teachers in self-assessing their dispositions toward problem solving.

The constructivist developmental perspective toward teachers' dispositions highlights the significance placed on nurturing and assessing the development of teachers' dispositions (Oja & Reiman, 2007). Within this theoretical perspective, teachers' dispositions are conceptualized developmentally. Early in this study, Beth asserted her belief that teachers are generally on a developmental continuum and will need someone who understands the continuum and is able to help support them and move them along the continuum. Furthermore, each of the six participants, to varying degrees, emphasized using assessment data for the purpose of teacher development, as summarized in Table 16. The assessment framework that resulted from this study could support mathematics teacher educators in the collection of, analysis of, and reflection on data related to teacher candidates' dispositions toward problem

solving. In turn, this process could assist prospective teachers in developing a professional growth plans that would likely result in more positive dispositions toward problem solving.

The teachers' dispositions-in-context perspective emphasizes the significance placed on finding dispositional evidence through the actions of teachers across contexts and as a pattern of behavior over time (Freeman, 2007). From this perspective, dispositions are a process rather than concepts or objects to attend to. Similar to the constructivist developmental perspective toward teachers' dispositions, the results of this study supported the view that secondary mathematics teachers' dispositions toward problem solving are traits to develop in teachers rather than abstract notions to address.

The teacher formation perspective toward dispositions stresses the significance placed on dispositions formation as a process that focuses on a "series of discernments" about personal identity, integrity and the Self in relationship to the role of the teacher (Hare, 2007). Viewing educators' dispositions from a teacher formation stance, Hare suggests that teachers ultimately teach who they are and from the Selves they are disposed to be rather than from the Selves that external forces maintain they are supposed to be (p. 143). The teacher formation perspective toward dispositions presents an interesting conundrum with respect to the findings of this study. This study sought to generate observable behaviors, attitudes, and practices that are likely to be consistent with secondary mathematics teachers' exhibiting positive dispositions toward problem solving. The behaviors, attitudes and practices were based on national expectations and standards. Participants' responses indicated that the resulting assessment framework that correlated dispositional indicators to affective measurement methods, at varying levels of inference, would be a valuable tool for teacher development. While this finding was consistent with the inherent features of the teacher formation perspective, the assessment

framework would be deemed an external force that indicates who teachers who are supposed to be with respect to exhibiting positive dispositions toward problem solving!

Finally, while the CCSS-M is increasingly overshadowing the expectations of other national organizations (i.e., NCTM), the findings of this study confirmed that to some extent all national expectations are viable when examining teachers' dispositions and laying the foundation for an assessment framework designed to measure secondary mathematics teachers' dispositions. Some sets of expectations include explicit standards for teachers' dispositions with few illustrative classrooms examples. Other sets fail to include explicit references to dispositions toward problem solving, but they provide the reader with a plethora of illustrative classroom examples of teachers' beliefs, attitudes and practices. This study built upon all relevant sets of national standards in order to generate an assessment framework. For example, the broad themes that were drawn from participants' descriptions of teachers' dispositions toward problem solving, particularly at the higher levels of the Affective Domain (i.e., *organization* and *characterization*), were consistent with an attention to equity, use of a stimulating curricula, effective teaching, commitment to learning with understanding, use of various assessments and use of various teaching tools including technology as described in the *NCTM Program Standards for Initial Preparation of Mathematics Teachers: Standards for Secondary Mathematics Teachers* (2003). Additionally, participants expected teachers with positive dispositions to be proactive members of a professional community and strong communicators with students (NCTM, 2003, p. 1).

Participants' descriptions of teachers' approaches to problem-solving instruction and students at the *organization* and *characterization* levels were also consistent with the 2012 NCTM CAEP version of the program standards for initial preparation of mathematics teachers. This more recent version expects teacher candidates to support the continual development of

students' productive dispositions toward mathematics. Given that the individuals tasked with revising the program standards were probably more positively disposed toward problem solving, this expectation was not surprising. However, it is important to recognize that the findings of this study aligned with the current knowledge base on secondary mathematics teachers' dispositions.

Two important ways in which this study contributes to the current knowledge base is by elaborating on teaching behaviors that (1) are consistent with a positive disposition toward problem solving and (2) indicate positive disposition is missing. As a result of this study, there exists an assessment framework that goes beyond vague references to *positive dispositions* and qualifies dispositions in terms of observable behaviors. The assessment framework and participants' descriptions of teachers' dispositions at each affective level (see Appendix D) assist with the identification of how teachers with positive dispositions toward problem solving are likely to act. Using this assessment framework, mathematics teacher educators can select assessment methods, at varying levels of inference, to describe secondary mathematics teachers' dispositions toward problem solving based on their observable behaviors.

Surprises

Several surprises emerged from the findings of this study. Throughout the course of this study, it was impossible for the researcher to resist stepping into the role of assessor of teachers' dispositions. As a result, participants' and the researcher's dispositions toward mathematics and problem solving were examined through the lens of affective measurement.

Wilkerson and Lang (2007) asserted that, by acknowledging the interrelatedness of knowledge, skills and dispositions, assessors are able to "acquire the cognitive understanding and affective values they need to move toward a more comprehensive and meaningful approach to teacher assessments" (p. 6). Ultimately, teachers' dispositions "may very well be

the most important element in the assessment framework” (p. 7). Purposeful sampling was employed to select participants who were highly knowledgeable about and skillful in doing and teaching mathematics. The researcher hoped that the resulting pool would be replete with participants exhibiting positive dispositions toward mathematics and the problem-solving process.

When asked why they chose a career in mathematics teaching and/or teacher education, participants’ responses consistently hinted at positive dispositions toward mathematics and problem solving (see phrases in bold type in Table 10). Jane talked about her enjoyment of school, love of mathematics and her natural ability to explain to students how to solve problems using own ways to a solution. Cathy described her inspiration to pursue a mathematics degree and how she was “meant to be a teacher” and how she really wanted to make a difference in how mathematics was taught. Anna *always* knew that she liked mathematics, wanted to be a teacher and referred to teaching as a calling, particularly with respect to preparing stronger teachers for rural areas. Beth answered her call to teach by sharing her love of mathematics with students and helping teachers become better teachers. Similarly, Andrew’s inspiration for teaching has been to help others see the connections between language and mathematics that he has so thoroughly enjoyed. Finally, Dumaine has always loved and enjoyed mathematics and has found it fun to help others understand it.

Moreover, all participants were committed to voicing their thoughts on secondary mathematics teachers’ dispositions throughout each step of this study, and many were voiced! Not a single participant dropped from the study. Although participants were *not* selected for their expertise in teachers’ dispositions or affective measurement, they appeared to value and show commitment to exploring these concepts throughout the study. This commitment reminded the researcher of dispositions defined as a “pattern of behavior that is exhibited

frequently and in the absence of coercion and constituting a habit of mind under some conscious and voluntary control, and that is intentional and oriented to broad goals” (Katz as cited in Wilkerson & Lang, 2007, p. 9). Participants consistently demonstrated, at each step in the study, patterns of behavior that were exhibited frequently and under voluntary control and were intentional and oriented toward the broad goal of this study.

This study also served as a “reality check” for the researcher in self-assessing her dispositions toward problem solving. As a result, the researcher was reminded of the state of her dispositions toward problem solving as evidenced through observable behaviors. An informal self-assessment based on participants’ descriptions of teachers’ dispositions at the six levels revealed her approach to problem-solving selection and students to be higher up the disposition ladder than her approach to instruction and assessment (see Appendix D and Figures 4 through 8). While she tended to seek out problems that promoted connections within mathematics, across disciplines and to the real world, she did not consistently introduce all content through problem solving. While she prioritized encouraging feedback as a major part of her interactions with students, she did not naturally think about both content and dispositions as she designed and analyzed student assessments. Through this informal self-assessment, the researcher also learned that she preferred not to attain the distinction of a teacher at the *characterization* level, as this extreme might be exhausting to attain. Wilkerson and Lang (2007) reasoned that although we might be “even happier” with a teacher at the *characterization* level, in comparison to one at the *organization* level, this teacher would either be a “major asset” or a “high risk for retention” as she would be approaching a dangerous level of planning or with respect to the focus of this study: problem solving instruction (p. 26). The researcher desired very much so to be the teacher described by participants at the *organization* level, but she was not entirely this teacher . . . yet!

Conclusions

Dispositions, although challenging to define and assess operationally, are a significant construct in the field of teacher education. The debate about dispositions is apparent through an increase in research and scholarly articles in the teacher education literature. The importance of assessing teachers' dispositions is evident in the NCATE and CAEP processes applied to evaluation of teacher education programs, in the expectations outlined by the NBPTS for certification as an accomplished teacher, and in the hiring and selection process of teachers (Vergari & Hess, 2002; NBPTS, 2002; Wasicsko, 2004). An assessment framework designed to assess secondary mathematics teachers' dispositions toward problem solving could serve the accreditation, certification, professional development and research goals of individuals working in the field of mathematics education.

Implications for Practice

The results of this study have the potential to impact mathematics teacher education programs by providing an assessment system for mathematics teacher educators to examine and identify the nature of secondary mathematics teachers' dispositions toward problem solving and, when necessary, identify inclinations that are inconsistent with positive dispositions toward problem solving and, if possible, remediate them. In turn, the results of this study have the potential to impact secondary mathematics teachers and their students. The assessment framework that resulted from this study can assist faculty in responding to the national expectations related to secondary mathematics teachers' dispositions. The assessment framework and descriptions of typical teaching behaviors at each taxonomic level of the Affective Domain provide mathematics teacher educators with additional tools to assist in the assessment and development of secondary mathematics teachers' dispositions toward problem solving.

The findings of this study also contribute to the dialogue on dispositions in teacher education by providing initial responses to three essential questions posed by Stooksberry (2007) as they apply to secondary mathematics teachers' dispositions. First, mathematics teachers and teacher educators need common definitions secondary mathematics teachers' positive dispositions toward problem solving if an assessment framework is to be designed to measure the construct. Second, any assessment framework designed to assess teachers' dispositions toward problem solving should ultimately be systematic and developmental. The system should provide multiple opportunities for teachers and teacher candidates to demonstrate the positive dispositions toward problem solving expected of highly skilled professionals. Third, the assessment framework should provide teachers and teacher candidates with evidence of their strengths, weaknesses, and growth over time.

By responding to Stooksberry's questions, the theoretical framework underlying this study could provide a practical structure for examining dispositions toward problem solving to support the development of secondary mathematics teachers. For example, this study generated a set of indicators of secondary mathematics teachers' positive dispositions toward problem solving and an assessment framework that mathematicians and mathematics teacher educators could use to cultivate *habits-of-mind* goals and dispositions that they desire in the teachers they are preparing (CBMS, 2001; CBMS, 2012). The results of this study could open up possibilities for creating undergraduate experiences that will allow future teachers to emerge with a more articulated sense of what it means to be positively disposed to problem solving.

Recommendations for Future Research

This research study employed the first two steps of the DAATS model (2007) with its accompanying tools and worksheets to develop indicators and select assessment methods as part of an assessment framework designed to measure secondary mathematics teachers'

dispositions toward problem solving. In theory, a comprehensive assessment framework containing multiple measures, at varying levels of inference, will more accurately describe teachers' dispositions toward problem solving. The assessment framework that resulted from this study is expected to change as developers create instruments, and items within instruments, aligned with the indicators of secondary mathematics teachers' positive dispositions toward problem solving. As instruments and items are developed and tested, the assessment framework would benefit from further refinement to ensure consistency and validity. In the process of refining the assessment framework and creating an overview of which indicators are covered and where the following questions could be explored along with a cost-benefit and coverage analysis of assessment methods (Wilkerson & Lang, 2007, p. 81):

- Is the indicator something that we must observe?
- Is the indicator something that we can ask teachers to self-report?
- Is the indicator something that we should ask children to tell us?
- Should we use a combination of assessment methods to measure the indicator?
- How many times do we need to check on an individual indicator before we have confidence that we have assessed what we want? (Wilkerson & Lang, 2007, p. 71)

In the process of refining the assessment framework, the additional assessments methods that were identified by participants in this study as useful in identifying teachers' dispositions toward problem solving could be explored further. Methods to explore include: (a) lesson plan analyses, (b) student questionnaires, (c) individual student interviews in conjunction with student focus groups, (d) annotated teacher journals, (e) video analyses and (f) student work samples in conjunction with a teacher's written or verbal reflections about the samples. However, not all of these methods are known measures of affect. Recall that, with the exception

of event reporting, the Wilkerson and Lang (2007) DAATS model includes commonly accepted measures of affect that can be scaled (Hopkins, 1998).

The examination of several questions posed by Osguthorpe (2008) and written in terms of dispositions toward problem solving would also be logical extensions to pursue. These strategies include interviewing participants to determine why we want teachers with positive dispositions toward problem solving, determining how positively disposed toward problem solving teachers need to be and deciding what to do if teachers exhibit negative dispositions toward problem solving. The primary purpose of this study was to develop and validate indicators of secondary mathematics teachers' positive dispositions toward problem solving. As a result, indicators of negative (or missing) dispositions were not a central focus in this study. However, they can be deduced from participants' responses to Worksheet 2.2 and participants' descriptions of teaching behaviors at the *unaware* level. Another area to pursue in future research would be to explore these indicators in more depth. Sherman (2013) described this process as follows:

Without looking a great deal at how candidates conduct themselves or by neglecting to piece together many snapshots, teacher educators may miss spotting a point of concern or ignore a suggestion of promise that could indicate either a troubling sign or signal a budding capacity for worthy teaching. Seeing candidates well enables teacher educators to be responsive to them because they may cultivate their potential as human beings in a general sense, and as teachers in a particular sense. They can ascertain what specific support may be needed, what additional experiences might be provided, or what explicit instruction can be given in order to move the candidate forward, enhance her potential, and assist his development (p. 128).

By developing and validating negative (or missing) dispositions, practitioners and researchers will be in a better position to diagnose and, if possible, remediate teachers' dispositions and, when necessary, exit teachers from the profession when their values are clearly in opposition to national, standards-based dispositions.

The third, fourth and fifth steps of the DAATS model are crucial to assessing and fostering the development of teacher candidates' dispositions and were beyond the scope of this study (see Table 6 in Chapter II). Faithfully completing DAATS Step 3 by creating instruments aligned with standards and consistent with the assessment framework, DAATS Step 4 by designing and implementing data aggregation, tracking and management systems, and DAATS Step 5 to ensure credibility and utility of the data, would be logical extensions of this research study. Developing instruments and testing them with secondary mathematics teacher and teacher candidate populations holds exciting possibilities for furthering the knowledge base of dispositions toward problem solving and would be consistent with the recommendation for teacher education programs to develop valid systems to assess teacher candidates' dispositions (Wilkerson & Lang, 2007; Diez, 2007).

In reviewing participants' responses to the Affective Domain worksheets, the researcher had not anticipated the difficulty of differentiating between the taxonomic levels, particularly neighboring levels in the middle of the continuum (i.e., *responding/valuing* and *valuing/organization*) as seen in participants' responses presented in Chapter IV (see participants' responses in bold type in Table 26 and 28). The delineation between adjacent levels blurred at times, and this difficulty should be revisited to either better delineate between adjacent taxonomic levels or collapse one or more of the levels if future studies reveal a strong rationale for doing so. Figures 4 through 8 provide an initial step in establishing typical teaching behaviors at each affective taxonomic level for each of the general indicators. However, the typical teaching behaviors at each taxonomic level would benefit from further refinement and validation before assessment methods and rubrics are developed and reviewed.

Finally, the assessment framework and typical teaching behaviors at each taxonomic level of the Affective Domain provide researchers in the field of mathematics teacher education

with additional tools to assess secondary mathematics teachers' dispositions toward problem solving. Future studies might apply the DAATS model in the assessment of students' dispositions toward mathematics. As a result of this study, and its approach to dispositions, researchers will be better equipped to design studies that investigate the relationship between secondary mathematics teachers' positive dispositions toward problem solving and the development of students' productive dispositions toward problem solving.

Concluding Remarks

This study examined the application of Wilkerson and Lang's (2007) Disposition Assessment Aligned with Teacher Standards (DAATS) model in the development of an assessment framework to be used to select existing instruments or design future instruments to assess secondary mathematics teachers' dispositions toward the mathematical problem solving. This study produced four major results. First, participants reached consensus on the purpose, use and content of an assessment framework designed to measure secondary mathematics teachers' dispositions toward problem solving (see Figure 3). Second, participants assisted in the development of indicators of secondary mathematics teachers' positive dispositions toward problem solving (see Table 19). Third, participants' responses generated a list of typical teaching behaviors for each general indicator and for each taxonomic level of the Affective Domain (see Figures 4 through 8). Fourth, participants assisted in the development of an assessment framework that correlated indicators with methods for assessing affect at varying levels of inference (see Tables 33-37). The four major results correspond directly to the four refined research questions that emerged from the central research questions that motivated the study.

The results of this study provide an opportunity for mathematics teacher educators to improve upon existing conceptualizations and assessment of teachers' dispositions through the use of affective measurement techniques that correspond to indicators of secondary

mathematics teachers' positive dispositions toward problem solving at varying levels of inference.

From the start of the study, the researcher grappled with a statement made by Wilkerson and Lang (2007) regarding the necessity of basing dispositional assessments on national standards, rather than morals and ethics:

Focusing on morality and ethics, rather than skill-based standards, is short-sighted, bordering, in our view, on the *real* immoral action, letting unmotivated teachers into the profession because of a failure to recognize the codependence of knowledge, skills, and dispositions (p. 13).

As the researcher read further, she found they supported assessment of dispositions that incorporated social justice, morality, and character education, but that they were advocating for embedding assessment of dispositions in a standards-based process. They were counseling us to look for the linkages between standards and morality. For example, the InTASC Model Core Teaching Standards (2011) delineates between knowledge, dispositions, and performances for each of the ten teaching standards, where "critical dispositions" are indicative of the "habits of professional practice and moral commitments that underlie the performances play a key role in how teachers do, in fact, act in practice" (p. 6).

Much of the work by Wilkerson and Lang (e.g., Englehart et al., 2012) demonstrated how standards-based assessment of dispositions can lead to effective interventions at the individual and program levels. This was consistent with the findings in this study. In writing about a legal battle lost by a college that had attempted to stop a student from graduating based purely on moral grounds (his belief in corporal punishment), Wilkerson and Lang (2007) stressed that a standards-based approach to assessing dispositions has the "teeth" to withstand scrutiny when intervention is not the preferred option:

We conclude that if we use the standards as a definition of the construct, rather than codes of ethics from professional or church-affiliated organizations, we stand a better chance of avoiding lawsuits, the wrath of the public, and the other consequences of

failing to cover the spectrum of teacher attitudes and values associated with a highly skilled professional. Our challenge becomes, then, how we identify, diagnose, and even dismiss a teacher whose values are clearly violations of standards-based dispositions. (pp. 13-14).

The researcher agreed that there is “much more to dispositions” than morals and ethics, particularly when ethics and morality are viewed from a religious standpoint. However, she recalled Parker Palmer’s (1995) reminder not to “think the world apart” by dissecting teachers’ dispositions into either-or choices. Throughout this study, the researcher attempted to “think the world together” by embracing opposites and appreciating the paradoxes within teachers’ dispositions and the complexity of the teaching practice. As she did this, she was reminded by Sizer and Sizer (1970) that she has a profound moral contract with her students, the teaching equivalent of the Hippocratic oath, whereby she is expected to practice the discipline she teaches, showing enthusiasm for the subject and serving as a “desirable model for a principled life” (pp. 15-16). She worried that thinking secondary mathematics teachers’ dispositions toward problem solving apart, into too many pieces (i.e., indicators) would result in her losing an integrative view of the construct and its place in the teaching landscape. She wondered if this process would diminish the profound moral contract that she held with her students and her. This contract inspired the central purpose of this study: to help the researcher ensure that mathematics teachers released into the classroom possess and practice the *right* attitudes, *right* values and *right* beliefs that are held to be important by practitioners in the field of mathematics education, outlined in national expectations, and in the best interests of our students.

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Appendix A

This appendix contains original worksheets from Wilkerson and Lang's (2007) *Assessing Teacher Dispositions: Five Standards-Based Steps to Valid Measurement Using the Disposition Assessments Aligned with Teacher Standards (DAATS) Model*. Worksheets adapted to the focus of this study (i.e., secondary mathematics teachers' dispositions toward problem solving) are inserted immediately following the original worksheets.

Below is a list of the original worksheets adapted for use with this study:

- Worksheet #1.1: Purpose, Use, Propositions, Content and Context Checksheet
(Wilkerson and Lang, 2007, pp. 55-56)
- Worksheet #1.2: Purpose, Use and Content Draft (p. 57).
- Worksheet #1.3: Propositions (p. 58)
- Worksheet #1.4: Contextual Analysis (p. 59)
- DAATS Chapter 2, Activity #2: Bloom and the INTASC Principles (p. 36)
- Worksheet #2.1: Organizing for Alignment (p. 76)
- Worksheet #2.2: Visualizing Dispositional Statement (p. 78)
- Worksheet #2.3: Selecting Assessment Methods for INTASC Indicators (p. 79)
- Worksheet #2.4: Assessment Methods for INTASC Indicators: Blueprint (p. 80)

DAATS STEP 1—WORKSHEET #1.1

Purpose, Use, Propositions, Content, and Context Checksheet

Explanation:

Complete this worksheet as your starting point for designing a disposition assessment process. Check all that apply and add your own as needed. Consider this as a rough draft.

Purpose:

- ☐ Ensure a common set of values in a population
- ☐ Improve the performance of individual teachers
- ☐ Improve teacher-training programs
- ☐ Impact the value systems of children (e.g., motivation to learn)
- ☐ Receive national accreditation or state program approval
- ☐ Encourage teachers to seek NBPTS certification
- ☐ Conduct research on teaching
- ☐ Justify funding of programs
- ☐ Select teacher candidates
- ☐ Demonstrate effectiveness of license or graduation decisions
- ☐ Other _____
- ☐ Other _____

Use:

- ☐ Advising or remediation only (low stakes)
- ☐ Program improvement (low stakes)
- ☐ Entry into the profession (graduation and licensure—high stakes)
- ☐ Continuation in the profession (rehire—high stakes)
- ☐ Other _____
- ☐ Other _____

(Continued)

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(Continued)

Content:

- _____ INTASC Principles
- _____ Locally defined values
- _____ State, district, and school standards
- _____ National professional association standards
- _____ Other _____
- _____ Other _____

Propositions or Principles:

- _____ Certain dispositions or affective traits are critical to effective teaching.
- _____ These dispositions can be identified and measured.
- _____ National standards and local missions and values contribute to the identification of these dispositions.
- _____ Measures of affect can be developed based on the standards identified and appropriate theories of affective measurement.
- _____ Teachers with high scores on affective measures are likely to be better teachers who can have a higher impact on K-12 learning.
- _____ Teachers with low scores on affective measures are likely to be poorer teachers who may cause harm to children.
- _____ Other _____
- _____ Other _____

Context:

- Faculty support level _____
- Fiscal resources available _____
- Personnel resources available _____
- Time available _____
- NCATE status _____
- Other _____

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DAATS Step 1 – Worksheet #1.1

Purpose, Use, Propositions, Content and Context Checksheet

Explanation:

Complete this worksheet as your starting point for designing a process to assess secondary mathematics teachers' dispositions toward the mathematical process of problem solving. Check all that apply and add your own as needed. Consider this a rough draft.

Purpose:

- _____ Ensure a common set of values in secondary mathematics teachers
- _____ Improve the performance of individual secondary mathematics teachers
- _____ Improve pre-service teacher preparation programs
- _____ Impact the value systems of children (e.g., motivation to learn)
- _____ Receive national accreditation or state program approval
- _____ Encourage teachers to seek NBPTS certification
- _____ Conduct research on teaching
- _____ Justify funding of programs
- _____ Select secondary mathematics teacher candidates
- _____ Demonstrate effectiveness of license or graduation decisions
- _____ Other _____
- _____ Other _____

Use:

- _____ Advising or remediation only (low stakes)
- _____ Program improvement (low stakes)
- _____ Entry into the profession (graduation and licensure – high stakes)
- _____ Continuation in the profession (rehire – high stakes)
- _____ Other _____
- _____ Other _____

Content:

- _____ NBPTS Adolescence and Young Adulthood Mathematics Standards for Teachers (2001)
- _____ NCATE/NCTM Program Standards for Initial Preparation of Secondary Mathematics Teachers
- _____ Other national professional association standards: _____
- _____ Other locally defined values _____
- _____ Other state, district, and school standards: _____
- _____ Other _____

Propositions or Principles:

- _____ A positive disposition toward problem solving is critical to effective mathematics teaching.
- _____ This disposition can be identified and measured.
- _____ National standards contribute to the identification of this disposition.
- _____ Local missions and values contribute to the identification of this disposition.
- _____ Using appropriate theories of affective measurement, measures of this disposition can be developed based on the standards and values identified.
- _____ Teachers with high scores on affective measures of this disposition are likely to be better teachers who can have a higher impact on students' productive disposition toward problem solving.
- _____ Teachers with low scores on affective measures of this disposition are likely to be poorer teachers who may harm students' productive disposition toward problem solving.
- _____ Other _____
- _____ Other _____

Context:

What external factors might impact the development and implementation of a process to assess secondary mathematics teachers' dispositions toward problem solving? Explain.

- Faculty support level: _____
- Fiscal resources available: _____
- Personnel resources available: _____
- Time available: _____
- NCATE status: _____
- Other: _____

DAATS STEP 1—WORKSHEET #1.2

Purpose, Use, and Content Draft

Explanation:

Write out a formal statement of your purpose(s). For each purpose, also write out a statement of how you will use the data and what the content of the assessment system will be. These should now be aligned. (Feel free to borrow from ours!) You may have more than three; use as many worksheets as you need or develop your own format.

	<i>Set #1</i>	<i>Set #2</i>	<i>Set #3</i>
Purpose: <i>Why are we assessing our teachers' dispositions?</i>			
Use: <i>What decisions will we make with our data?</i>			
Content: <i>What will we assess (e.g., standards)?</i>			

DAATS Step 1 – Worksheet #1.2

Purpose, Use, and Content Draft

Explanation:

Write out a formal statement of the purpose of assessing secondary mathematics teachers' dispositions toward problem solving. For each purpose, also write out a statement of how you will use the data and what the content of the assessment framework will be. These should now be aligned. You may have more than three; use as many worksheets as you need or develop your own format.

	Set #1	Set #2	Set #3
Purpose: Why would secondary mathematics teacher educators assess secondary mathematics teachers' dispositions toward problem solving?			
Use: What decisions could be made with the data? How could educators use the results?			
Content: What will be assessed? Which propositions and principles will serve as the foundation for our assessment framework?			

DAATS STEP 1—WORKSHEET #1.3

Propositions

Explanation:

Write out a formal statement of the propositions that will guide your work. Answer this question: "What are the fundamental truths about teaching and assessing dispositions that guide our thinking?" (Feel free to borrow from ours!)

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____

DAATS Step 1 – Worksheet #1.3

Propositions

Explanation:

Write out a formal statement of the propositions that will guide your work. Answer this question:

What are the fundamental truths about teaching and assessing secondary mathematics teachers' dispositions toward the mathematical process of problem solving?

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____

DAATS STEP 1—WORKSHEET #1.4

Contextual Analysis

Explanation:

Write out a formal statement of the context within which your assessment process will be built. Answer this question: "What are the factors that will help or hinder implementation of the envisioned assessment system?"

Factors that help:

Factors that hinder:

DAATS Step 1 – Worksheet #1.4

Contextual Analysis

Explanation:

Write out a formal statement of the context within which an assessment process for secondary mathematics teachers' dispositions will be built. Answer this question:

What are the factors that will help or hinder implementation of the envisioned assessment framework?

Factors that help:

Factors that hinder:

DAATS CHAPTER 2—ACTIVITY #2

Bloom and the INTASC Principles

Explanation:

Convene your faculty and assign them to nine work groups, one for each INTASC Principle except #7 on planning. Have them complete the taxonomy chart with a description of a teacher at each level of the taxonomy for the INTASC Principle assigned. Report out.

INTASC Principle: _____

<i>Affective Taxonomic Level</i>	<i>Description of Teacher at This Level</i>
<i>Receiving:</i> attends, becomes aware of an idea, process, or thing.	
<i>Responding:</i> makes response at first with compliance, later willingly with satisfaction.	
<i>Valuing:</i> accepts worth of a thing, prefers it, consistent in responding, commitment	
<i>Organization:</i> organizes values, determines interrelationships, adapts behavior to value system	
<i>Characterization:</i> generalizes value into controlling tendencies, integrates these with total philosophy.	

Affective Domain Taxonomic Levels Worksheets

Explanation:

The participants assisted in the completion of the taxonomy chart with a description of a secondary mathematics teacher at each level of the taxonomy for the standards identified during the first step of the study.

Principle or Standard: _____

<i>Affective Taxonomic Level</i>	<i>Description of Teacher at This Level</i>
<i>Prereceiving (Unaware):</i> has not considered; may be opposed	
<i>Receiving:</i> awareness of an idea, process, or thing; willingness to hear; selected attention	
<i>Responding:</i> active participation; attends and reacts to a particular phenomenon; makes response at first with compliance, later willingness with satisfaction	
<i>Valuing:</i> internalizes; accepts the worth of a thing and prefers it; consistent in responding; expresses commitment	
<i>Organization:</i> organized values into priorities; determines interrelationships; adapts behavior to value system	
<i>Characterization (Internalizing Values):</i> generalizes value into controlling tendencies; exhibits behaviors that are pervasive, consistent, predictable and characteristic; integrates values with larger philosophy	

Taxonomic chart adapted from:

- Krathwohl, D. R., Bloom, B. S., & Masia, B. B. (1973). *Taxonomy of Educational Objectives, the Classification of Educational Goals. Handbook II: Affective Domain*. New York, NY: David McKay Co., Inc.
- Wilkerson, J. R. (2012, January). Measurement and evaluation perspectives on scaling teacher affect with multiple measures. *The International Journal of Educational and Psychological Assessment*, 9(2), 165-191.
- Wilkerson, J. R., & Lang, W. S. (2007). *Assessing teacher dispositions: Five standards-based steps to valid measurement using the DAATS Model*. Thousand Oaks, CA: Corwin Press.

DAATS STEP 2—WORKSHEET #2.2

Visualizing the Dispositional Statements

Explanation:

List the behaviors you think demonstrate that a teacher has the values you are looking for, based on a specific standard. Then, list the behaviors that show the value is missing.

Standard or Principle: _____

List the indicators you can assess for this standard or principle. Use the model for critical thinking in this chapter. Underscore the words that show this is a disposition and not just a skill.

1: *The teacher* _____

2: *The teacher* _____

3: *The teacher* _____

4: *The teacher* _____

5: *The teacher* _____

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DAATS Step 2 – Worksheet #2.2

Visualizing the Dispositional Statements

Explanation:

List the behaviors you think demonstrate that secondary mathematics teachers exhibit positive dispositions toward the mathematical process of problem solving, based on a specific standard. Then, list the behaviors that show the attribute is missing.

Standard or Principle: _____

List the behavioral indicators you can assess for this standard or principle. Underscore the words that show this is a disposition and not just a skill.

1. *The teacher* _____
2. *The teacher* _____
3. *The teacher* _____
4. *The teacher* _____
5. *The teacher* _____

What behaviors show the disposition is missing?

DAATS STEP 2—WORKSHEET #2.3

Selecting Assessment Methods for INTASC Indicators

Explanation:

Write the word *yes*, or place a check mark, in each cell where you think you might create an item for the indicator. If you think of another method for one of the indicators, note it next to the indicator number.

Indicator	Scale	Questionnaire	Focus Group	Event Report	Observation
1.1					
1.2					
1.3					
1.4					
2.1					
2.2					
3.1					
3.2					
3.3					
3.4					
3.5					
4.1					
4.2					
5.1					
5.2					
5.3					
5.4					
5.5					
6.1					
6.2					
6.3					
6.4					
7.1					
7.2					
7.3					
8.1					
8.2					
9.1					
9.2					
9.3					
9.4					
9.5					
10.1					
10.2

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DAATS Step 2 – Worksheet #2.3

Selecting Assessment Methods for Behavioral Indicators

Explanation:

Place a check mark in each cell where you think you might create an item for the indicator. If you think of another method for one of the indicators, note it next to the indicator number.

<i>Indicator</i>	<i>Scale</i>	<i>Questionnaire</i>	<i>Focus Group</i>	<i>Event Report</i>	<i>Observation</i>	<i>Situational Analysis Test</i>

Supplemental Protocol for Worksheet #2.3

For each indicator, decide the extent to which each assessment method would be useful in assessing the indicator in secondary mathematics teachers. Classify each method as:

1. MUST (or should) be used
2. COULD be used, or
3. would NOT be useful

If you think of other methods of assessment for any of the indicators, please note this at the end of the form in the open response section.

Below are examples of the assessment methods listed below each indicator.

Scale (e.g., attitudinal scales, Likert scales, rating scales)

Questionnaire (e.g., written set of questions, teacher interview)

Focus group (e.g., questions answered by students in a small group setting)

Observation (e.g., classroom observation, behavioral checklist)

Event Report (e.g., report of a behavior that is in opposition to the indicator)

Situational Analysis Test (i.e., teachers are asked to interpret a situation, picture, or video they are shown)

DAATS STEP 2—WORKSHEET #2.4

Assessment Methods for INTASC Indicators: Blueprint

Explanation:

Fill in the INTASC indicators for each INTASC Principle to be measured by the assessment method, transferring your work from Worksheet #2.3.

<i>Indicator</i>	<i>Scale</i>	<i>Questionnaire</i>	<i>Focus Group</i>	<i>Event Report</i>	<i>Observation</i>
INTASC 1					
INTASC 2					
INTASC 3					
INTASC 4					
INTASC 5					
INTASC 6					
INTASC 7					
INTASC 8					
INTASC 9					
INTASC 10					

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DAATS Step 2 – Worksheet #2.4

Assessment Methods for Behavioral Indicators: Blueprint

Explanation:

Fill in the behavioral indicators for each standard or principle to be measured by the assessment method, transferring the work from Worksheet #2.3.

<i>Indicator</i>	<i>Scale</i>	<i>Questionnaire</i>	<i>Focus Group</i>	<i>Event Report</i>	<i>Observation</i>	<i>Situational Analysis Test</i>

DAATS STEP 2—WORKSHEET #2.5

Cost-Benefit and Coverage Analysis of Assessment Methods

Explanation:

Place a *yes* or a *no* in response to each question in each cell. Replicate this worksheet for all standards sets, including any locally defined standards, indicators, or outcomes.

<i>Indicator</i>	<i>At Least One Item on Each Instrument for This Principle?</i>	<i>At Least One Item for Each Indicator Principle?</i>	<i>Minimal Cost for This Principle?</i>	<i>Maximum Benefit of each Instrument for This Principle?</i>	<i>Faking Minimized?</i>
INTASC 1					
INTASC 2					
INTASC 3					
INTASC 4					
INTASC 5					
INTASC 6					
INTASC 7					
INTASC 8					
INTASC 9					
INTASC 10					

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Appendix B

This appendix contains the list of two broad value statements and ten corresponding elaborative descriptions, along with an alignment to sets of national standards. Using the two broad value statements and ten principles, the researcher generated versions of the Affective Domain taxonomic level worksheets and Worksheet 2.2.

Standards and Principles

Broad Standard (NCTM/NCATE 2012 Standard 4, Indicator 4a; Standard 2, Indicators 2a, 2c, 2f)
Effective teachers know and understand the importance of problem solving and demonstrate positive dispositions toward problem solving by:

Elaborative Descriptions

1. Encouraging all students to build new mathematical knowledge through problem solving (NCTM PSSM Problem-solving process Standard Indicator #1; NCATE/NCTM 2003 Indicators 7.1, 7.2, 7.3, 7.4, 8.8)
2. Encouraging all students to solve worthwhile mathematical problems that arise in mathematics and in other contexts (CCSS-M Standards for Mathematical Practice Standard 4; NCTM PSSM Problem-solving process Standard Indicator #2; NCATE/NCTM 2003 Indicators 1.2, 7.1, 7.2, 7.3, 7.4, 8.8, MTT Standards 2 and 3)
3. Encouraging all students to apply and adapt a variety of appropriate strategies to solve problems (CCSS-M Standards for Mathematical Practice Standard 1; NCTM PSSM Problem-solving process Standard Indicator #3; NCATE/NCTM 2003 Indicators 1.1, 7.1, 7.2, 7.3, 7.4, 8.8, MTT Standard 2)
4. Encouraging all students to monitor and reflect on the process of mathematical problem solving (CCSS-M Standards for Mathematical Practice Standard 1; NCTM PSSM Problem-solving process Standard Indicator #4; NCATE/NCTM 2003 Indicators 1.4, 7.1, 7.2, 7.3, 7.4, 7.5, 8.8)
5. Encouraging all students to reason, construct and evaluate mathematical arguments (CCSS-M Standards for Mathematical Practice Standard 1; NCATE/NCTM 2003 Indicator 1.3, 7.1, MTT Standards 3, 4 and 5)
6. Encouraging all students to develop an appreciation for mathematical rigor and inquiry (NCATE/NCTM 2003 Indicator 1.3, 7.1, MTT Standards 4 and 5)
7. Encouraging all students in selecting, applying and translating among mathematical representations to solve problems (NCATE/NCTM 2003 Indicators 5.3, 7.1)
8. Encouraging all students to use a variety of tools including technology to solve problems (CCSS-M Standards for Mathematical Practice Standard 5; NCATE/NCTM 2003 Indicators 7.1, 7.2, 7.3, 7.4, 7.6, 8.8, 10.5, 13.3, MTT Standards 4 and 5, NCTM PSSM Technology Principle)

Broad Standard (NCTM/NCATE 2012 Standard 5, Indicator 5b)

Effective teachers of secondary mathematics verify (i.e., provide evidence) that secondary students demonstrate productive dispositions toward mathematics by:

Elaborative Descriptions

9. Engaging in ongoing analysis of students' dispositions (i.e., confidence, interest, enjoyment, and perseverance) toward mathematics (CCSS-M Standards for Mathematical Practice, MTT Standard 6).
10. Examining the effects of a particular task on students' mathematical dispositions (MTT Standard 7).

Appendix C

The Affective Domain taxonomic level worksheets were designed to elicit descriptions of what teachers “look like” along the Krathwohl and Bloom (1956) Affective Domain continuum (i.e., *receiving, responding, valuing, organization, and characterization*) combined with the *unaware* level added for assessment purposes (Wilkerson, 2012). A sample participant response, for a single value statement and elaborative description, is provided in Appendix C.

DAATS Step 2 – Worksheet #2.2 and Affective Taxonomic Level Worksheet

Visualizing the Dispositional Statements

Beth's Response to Elaborative Description #4

List the behaviors you think demonstrate that a secondary mathematics teacher has a positive disposition toward the mathematical process of problem solving, based on the specific description listed below. Then, list the behaviors that show the attribute is missing.

"Effective teachers know and understand the importance of problem solving and demonstrate positive dispositions toward problem solving by encouraging all students to monitor and reflect on the process of mathematical problem solving."

Prompts	Your Responses for Indicator #4
<p>What behaviors indicate a teacher has a positive disposition toward problem solving (in relation to this standard)?</p> <p>List the behavioral indicators you can assess for this standard. Underscore the words that show this is a disposition and not just a skill. Begin each statement with "The teacher . . ."</p>	<p>I see the teacher modeling the reflection on mathematical problem solving. The students are engaged in problem solving throughout the activity. The teacher may stop students in the process and ask students what they are thinking and where they are with solving the problem. This will help the students "move" forward. The teacher asks questions to elicit student thinking and strategies. For example, if a student is using a "guess and check" strategy the teacher may ask students: "What did you do to get started?" "Did you see how this is familiar to something else you've done?" The teacher helps students make connections with what they already know. At the end of the problem solving activity, the teacher could have students write a quick reflection that includes questions that they might still have about a problem. This problem would probably be extending over a period of time, and the teacher would have written prompts to facilitate this process along the way.</p>
<p>What behaviors show the disposition is missing (in relation to this standard)?</p>	<p>The teacher would be more concerned about how the time is allotted during the class period and would move on with the material no matter where the students are in the process. The class would be more teacher-driven, where the teacher would debrief the problem and not be looking for multiple pathways for solving the problems. The teacher would be more concerned with getting the problem solved one way rather than looking at different ways of solving it. The teacher would expect only one answer and have a very closed format for students' responses. The teacher would limit the modality (i.e., only written or only verbal) for students' responses. The teacher would even limit the tools</p>

	(i.e., resources, technology, manipulatives, strategies such as working individually or in groups) that students could use to solve the problem.
<i>Imagine a secondary mathematics teacher with a more positive (or more negative) disposition toward problem solving (in relation to this standard). What does the teacher demonstrate (or look like) along this continuum?</i>	
Briefly describe typical teaching behavior at the "unaware" level for this standard.	<p>The teacher looks at math as having a right or wrong answer. What's really important to this teacher is the mechanics of mathematics. There could be some writing but the writing would be very procedural and mechanical. It would not be deep thinking and be low in terms of cognitive demand.</p> <p>I'm interested in the oppositional piece. There could be a disposition or attitude that it is waste of time to have students monitor and reflect on the problem-solving process.</p>
Briefly describe typical teaching behavior at the "receiving" level for this standard.	<p>If they are beginning to think about having students monitor and reflect on the problem-solving process then they are probably going to start asking questions from colleagues who know how to do this or who are "more developed" along the continuum.</p> <p>The teacher starts looking for resources on how to get students to reflect on their process.</p> <p>In the classroom the teacher asks for responses from students although it might still be at a very low level in terms of cognitive demand. For example, the teacher may have students write the problem in numerical format without writing any of their thinking down. Even if it is a verbal response, there won't be any probing of students' thinking, and the teacher will accept the students' attempts without going deeper.</p>
Briefly describe typical teaching behavior at the "responding" level for this standard.	<p>I think at this level the teacher will start to include monitoring and reflecting into the lesson plan. It would be a small portion of the lesson plan and would also be in the most familiar mode for the teacher.</p> <p>If the teacher runs out of time and has to make some on-the-spot decisions, it would be the first thing to get dropped as it would be a lower priority for this teacher.</p> <p>At this level there would be strong correlation between the teacher's personal style (i.e., mode) of</p>

	<p>monitoring and reflecting and what they would ask the students to do. There might not be a lot of equity for all students. If the teacher is better at or more familiar with reflecting through writing then that's what she will ask students to do.</p> <p>The students are still reflecting and monitoring at a low level of cognitive demand.</p>
Briefly describe typical teaching behavior at the "valuing" level for this standard.	<p>In the valuing stage I view the monitoring and reflection that is going on in the classroom as being more part of the class environment. On a certain day if there is some monitoring and reflection going on, it will be revisited and shared in the community. The teacher might say "Remember yesterday when <i>Student A</i> or <i>Student C</i> said or did this . . ." It begins to become more of the larger mathematical community. There is evidence that it is a continual process rather than an isolated event. The teacher goes back and connects what students are currently doing to past experiences in order to move forward on current mathematical endeavors. What they are doing as a group becomes a part of the community's math knowledge. The community creates new resources that can be used in the future.</p> <p>If a teacher is really valuing monitoring and reflection and accepts its worth, then it is at this point that the teacher really starts thinking about and asking whether she is reaching all students and whether the process is of value for all. It becomes less mechanical, and the level of fluency changes. The teachers and students become more fluent where the teacher is able to adapt to the students and their needs.</p> <p>I also see valuing as a real cut-off point between a teacher at the responding level and one who values the process. There is a real change in a teacher and how she approaches the process of monitoring and reflection when she moves from responding to valuing.</p>
Briefly describe typical teaching behavior at the "organization" level for this standard.	<p>I think that there would be classroom routines where the students would monitor and reflect daily. The classroom routine might include an "opening pass" that requires students to reflect on what they did they day before.</p> <p>Students would work in math journals where they</p>

	<p>would respond to questions. The routines are so well known to both teacher and students so the students would automatically do reflection without being prompted. There is less control exerted from the teacher, and the class is student driven. This can be seen in all aspects whether the students are working individually, in pairs or in groups. The students are questioning each other about how they are approaching the problem. I think that the task the teacher gives students, whether an engagement or assessment task, will consistently include monitoring and reflecting.</p>
<p>Briefly describe typical teaching behavior at the "characterization" level for this standard.</p>	<p>The cognitive demand will be more rigorous because the teacher is more comfortable with monitoring and reflection. I think that at this level in the classroom you are going to have the teacher reflecting personally on the math problem solving that is going on in the classroom. The teacher might be journaling and setting goals around the students and their reflection process. You might see portfolios where the students have to show their reflection process and growth in problem solving. I think as a teacher introduces a concept it would be through a problem-solving approach where students are thrown into a situation that is new and they would struggle and realize that they needed a "piece" of math that they don't yet have. The teacher would help them realize that they need a "piece" they don't have to solve the problem and be ready to teach the missing "piece" to help students progress. The teacher would encourage students to ask for and use more mathematical tools. The teacher would push the students to a very uncomfortable state but where the teacher knows just how far to push a student in the reflection process to progress.</p>

Appendix D

Appendix D provides tables of participants' aggregated responses for each of the six taxonomic levels. Each table lists typical teaching behaviors classified into four categories (i.e., approach to problem solving instruction, approach to problem selection, approach to students and approach to problem solving assessment). The number of participants citing a specific behavior as indicative of teachers at particular taxonomic levels is given in parentheses.

Participant Descriptions of a Teacher at the Unaware Level

Approach to problem solving instruction	Approach to problem selection
<ul style="list-style-type: none"> • Has not considered teaching math through problem solving (6) • Presents math as being little more than mechanical in nature (5) • Unaware that students can build new mathematical knowledge through problem solving (5) • Unaware of or unfamiliar with specific problem solving strategies (4) • May be opposed to teaching math through problem solving (3) • Has not considered or is unsure about methods of solving problems as if there is one best way to solve a problem (3) • Does not recognize the value in solving problems using multiple representations (3) • Unaware of what is possible with different technology/tools (3) • May be opposed to the use of tools in problem solving (2) • Unaware of the beauty of learning math through problem solving (2) • Insists that students must be directly taught math or how to solve problems (2) • May express negative opinions toward specific strategies (e.g., strategies outside those taught in class) (2) • Believes there is one way to solve problems (2) 	<ul style="list-style-type: none"> • Does not recognize problem-solving situations that arise in other contexts that promote connections within mathematics, to other subjects or to the real world (5) • Views mathematical problems only for the mathematical content that can be learned (4) • Is unaware of the value of non-standard problems with more than one answer or solution path (4) • Does not attempt to teach outside the prescribed curriculums (3) • Has not considered using particular problem solving tasks to assist students in building mathematical knowledge (2) • Has not considered the varying levels of cognitive demand in problems (2) • Views problems as strictly falling within a prescribed curriculum, such as Algebra or Geometry (2) • Has not considered the impact of worthwhile tasks on students' mathematical dispositions (2)
Approach to students	Approach to problem solving assessment
<ul style="list-style-type: none"> • Has not considered the value of students' input (e.g., does not encourage students to do the thinking and does not elicit students' responses) (5) • Unaware that a student's disposition impacts performance (4) • May actively seek to discourage some students (3) • Opposes the idea that all students are capable of engaging in rigorous mathematical tasks (3) • Unaware of the importance of developing students' mathematical reasoning abilities (2) 	<ul style="list-style-type: none"> • Accepts limited types of student responses, such as "answer only" or problems with minimal cognitive demand requiring only mechanical steps leading to an answer (3) • Values assessments that only assess mathematical content. (3) • Does not recognize the importance of students showing steps or processes (2) • Does not recognize the value of assessment tasks that are high in cognitive demand (i.e., mathematical rigor) (2) • Values completion of tasks irrespective of students' relational understanding of math (2) • Unaware of the importance of students monitoring and reflecting on the problem-solving process (2)

Participant Descriptions of a Teacher at the Receiving Level

Approach to problem solving instruction	Approach to problem selection
<ul style="list-style-type: none"> • Knows and understands the importance of problem solving but is uncertain how to implement it (5) • Excited about the idea of including problem solving (4) • Listens to colleagues' approaches to problem solving instruction (4) • Has some exposure to the tools of problem solving, such as of the defined strategies, and may name specific strategies during instruction (4) • May provide a promise to use problem solving but does not consistently implement during instruction (4) • May feel positively towards problem solving but does not see it in relation to day-to-day instruction (3) • Has read about problem solving or saw it at a conference (3) • Shows interest in using different technology/tools (3) • Might believe he is teaching problem solving strategies, but cannot articulate specific examples or provide external evidence of such (3) • Believes multiple representations and solutions pathways build connections between math concepts and allow students to understand concepts more deeply (3) • May make statements that show awareness of problem-solving and its importance, but these statements demonstrate a lack of deep understanding of the skills (2) 	<ul style="list-style-type: none"> • Is able to articulate the importance of solving worthwhile/purposeful/open-ended mathematical problems but has few examples of such problems (5) • Puts little effort into seeking out supplemental materials and resources (4) • Teaches just as problem solving is laid out in adopted curriculum, nothing more nothing less (4) • Is able to discriminate between problems according to the strategies used to solve them (4) • Intrigued by problems that can be solved with a variety of representations (4) • Occasionally includes problems relevant to students' lives and/or future development in math (3) • Is able to identify problems that allow students to connect and extend specific mathematical content and processes (3) • Is able to determine the cognitive demand of mathematical tasks (3) • May not consistently recognize how particular problems can be translated from one representation to another (2)
Approach to students	Approach to problem solving assessment
<ul style="list-style-type: none"> • Aware that affective domain (i.e., students' dispositions) plays a variable role in students' success in mathematics, but does not know how to develop this (5) • Assigns students problems to solve but devotes little time for discussion (4) • Allows, and is pleased when, students use strategies or tools (4) • May recognize that student thinking is an important part of the problem-solving process and accepts students' responses but without probing their thinking (i.e., low cognitive demand) (3) • Tries to use motivational techniques with students at various times but the students do not feel encouraged to consistently attempt problem solving (2) • Beginning to regard students' problem-solving skills as important, but does not know how to develop them (2) 	<ul style="list-style-type: none"> • Considers using problem solving assessment and feedback as part of the course (5) • Assessment of student growth in problem solving would be minimal, if at all (4) • Starts looking for resources on how to assess students' problem solving (4) • Is interested in assessing and analyzing student dispositions (4) • Approach to in-class assessment is similar to unaware level (3) • May have students write a problem solution in numerical format without writing any of their thinking down (3) • Starts looking for resources on how to develop students' reflection process (2)

Participant Descriptions of a Teacher at the Responding Level

In addition to incorporating the positive aspects of the previous taxonomic levels, a teacher at this level also:

Approach to problem solving instruction	Approach to problem selection
<ul style="list-style-type: none"> • Is comfortable trying to teach some mathematical content using problem solving strategies but has difficulty implementing learning through problem solving on a consistent basis (5) • Values a variety of problem solving strategies (5) • Focuses instruction on students learning specific strategies rather than developing a problem-solving approach to learning math (4) • Pre-teaches skills needed for problem solving activity (4) • Values problem solving instruction and wants to be successful (4) • Consistently uses uncommitted time (such as after a test) to provide students with problem-solving opportunities (4) • Models the use of a variety of problem solving strategies, tools and representations to demonstrate a math concept within a prescribed lesson (4) • Eliminates problem solving as part of a lesson if time is a factor (4) • Notices problem solving situations that arise in class and in real life (4) • Uses readily available resources to incorporate problem solving in lessons (3) 	<ul style="list-style-type: none"> • Occasionally provides an extra credit problem oriented towards problem solving if time permits (5) • Selects problems from readily available resources (4) • Selects mathematical tasks with higher levels of cognitive demand (3) • Provides students with real-world applications of math sporadically (3) • Provides extra credit problem-solving opportunities that are not paired with specific parts of the curriculum (3) • Selects problems that use a variety of representations (2)
Approach to students	Approach to problem solving assessment
<ul style="list-style-type: none"> • Encourages students to learn through problem solving in a controlled setting and if time permits (4) • Devotes some class time to problem solving discussion, but is not comfortable with students taking the lead (4) • Encourages students to use tools as prescribed in a lesson (4) • Aware of and actively monitors students' dispositions toward mathematics, differentiating between positive and negative student responses to a task (4) • Believes that encouraging students' productive disposition toward problem solving will produce stronger academic outcomes (4) • Uses readily available resources to occasionally engage students in problem solving (3) • Intends to teach through problem solving on a consistent basis, but reduces the frequency of this if it becomes too difficult (3) • Directs students to try a specific strategies and representations (3) • Models positive disposition toward mathematics (3) • Allows students to explain their thinking and construct arguments but dedicates little time to the evaluation of each other's arguments (2) 	<ul style="list-style-type: none"> • Uses only one, maybe two, methods of assessment to analyze the task (4) • Aware of and actively monitors students' dispositions toward mathematics, differentiating between positive and negative student responses to a task (4) • Assesses students' mathematical dispositions if time permits (3) • Practices questioning students about their mathematical thinking and processes (3) • Administers pre-made surveys or inventories to solicit information from students about their dispositions (3) • Includes written assessments of students' problem-solving process (3) • Values assessment of students' mathematical arguments but feels it would take too much class time to facilitate (2) • Includes all dispositions (i.e., interest, enjoyment, confidence, perseverance) in assessments, but to varying degrees (2)

Participant Descriptions of a Teacher at the Valuing Level

In addition to incorporating the positive aspects of the previous taxonomic levels, a teacher at this level also:

Approach to problem solving instruction	Approach to problem selection
<ul style="list-style-type: none"> • Values the problem-solving process (5) • Routinely commits time and effort to create worthwhile lesson plans using problem solving as a way of teaching and learning mathematics (4) • Consistently teaches familiar mathematical content through problem solving, but there is still some uncertainty of how to do this with unfamiliar content (4) • Has a number of “go to” resources illustrating the problem-solving approach (4) • Routinely includes a variety of familiar strategies, representations and tools (4) • Designs instruction that engenders a productive disposition toward math (3) • Routinely uses assessment results to inform problem solving instruction (3) • Builds into lessons the necessary time to expand and extend problems (3) • Provides problem solving opportunities that are more fluid and less mechanical (2) • May not be comfortable with inclusion of student-created problems (2) • Interrupt the problem-solving process to teach skills students need to continue (2) 	<ul style="list-style-type: none"> • Has a number of "go to" resources for finding the type of open-ended problems needed (5) • Prefers problems that encourage building new math knowledge through problem solving over those that do not (4) • Seeks out problems that have opportunities for expansion and extension (4) • Seeks out problems that have an application in daily life (4) • Seeks out problems to use in teaching specific strategies (4) • Seeks out problems that have an impact on students' mathematical dispositions (3)
Approach to students	Approach to problem solving assessment
<ul style="list-style-type: none"> • Values teaching through problem solving (5) • Devotes time in class to review, discuss, expand and extend familiar problems (5) • Encourages most students to engage in and internalize the problem-solving process (5) • Commits enough time to problem solving that students are aware it is important (4) • Routinely models and encourages mathematical reasoning about a problem (4) • Presents and encourages student use of a variety of strategies/representations (4) • Accepts the importance of students' disposition towards mathematics and the teacher's role in developing disposition (4) • Routinely questions students about their discoveries, observations, conclusions and reflections without telling them the process/result (4) • Routinely includes tools for student use (4) • Fosters a problem solving community through discussion (4) • Welcomes diversions into other topics (2) • Adapts to the students' problem solving abilities and needs (2) • Provides opportunities for students to lead the discussion and create problems (2) 	<ul style="list-style-type: none"> • Routinely assesses students on their discoveries, observations, conclusions and reflections (5) • Requires students to explain their mathematical thinking and reasoning in verbal and written form (4) • Solicits regular feedback from students about their dispositions (e.g., journal prompts, exit tickets, discussions, conferences) (4) • Assesses students on their use of a variety of representations in solving problems (3) • Occasionally uses analysis of assessments to inform future problem solving instruction (2) • Presents students with incorrect solutions to evaluate (2) • Asks students to set and assess goals for improvement (2) • Actively seeks to provide assessment feedback on both students' dispositional and mathematical development (2)

Participant Descriptions of a Teacher at the Organization Level

In addition to incorporating the positive aspects of the previous taxonomic levels, a teacher at this level also:

Approach to problem solving instruction	Approach to problem selection
<ul style="list-style-type: none"> • Routinely plans inquiry-based lessons and organizes class time to ensure most students engage in and learn through problem solving (5) • Organizes instruction to assure that problem-solving skills are sufficiently taught and then mastered by most students (4) • Integrates a variety of appropriate tools to support problem solving instruction (4) • Consistently introduces new math concepts by invoking a variety of problem-solving strategies (4) • Plans units that illustrate connections between mathematical topics through the use of multiple representations (3) • Plans units and individual lessons based on students' learning preferences, development needs, interests and feedback (3) • Plans problem solving activities that are just beyond students' current knowledge and skill level (2) • Supports problem-solving processes with mini-lessons based on student needs (2) • Prioritizes developing students' confidence with mathematics (2) • Incorporates assessment results in the instructional planning process (2) 	<ul style="list-style-type: none"> • Creates worthwhile problems with high cognitive demand (4) • Purposefully selects problem-solving exercises as part of classwork and/or homework (4) • Searches for real-world problems that can serve as a focal point of lessons (3) • Has numerous resources within which they can usually find the type of open-ended problems they are looking for (3) • Selects authentic problems for teaching nearly all content (3) • Encourages students to generate their own problems (3) • Puts for consistent effort to find problems that incorporate multiple representations (3) • Selects (or designs) tasks that require students to use a variety of mathematical tools (3)
Approach to students	Approach to problem solving assessment
<ul style="list-style-type: none"> • Expects all students to successfully learn through problem solving (5) • Models the problem-solving process on an ongoing basis (5) • Establishes a mathematically-rich, risk-free problem-solving environment for nearly all students (5) • Routinely encourages most students to justify (and share) their reasoning (4) • Routinely encourages discussion where students compare and contrast their thinking with that of other students (4) • Consistently uses effective, probing questioning strategies (4) • Provides tools and resources to support students' problem solving (4) • Adapts approach (i.e., tools, resources, representations, strategies) for individual students (4) • Expects most students to extend and/or design problems (3) • Encourages student choice of tools, strategies and representations (3) • Encourages reflective processes so students can report when and how they need support (2) 	<ul style="list-style-type: none"> • Formally assesses student disposition in a variety of settings or situations (i.e., projects, discussion, journal reflections, writing prompts) (4) • Consistently provides verbal or written feedback about their problem solving progress (4) • Assesses students' mathematical knowledge and problem-solving skills in a variety of contexts and new situations (4) • Tracks student growth from student responses to prompts (3) • Plans tasks with colleagues to examine the disposition of students (3) • Expects students to justify their choice of strategy, representation and/or tool (3) • Solicits feedback from students to determine how a task impacted their disposition and how it could be improved (2) • Has students reflect on which tasks they are more comfortable with and which ones challenge them (2)

Participant Descriptions of a Teacher at the Characterization Level

In addition to incorporating the positive aspects of the previous taxonomic levels, a teacher at this level also:

Approach to problem solving instruction	Approach to problem selection
<ul style="list-style-type: none"> Consistently introduces all content through problem solving (5) Explicitly requires students to extend problem solving to other content areas and contexts (5) Intentionally uses a variety of tools whenever possible (4) Designs instruction that recognizes mathematics content, processes and dispositions as equally important in the learning process (4) Plans and facilitates learning through problem solving on a daily basis, providing direct instruction only if required or requested by students (3) Designs instruction to motivate student learning through problem solving (3) Has a clear vision for how problem solving will work in a lesson (3) Purposefully highlights the utility of mathematics in solving problems (2) 	<ul style="list-style-type: none"> Seeks out problems that promote connections within mathematics, across disciplines, and to the real world (5) Devotes personal time to seek out purposeful, open-ended problems that target specific mathematical content (4) Selects problems over exercises whenever possible (4) Insists all problems have a context that is authentic and interesting to students (3) Selects problems that go beyond the use of problem solving strategies (3) Displaces adopted curriculum in favor of problem-solving instruction (3) Provides problems that encourage students to extend uses of mathematics outside of class time (2)
Approach to students	Approach to problem solving assessment
<ul style="list-style-type: none"> Expects and encourages students to persevere (6) Displays an encouraging and confident attitude that all students will learn through problem solving (5) Ensures a mathematical rich and risk-free environment where students are encouraged to share, evaluate and build off each other's ideas (4) Organizes problem solving learning around the needs of adolescents (e.g., academic, social, developmental and psychological) (4) Encourages a technology/tool rich environment (i.e., meaningful use that provides students access to the math) (4) Welcomes all students' ideas (3) Expects students to research and create authentic tasks (3) Ensures that students are actively engaged in problem solving (3) Throws students into situations that are new where they will struggle (3) Explicitly encourages dispositional factors in students, such as confidence, interest, enjoyment, and perseverance (3) Expects students to lead the discussion (3) Expects all students to clearly communicate their reasoning (2) Ensures students develop an appreciation for the power of mathematics (2) Ensures students recognize the value of introspection and learning from their mistakes (2) 	<ul style="list-style-type: none"> Naturally thinks about both content and dispositions as they design and analyze assessments (4) Explicitly requires students to demonstrate the ability to make mathematical arguments and explain their reasoning (4) Prioritizes encouraging feedback as a major part of his interactions with students (4) Conveys the importance of students' disposition toward math by incorporating dispositional ideas in various types of assessments (i.e., observations, interview, exit slips, journal writing, self-assessments) (4) Makes instructional decisions based on the analysis of dispositional assessments (3) Explicitly requires all students to be fluent with all tools available (3) Explicitly requires students to demonstrate the ability to translate among representations (2) Includes portfolios where students have to show their reflection process and growth in the area of problem solving (2)

Appendix E

The analysis for this worksheet began with reviewing the responses of all six participants to obtain a general sense of those assessment methods that the participants identified as useful in assessing particular indicators. Following an initial review, the researcher tallied the number of participants who identified the assessment methods as not useful (coded as *no*), possibly being useful (coded as *possibly*) and absolutely necessary (coded as *yes*) in assessing the individual indicators. The tables that follow list the tallies for each indicator. The researcher reviewed for consistency participants' selections of assessment methods with particular attention to the indicators where responses were spread across the three categories (i.e., yes, possibly, no). All indicators with their corresponding assessment methods were reviewed for consistency in order to generate the assessment frameworks (see Tables 33 to 37). However, the consistency of the assessment frameworks was impacted by the small number of participants in this study. Although the researcher reviewed for consistency participants' selections of assessment methods where the responses were spread across the three categories (yes, possibly, no), the decision about *yes*, *possibly*, or *no* could be significantly impacted by a single participant's vote. Assessment developers should use the assessment framework as guide only, to be confirmed and adjusted locally. If developers are able to identify good items for an indicator with a corresponding assessment method classified as a *no*, they should be comfortable in using the items, since as many as four of the six respondents may have indicated that such items could be developed.

Tallies of Participants' Selections of Assessment Methods for Indicators 1.1 to 1.6

General and Specific Indicator(s)		SC			QU			FG			OB			ER			SA		
		Y	P	N	Y	P	N	Y	P	N	Y	P	N	Y	P	N	Y	P	N
<i>The teacher values worthwhile mathematically rigorous problem solving.</i>		2	3	1	1	5	0	1	3	2	5	1	0	0	3	3	2	4	0
As part of teaching through problem solving, the teacher:																			
1.1	Values open-ended problems that have multiple and/or unclear paths to a solution.	2	2	0	2	4	0	1	3	2	5	1	0	0	4	2	3	3	0
1.2	Values purposeful problems that encourage students to apply specific mathematical content and processes to other subjects and in real-world contexts.	3	2	1	3	3	0	2	4	0	3	3	0	0	3	3	2	4	0
1.3	Values problems that highlight a variety of problem solving strategies.	2	2	2	2	4	0	0	6	0	6	0	0	0	2	4	3	3	0
1.4	Values problems that require students to build new mathematics knowledge through problem solving.	2	2	2	1	4	1	1	4	1	4	2	0	0	2	4	2	3	1
1.5	Values cognitively demanding tasks that stretch students.	3	1	2	1	5	0	3	3	0	5	1	0	1	2	3	2	4	0
1.6	Believes that ample class time must be dedicated to student solution and discussion of problems.	3	2	1	2	4	0	2	3	1	6	0	0	1	2	3	1	4	1

Note. SC = scales; QU = questionnaires; FG = focus group; OB = Observation; ER = Event Report; SA = Situational Analysis Test; Y = must be used; P = possibly useful; N = not useful

Tallies of Participants' Selections of Assessment Methods for Indicators 2.1 to 2.5

General and Specific Indicator(s)		SC			QU			FG			OB			ER			SA		
		Y	P	N	Y	P	N	Y	P	N	Y	P	N	Y	P	N	Y	P	N
<i>The teacher values diversity of students' explanations, ideas and observations about mathematical problems.</i>		2	3	1	1	5	0	3	2	1	6	0	0	0	4	2	2	4	0
As part of teaching through problem solving, the teacher:																			
2.1	Believes all students have unique ways of expressing their mathematical thinking and reasoning.	2	4	0	2	4	0	1	4	1	4	2	0	0	2	4	2	3	1
2.2	Values both written and verbal explanations of reasoning.	2	4	0	2	4	0	3	3	0	5	1	0	0	1	5	1	5	0
2.3	Values a variety of problem-solving strategies, including solution paths that vary from what was taught in class.	1	2	3	1	5	0	2	2	2	5	1	0	0	4	2	0	5	1
2.4	Values use of various representations, highlighting them whenever possible.	2	2	2	2	3	1	3	3	0	5	0	1	0	1	5	1	4	1
2.5	Values varying opinions and different ways of thinking.	2	4	0	3	3	0	4	2	0	5	1	0	1	5	0	1	5	0

Note. SC = scales; QU = questionnaires; FG = focus group; OB = Observation; ER = Event Report; SA = Situational Analysis Test; Y = must be used; P = possibly useful; N = not useful

Tallies of Participants' Selections of Assessment Methods for Indicators 3.1 to 3.6

General and Specific Indicator(s)	SC			QU			FG			OB			ER			SA		
	Y	P	N	Y	P	N	Y	P	N	Y	P	N	Y	P	N	Y	P	N
<i>The teacher values a risk-free problem-solving environment that encourages all students.</i>	3	2	1	2	4	0	4	2	0	6	0	0	0	4	2	1	5	0
As part of teaching through problem solving, the teacher:																		
3.1 Values respectful discourse.	2	2	2	2	4	0	2	4	0	5	1	0	0	4	2	0	5	1
3.2 Values an environment where students are problem-solving authorities.	1	4	1	2	4	0	4	2	0	5	1	0	1	4	1	0	6	0
3.3 Believes all students' comments are valuable.	2	4	0	1	5	0	3	2	1	5	1	0	0	6	0	1	5	0
3.4 Believes students learn through their mistakes.	3	3	0	2	4	0	1	5	0	3	3	0	0	2	4	0	6	0
3.5 Is committed to individualized instructional support to ensure success of all students.	1	4	1	1	5	0	3	1	2	5	1	0	0	2	4	0	4	2
3.6 Believes every student is capable of solving rigorous mathematical problems.	1	4	1	2	4	0	2	4	0	4	2	0	0	3	3	1	4	1

Note. SC = scales; QU = questionnaires; FG = focus group; OB = Observation; ER = Event Report; SA = Situational Analysis Test; Y = must be used; P = possibly useful; N = not useful

Tallies of Participants' Selections of Assessment Methods for Indicators 4.1 to 4.3

General and Specific Indicator(s)	SC			QU			FG			OB			ER			SA		
	Y	P	N	Y	P	N	Y	P	N	Y	P	N	Y	P	N	Y	P	N
<i>The teacher values a variety of tools, including technology, to solve problems.</i>	1	3	2	1	5	0	3	3	0	5	1	0	0	2	4	2	4	0
As part of teaching through problem solving, the teacher:																		
4.1 Values using a variety of tools to solve problems.	1	3	2	1	5	0	2	4	0	5	1	0	1	1	4	1	4	1
4.2 Is committed to providing tools to students at all times.	2	3	1	1	5	0	2	4	0	4	2	0	0	3	3	1	2	3
4.3 Is committed to discovering new tools (or novel uses of traditional tools) to solve problems.	1	5	0	3	3	0	2	4	0	4	2	0	0	2	4	1	2	3

Note. SC = scales; QU = questionnaires; FG = focus group; OB = Observation; ER = Event Report; SA = Situational Analysis Test; Y = must be used; P = possibly useful; N = not useful

Tallies of Participants' Selections of Assessment Methods for Indicators 5.1 to 5.5

General and Specific Indicator(s)	SC			QU			FG			OB			ER			SA		
	Y	P	N	Y	P	N	Y	P	N	Y	P	N	Y	P	N	Y	P	N
<i>The teacher believes that all students must develop productive dispositions toward problem solving (i.e., confidence, interest, appreciation, enjoyment, and perseverance).</i>	4	2	0	3	3	0	2	3	1	5	1	0	1	2	3	0	6	0
As part of teaching through problem solving, the teacher:																		
5.1 Values problem-solving experiences that support the development of positive dispositions in students.	3	3	0	2	4	0	2	2	2	4	2	0	0	3	3	0	6	0
5.2 Attends to students' dispositions in the planning and delivery of instruction.	2	3	1	4	2	0	1	3	2	5	1	0	1	2	3	1	2	3
5.3 Values feedback given to students that fosters productive dispositions (i.e., commitment, perseverance, confidence).	2	3	1	3	3	0	3	3	0	3	2	1	0	4	2	0	5	1
5.4 Values a variety of assessments to measure students' dispositions (e.g., observations, interviews, exit slips, journal writing, self-assessments).	1	4	1	3	3	0	2	4	0	5	1	0	0	3	3	0	5	1
5.5 Believes challenging tasks motivate students.	2	3	1	2	4	0	0	4	2	3	3	0	0	2	4	1	4	1

Note. SC = scales; QU = questionnaires; FG = focus group; OB = Observation; ER = Event Report; SA = Situational Analysis Test; Y = must be used; P = possibly useful; N = not useful

CURRICULUM VITAE

Alison L. Mall
Assistant Principal
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Academic Background & Degrees

Doctoral Candidate, Ph.D. in Curriculum and Instruction with an emphasis in rural mathematics education through the Appalachian Collaborative Center for Learning, Assessment, and Instruction in Mathematics, University of Louisville, May 2014
Educational Leadership Program, University of Alaska Anchorage, May 2006
MA Teaching, University of Alaska Anchorage, May 1995
BA Mathematics, Spanish minor, University of Alaska Anchorage, December 1994
Diploma, Chugiak High School, Chugiak, Alaska, May 1991

Current Position

Assistant Principal, Kenai Peninsula Borough School District, Homer High School,
July 2013 – present

Certifications

Alaska Type A Professional Advanced Teaching Certificate, Grades 7-12, Mathematics
Alaska Type B Administrative Certificate, Grades K-12
National Board Certification, Adolescent and Young Adult Mathematics Teaching, National Board of Professional Teaching Standards, November 2004
Advanced Certificate of Nepalese Language Proficiency, U.S. Peace Corps, February 1998
Laubach Literacy Action English as a Second Language (ESOL) Tutor Certification, 1990

Recognition

Selkregg Award, University of Alaska Anchorage, April 2013

Outstanding Faculty Member, UAA College of Education, May 2012

Top 40 Under 40 Recipient, Alaska Journal of Commerce, January 2012

Technology Fellow, University of Alaska Anchorage, May 2009 & 2010

Presidential Award for Excellence in Mathematics and Science Teaching, 2005

Larry Graham Exemplary Instructional Leadership Scholarship Recipient, 2005

Certificate, UAA College of Education, Exceptional Standards of Professional Excellence, March 2005

Dedication to Excellence in Education, MAA American Mathematics Competitions, 2004 – 2005

Honor Roll, NEA-Aktivist Recognition for NFIE Learning and Leadership Grant, January 2003

Bartlett High School Teacher of the Month, October 2002

Leading Educator Award, University of Alaska Anchorage, 1995

Public Employees Roundtable Public Service Award, August 1993

Leadership Honors, University of Alaska Anchorage, March 1995

Senior Math Wrangler, University of Alaska Anchorage Department of Mathematics Sciences, 1995

Champion, Alaska State Foreign Language Declamation Competition, 1991

Teaching, Clinical Faculty & Mentoring Experience

Assistant Professor, University of Alaska Anchorage, August 2007 – June 2013

As a teacher educator in the Master of Arts in Teaching Program in the Department of Teaching and Learning at the University of Alaska Anchorage College of Education, I prepared pre-service and in-service teachers through the College of Education via face-to-face and distance learning teaching methods.

Clinical Faculty, University of Alaska Anchorage, August 2007 – June 2013

Supervised 30+ mathematics teacher candidates in year-long internships at the middle and high school levels through the Master of Arts in Teaching Program in the Anchorage and Matsu Borough School Districts.

Clinical Faculty, Idaho State University, Fall 2011

Supervised a mathematics teacher candidate at the middle school level in the Anchorage School District.

Statewide Mathematics Network Facilitator, University of Alaska Anchorage, 2007 – 2010

Facilitated a mathematics education network for rural and urban teachers in Alaska to collaborate and further our collective, professional knowledge in working with students in high needs rural schools through the Alaska Educational Innovations Network.

Alaska Statewide Mentor, Alaska Statewide Mentor Project, June 2006 – October 2006

Applied mentoring techniques and tools from the Formative Assessment framework developed by the New Teacher Center, Santa Cruz, California, to mentor teachers working in rural Alaska with underserved student populations.

Mentor Teacher, Bartlett High and Clark Middle Schools, Anchorage, Alaska, 2004 – 2007

Mentored new-to-district teachers in administrative and school-wide procedures and general instructional strategies.

Mentor Teacher, Alaska Partnership for Teacher Enhancement, 2001 – 2004

Mentored three mathematics teacher candidates enrolled in a year-long internship program and collaborated in the development of their portfolios to demonstrate that they had met the *Standards for Alaska's Teachers*.

Co-Leader/Instructor, Alaska Math Consortium, Spring 2005, Spring 2007, 2010 – 2011

Designed and implemented secondary mathematics methods and content experiences for K-12 in-service mathematics teachers as part of a four-credit graduate course in collaboration with elementary and middle school mathematics specialists. The philosophy of this course is that improved teacher understanding and delivery of math concepts will result in improved math performance by students.

Mathematics Teacher, Bartlett and East High Schools, Anchorage, Alaska, 1998 – 2007

Successfully taught pre-algebra, basic math, survey of algebra, integrated mathematics, informal geometry, geometry, algebra, intermediate algebra, precalculus/trigonometry and calculus. Developed and taught two double-up programs (Geometry/Algebra II and Algebra II/Pre-Calculus Trigonometry) to meet the needs and interests of talented and emerging mathletes, many of whom were not currently enrolled in a mathematics course that would allow them to reach advanced study in mathematics prior to high school graduation. Implemented remediation programs for students in Algebra I, Algebra II and Consumer Economics. Designed and implemented tutorial sessions to prepare students for the state exit examination. Served five years as the chair of the mathematics department at Bartlett High School.

Instructor, Journeys in Mathematics, University of Alaska Anchorage, 2005 – 2006

Increased the mathematical knowledge and teaching skill of Alaskan K-8 teachers, improving student academic achievement in mathematics and the mathematical learning environment for teachers. Prepared K-8 teachers in the content areas of problem solving, algebra, data analysis and probability, modeling best practices and research-based methodologies.

Adjunct Professor, University of Alaska Anchorage, August 2001 – May 2006

Instructed for three departments in four distinct areas. Partnered with the Cook Inlet Tribal Council to develop and implement a mathematics program of study for a group of rural, Alaska Native high school students participating in a two-week summer bridging institute. Instructed students in introductory algebra and intermediate algebra from 2001 to 2006 as part of a mastery program through the College of Preparatory and Developmental Studies. Instructed an intensive 6-week Trigonometry course for high school and college students during the university's summer session. Designed and facilitated four, year-long Professional Learning Teams (PLTs) of 9-12 mathematics teachers through my work with UAA's Professional and Continuing Education. Foci for

each year included: Principles & Standards for School Mathematics, Navigating Through Algebra in Grades 9-12, Navigating Through Geometry in Grades 9-12, and Navigating Through Data Analysis in Grades 9-12 by the National Council of Teachers of Mathematics.

Mathematics Teacher, Upward Bound, University of Alaska Anchorage, 2000 – 2002

I developed and implemented an integrated, four-week mathematics program for at-risk high school students during the summer session.

Mathematics Teacher-Trainer, Primary Teacher Training Center, Nepal, 1997 – 1998

Trained and supervised 789 teachers in mathematics and teaching English as a Second Language (ESL) methods as a US Peace Corps volunteer. Wrote a mathematics teacher-training and math methods manual for teacher-trainers. Researched, organized and secured funding for resource libraries at all nine Primary Teacher Training Centers in Nepal.

Mathematics Teacher, Shree Radha Krishna School, Nepal, 1995 – 1996

Taught mathematics five periods per day to approximately 250 students in grades 2, 5, 6, 7 and 10, as a US Peace Corps volunteer.

Supervisor, School of Education Computer Lab, University of Alaska Anchorage, 1993 – 1995

Guided skill development of undergraduate and graduate students in the use of current technology as it applies to education. Maintained the computers in the lab (e.g. hard drive set-up, software and hardware installation, VAX and LAN connections, etc.). Assisted in general revisions and design of the computer competency manual, creating and organizing resource materials to assist students in completing the technology requirements for their respective degrees.

Instructional Activities

Courses taught at the University of Alaska Anchorage

Mathematics Coursework:

MATH 050 – Basic Mathematics
MATH 055 – Elementary Algebra
MATH 105 – Intermediate Algebra
MATH 108 – Trigonometry

Mathematics Content & Pedagogical Content Knowledge Coursework:

MATH 520 – Alaska Mathematics Consortium Basic Institute
ED 560 – Teachers Teaching Teachers: Principles & Standards for School Mathematics
ED 560 – Teachers Teaching Teachers the Standards: Algebra
ED 560 – Teachers Teaching Teachers the Standards: Geometry

ED 560 – Teachers Teaching Teachers the Standards: Data Analysis & Probability
 EDSY 665A – Middle/High School Teaching Methods I
 EDSY 665B – Middle/High School Teaching Methods II
 EDSY 665 – Teaching Mathematics in Secondary Schools
 EDME 608 – Mathematical Problem Solving: Overview for K-8 Teachers
 EDME 685 – Data Analysis and Probability: Content and Pedagogy for K-8 Teachers
 EDME 680 – Geometry and Measurement: Content and Pedagogy for K-8 Teachers
 EDME 689 – Capstone: Advanced Topics in Mathematics for the K-8 Teacher
 EDSE 625 – Teaching Mathematics to Special Learners
 ED 560 – Teaching to the Proposed Alaska Standards for Secondary Mathematics

General Teacher Education Coursework:

EDFN 603 – Foundations: Educational History and Sociology
 EDFN 601 – Foundations: Philosophy of Education
 EDSY 644 – Developing a Community of Learners in Content Area Classrooms
 EDSY 661 – General Methods for Secondary Classrooms
 EDFN 649 – Capstone Seminar: Inquiry in Teaching and Learning

Courses taught in the Anchorage School District:

Math 7, Pre-Algebra, Algebra A, Algebra B, Algebra I, Survey of Algebra, Informal Geometry, Geometry, Integrated Mathematics, Algebra II, Pre-Calculus & Trigonometry, AP Calculus, Consumer Mathematics, Consumer Economics

Publications

National Publications:

Mall, A. & Risinger, M. (2013, December). My favorite lesson: Modeling exponential decay, *Mathematics Teacher*, 107(5), 400.
 Mall, A. (2012, February). Alaska Native Knowledge Network: A review of culturally based curricular resources for the mathematics educator. *Rural Math Educator*, 10(3), 26-37.

State Publications:

Mall, A. (2012, February). Developing the mathematical practices in our students and ourselves: Reflections on a workshop from the 16th annual conference of the Association of Mathematics Teacher Educators. *Alaska Council of Teachers of Mathematics Newsletter*, 23(3), 11-13.

Mall, A. (2003, December). Manipulating student learning: Prime problem solving days and the normal curve. *Alaska Council of Teachers of Mathematics Newsletter*, 16(4), 5.

Mall, A. (2003, December). Teachers teaching teachers: A professional learning community studying the algebra standard. *Alaska Council of Teachers of Mathematics Newsletter*, 16(4), 5.

Conference Proceedings:

Mall, A. (2012, July). *Assessing Mathematics Teacher's Disposition Toward Problem Solving*. Paper presented at the Twelfth International Congress on Mathematics Education, Seoul, South Korea. Retrieved from www.icme12.org/upload/UpFile2/WSG/0495.pdf

Mall, A. (2004). A summary of discussion group 16: The role of mathematical competitions in mathematics education. In *Reports on the Tenth International Congress on Mathematical Education: Copenhagen, Denmark* (pp. 236-241).

Other Publications:

Mall, A. (2011). *External evaluation of the KEAS/KEMS mathematics intervention program: Year one progress report*, submitted to Matanuska Susitna Borough School District, Alaska

Mall, A. (2003, January). Educator spotlight. *Newspapers in Education*. Anchorage, AK: Anchorage Daily News.

Mall, A. (1998, February). *Mathematics training guide for United States Peace Corps Volunteers*. Kathmandu, Nepal: U.S. Peace Corps/Nepal.

Presentations & Workshops

International (Refereed):

Mall, A. (2012, July). *Assessing Mathematics Teacher's Disposition Toward Problem Solving*. Workshop presented at the Twelfth International Congress on Mathematics Education, Seoul, South Korea.

Mall, A. (2012, July). *Secondary mathematics teacher candidates' reflections on creating a campus math trail*. Poster and roundtable discussion at the Twelfth International Congress on Mathematics Education, Seoul, South Korea.

National (Refereed):

- Mall, A. (2013, May). *The Socratic Oath: A right of passage for future teachers*. Workshop presented at the Lilly Conference on College and University Teaching, Bethesda, Maryland.
- Mall, A. (2013, May). *Assessing teachers' dispositions: The affective domain revisited*. Poster presented at the Lilly Conference on College and University Teaching, Bethesda, Maryland.
- Mall, A. (2013, April). *Teaching math for social justice: Health disparities in Alaska*. Presented at the NCTM's 2013 Annual Meeting and Exposition: Equity Strand, Denver, Colorado.
- Mall, A. (2005, April). *Babysitting: An exploration of the laws of supply and demand*. Presented at NCTM's 83rd Annual Meeting and Exposition: Embracing Mathematical Diversity, San Antonio, Texas.
- Mall, A. (2004, April). *Walking down the line: A kinesthetic approach to operations with integers*. Presented at NCTM's 82nd Annual Meeting: Defining Mathematics for All, Philadelphia, Pennsylvania.

State (Refereed):

- Mall, A. (2012, February). *Exploring symmetry*. Workshop presented at the Anchorage Association for the Education of Young Children Early Childhood Conference.
- Mall, A. (2011, September). *Math Trails for K-12 Classrooms*. Presented at the 2011 Alaska Math & Science Conference in Anchorage, Alaska.
- Mall, A. (2011, May). *Building climate bridges through classrooms: Math trails for K-12 classrooms*. Presented at Classrooms for Climate: A Symposium on the Changing Chugach, Northern Ecosystems, and the Implications for Science and Society in Anchorage, Alaska.
- Mall, A. (2009, October). *The twelvefold way*. Presented at the Alaska Math & Science Conference, Juneau, Alaska.
- Mall, A. (2007, October). *Symmetry 101: Explorations of rotational and reflectional symmetry*. Presented at the 2007 Alaska Mathematics and Science Conference, Anchorage, Alaska.
- Mall, A. (2004, October). *Babysitting: An exploration of the laws of supply and demand*. Presented at the 2004 Alaska Mathematics and Science Conference, Fairbanks, Alaska.
- Mall, A. (2001). *Teaching Tessellations through Technology*. Workshop presented at the Alaska Society for Technology in Education Conference, Anchorage, Alaska.
- Mall, A. (2000). *Standards-based units of practice: Integrating technology for math 7, 8 and pre-algebra*. Workshop presented at the Alaska Society for Technology in Education Conference, Anchorage, Alaska.

Local (Invited):

- Walker, K., **Mall, A.**, & Hsiao, W. Y. (2013, February). *Productivity apps for teachers on the iPad*. Workshop presented at the Alaska Society of Technology in Education annual meeting, Anchorage, Alaska.
- Mall, A. (2013, October). *Engaging secondary mathematics teachers in teaching mathematics for social justice*. Talk and workshop as part of the *Tracking Trends in Mathematics and Science Classrooms* strand at the 8th Biennial Alaska Mathematics and Science Conference in Anchorage, Alaska.
- Mall, A. (2013, April). *Let's remember the 'M' in STEM*. Talk at the "Micro to Macro": A Collaborative Approach to STEM Education conference and teacher training in Anchorage, Alaska.
- Mall, A. (2012, March). *Google Sketchup Pro: Applications in secondary classrooms*. Workshop presented at the Alaska Society for Technology in Education Report Out in Anchorage, Alaska.
- Mall, A. (2012, March). *Becoming a teacher: A presentation on the education fields*. Workshop presented at the 2012 Career and Technical Student Organizations Alaska Performance Based Assessment Conference in Anchorage, Alaska.
- Mall, A. (2011, October). *University of Alaska Anchorage: A Mathematical Campus*. Presented at the UAA Fall Preview Day, Anchorage, Alaska.
- Mall, A. (2011, September). *UAA College of Education Core Values and Alaska Beginning Teacher Standards*. Presented at the UAA College of Education Residential Life Retreat, Anchorage, Alaska.
- Mall, A. (2011, August). *Instructional Use of Technology in Content Area Classrooms*. Presented at the UAA Master of Arts in Teaching Program Orientation, Anchorage, Alaska.
- Mall, A. (2011, July). *External evaluation of the KEAS/KEMS mathematics intervention program: Year one progress report*, Matanuska Susitna Borough School District, Alaska.
- Mall, A. (2009). *Challenges that confront all humanity*. Model United Nations Assembly, Anchorage, Alaska.
- Mall, A. (2008, September). *AEIN Mathematics Mini-Network: An Ongoing Dialogue of Mathematics Education*. Poster session presented at the Alaska Educational Innovations Network Academy, Anchorage, Alaska.
- Mall, A. (2006, November). *Future of Mathematics Education in Alaska*. Presented at Lee Gorsuch Public Policy Forum on Education, Anchorage, Alaska.
- Mall, A. (2006, September). *Schoolhouse Rock: Future of Education*. Presented at the 2006 Hugh O'Brian Youth Leadership Seminar at Alaska Pacific University, Anchorage, Alaska.
- Mall, A. (2005, January). *Practical Methods of Using Standardized Based Assessment Results to Improve Mathematics Instruction and Student Learning*. Presented at the No Child Left Behind Alaska Statewide Conference, Anchorage, Alaska.

- Mall, A. & Slattery, J. (2005, January). *Developing Practice Items Aligned to the Alaska High School Graduation Qualification Examination*. Presented at the No Child Left Behind Alaska Statewide Conference, Anchorage, Alaska.
- Mall, A. (2004, August). Moving Toward Smaller Learning Communities: Development and Facilitation of an Effective Student Advisory Program. Presented at the Anchorage School District Smaller Learning Communities Conference, Anchorage, Alaska.
- Mall, A. (2004, March). *Walking down the line: A kinesthetic approach to operations with integers*. Presented at the Anchorage School District Wide In-service, Anchorage, Alaska
- Mall, A. (2003). *Implementing an Effective Mathematics Peer Tutorial Program*. Presented at the Anchorage School District Wide In-service, Anchorage, Alaska.
- Mall, A. (2000). *Applications of Technology in Mathematics Education*. Presented at the Anchorage School District Wide In-service, Anchorage, Alaska.
- Mall, A. (1999, April). *Diversity Day*. Presented at Bartlett High School, Anchorage, Alaska.
- Mall, A. (1995, April). *Apple Computers in Education*. Facilitated Workshop for CIRI Alaska Native Students Visiting the UAA Campus, Anchorage, Alaska.
- Mall, A. (1995, March). *The Pythagorean Theorem*. Paper presented at the 1995 University of Alaska Anchorage Student Showcase Academic Conference.
- Mall, A. (1991, September). *Majoring in Mathematics*. Talk at the CTY joint John Hopkins University and UAA College Colloquium, Anchorage, Alaska.

Other Presentations (Refereed):

- Mall, A. (2004, July). *Teachers Teaching Teachers the NCTM Standards: Professional Learning Communities in Action*. Poster presented at the Tenth International Congress on Mathematics Education, Copenhagen, Denmark.

Other Presentations:

- Mall, A. (2009, May). *The ACCLAIM internship: An innovative residency*. Poster presented at the ACCLAIM Research Symposium Retrospective to Congratulate, Celebrate and Conclude, Newark, Ohio.

Professional Development

Selected Workshops, Seminars, Institutes & Coursework:

- Solution Tree PLC Training and Workshops, August 2012 – present
- iTeach Instructional Technology and Design Intensive, June 2012
- ACCLAIM Online Research Symposium, July 2011
- ACCLAIM Research Symposium, January 2011

- UAA Technology Fellows Institute, 2010
- Center for Advancing Faculty Excellence, Seminar Series on Best Practices in Teaching, 2008
- Action Research Retreat, Homer, Alaska, August 2008
- AEIN Distance Education Technology Institute, May 2008
- Alaska 10th Grade Standards Based Assessment Alignment Institute, September 19-20, 2005.
- Staff Development for Educator's Program, It's Never too Late Literacy Institute, August 2005
- NCTM Academies:
 - NCTM Institute for the 9-12 Grade Band: From Principles to Practice: From Words to Action, April 2001
 - Making Sense of Algebra in Grades 9-12, April 2002
 - Making Sense of Geometry in Grades 9-12, April 2003
- Key Curriculum Press Fathom Statistics Software Workshop, June 2002
- Integrating Mathematics and Economics Institute, March 2002
- Carnegie Learning Cognitive Tutor Pre-Service Program Algebra I & Geometry Certification, 2002
- Geometry: Inductive Approach with an Emphasis on Manipulatives & Technology, August 2001
- Math Standards for Teachers, Alaska Partnership for Teacher Enhancement, Bethel Alaska, June 2001
- Key Curriculum Press Geometer's Sketchpad Workshop, June 2000
- Making Best Use of the Internet for K-12 Instruction, June 2000
- Alaska Quality Schools Institute, September 1999
- Reading Institute: Strategic Reading in the Content Areas, Grades 4-10, December 1999
- UAA Educational Leadership Institute: Change in the 21st Century, July 1999
- Technology Integration: Science/Math with Emphasis on Spreadsheet Applications, 1999
- Achieving AK Math Standards with Emphasis on the conceptual mathematics, 1999
- Integrated Applications Into Middle School Mathematics, 1999
- Visual Math III, The Mathematics Learning Center Institute, 1999
- Linking Math and Science Secondary Teacher Workshop, 1999
- Alaska Technology Leadership Seminar, 1999
- Alaska Math Consortium/Teachers K-12, 1999

Conferences:

- Lilly Conference on College and University Teaching, 2013
- Educause Learning Initiative Annual Meeting, 2012
- Association of Mathematics Teacher Educators Annual Conferences, 2009, 2010, 2011, 2012, 2013
- National Council of Teachers of Mathematics Annual Meetings, 2001, 2002, 2003, 2004, 2005, 2009, 2010, 2013
- 9th, 10th, and 12th International Congress on Mathematics Education, Japan (2000), Denmark (2004), Korea (2012)
- Alaska Council of Teachers of Mathematics Statewide Conference, 2001, 2004, 2007, 2009, 2011
- Personalizing Education for High School Students Conference, 2004, 2005
- Alaska Society for Technology in Education Conference in Anchorage, 2000, 2001, 2012

Professional Service

National Service:

- Referee, *Mathematics Teacher Educator*, 2011 – present
- Panelist, National Selection Committee (NSC) for the Presidential Awards for Excellence in Mathematics and Science Teaching (PAEMST), July 2011
- Referee, *The Mathematics Teacher*, 2009 to Present
- Reviewer, *NCATE/NCTM Specialized Professional Associations Program Report*, 2010 – present
- Referee, *Association for Mathematics Teacher Educators Annual Conference*, 2009 – present
- Reviewer, *Teaching Mathematics in the Middle School*, 2009 – present
- Mentor, Presidential Award for Excellence in Mathematics and Science Teaching (PAEMST), 2006 – present
- Respondent, ETS Survey on Basic Academic Skills for Teacher Preparation Programs, 2010 – 2011
- Panelist, Hugh O'Brian Youth Foundation Education Panel, 2004 & 2005
- Delegate, U.S. National Mathematics Commission, Tenth International Congress on Mathematics Education, Copenhagen, Denmark, July 2004
- Volunteer, NCTM's 82nd Annual Meeting in Philadelphia, Pennsylvania, May 2004

State Service:

- Co-leader, Alaska Mathematics Consortium, 2005 – 2012
- Developer, Math-in-CTE Curriculum Map & Lesson Plans, August 2011

- Facilitator, Statewide Alaska Mathematics Network, Alaska Educational Innovations Network Grant, 2007 – 2010
- Discussant, *Forum on College- and Career-Readiness, Transition from K-12 to College, and Mathematics Curriculum Alignment*, Alaska Mathematics & Science Conference, October 2009
- Panelist, Lee Gorsuch Public Policy Forum on Education on Strengthening Education in Alaska, November 2006
- Writer & Evaluator, Development Team for the Alaska Comprehensive Statewide Student Assessments, 10th Grade Alignment Study, September 2005
- Senior Fellow, Alaska Mathematics Consortium Basic Institute, 2001 – 2002

Service to Area Schools & Districts:

- Instructor, Teaching to the Proposed Alaska Standards for Secondary Mathematics, May 2012
- Co-designer, Anchorage School District sessions to prepare K-12 teachers to participate in the K-8 curricular materials review process, Spring 2012
- College Representative, Anchorage School District STEM Curriculum Committee, 2010 – 2013
- External Evaluator, Matanuska-Susitna Borough School District KEAS/KEMS Mathematics Intervention Program, June 2011
- Presenter, Serving in the U.S. Peace Corps, Nicholas J. Begich Middle School, May 2011
- Presenter, Teaching Mathematics in the U.S. Peace Corps, East High School Mathematics Club, February 2011
- Consultant, Winterberry Charter School Mathematics Curriculum Adoption, Summer 2010
- University Representative, Anchorage School District Mathematics Curriculum Committee, 2007 – 2009
- Mentor, National Board Certification Process, 2004 – present
- Presenter, Kasuun Elementary School Book Fair at Barnes and Noble, November 2009
- Presenter, Russian Jack Elementary School 21st Afterschool Program, November 2009
- Presenter, 6th grade class on Fibonacci sequence and geometrical spiral, Winterberry Charter School, October 2009
- Writer, High School Graduation Qualifying Examination Test Preparation Item Development, Anchorage School District, Summer 2004
- Contributor, Middle School Girls Mathematics Conference, 1998 – 2004
- Chair, Bartlett High School Mathematics Department, 2001 – 2006

University Service:

- Appointed College Representative, Academic Computing, Distance Learning, Instructional and eLearning (ACDLiTe) Committee, 2012 – 2013
- Panelist, Educause Learning Initiative Panel, University of Alaska Anchorage, February 2012
- Faculty Evaluator, eText usage through Blackboard, Fall 2012
- Faculty Evaluator, Blackboard 9.1 Testing, Fall 2011
- Member, UAA College of Education Curriculum Committee, 2011 – 2013
- Participant, College of Education iPad Instructional Users Group, Fall 2011 – 2013
- Contributor, UAA Professional Development Committee, Fall 2011
- Appointee & Co-chair, UAA Chancellor's Sustainability Action Board, 2009 – 2011
- Author, NCATE/NCTM Specialized Professional Associations Report, 2010
- Member, UAA College of Education Teacher Education Council, May 2008 – 2013
- Faculty Advisor, UAA Student Sustainability Club, 2008 – 2011
- Chair, UAA Green Fee Subcommittee, Spring 2011
- Co-Chair, UAA College of Education Graduate Committee, 2010 – 2011
- Member, Science Education Faculty Search Committee, Spring 2011
- Member, Mathematics Education Faculty Search Committee, Summer 2010
- Contributor, UAA E-portfolio Working Group, 2010 – 2012
- Author, NCTM/NCATE Specialized Professional Associations Report, 2010
- Contributor, NCATE Standard 1 Accreditation/Self-Study Report 2010
- Representative, Alaska Teacher Placement Educator Expo, 2010 – 2013
- Presenter, U.S. Peace Corps, UAA Global Opportunities Expo, 2010 – 2013
- Presenter, *Teaching Mathematics Today*, UAA Fall Preview Day, 2009 – 2012
- Member, UAA College of Education Teacher Education Council, 2010 – 2013
- Author, UAA College of Education Travel Committee Selection Criteria Committee, 2008
- Reviewer, UAA Master of Arts in Teaching Program Scholarship Committee, 2007 – 2013
- Member, Alaska Partnership for Teacher Enhancement Committee, Anchorage, Alaska, 2003 – 2005

Community Service:

- Sponsor, Any Soldier Program, U.S. Armed Forces, 2010 – 2011
- Volunteer, National Trails Day, 2009 – 2012
- Trail Crew, Single Track Advocates, Hillside Trails Crew, 2008 – 2011

- Pourer, Great Alaska Beer & Barley Wine Festival, American Diabetes Association, 2006 – present
- Volunteer, Renewable Energy Alaska Project, 2006 – 2012
- Volunteer, Anchorage International Film Festival, 2006 – 2010
- Organizer, Adopt-a-Road Cleanup, Penland Parkway, Anchorage, Alaska, 1998 – present
- Co-facilitator, Dining for Women Anchorage Alaska Chapter Events, March 2011 and September 2011
- President, Alaska Returned Peace Corps Volunteers, 1998 – 2006, 2010 to 2013
- Buddy, Special Olympics Alaska, 1992, 2000, 2005

Grants and Awards

- **Selkregg Community Engagement and Service Learning Award**, 2013, to engage rural and urban secondary mathematics teachers in teaching mathematics for social justice
- **Alaska Math-in-CTE Professional Development Academy Recipient**, 2011, to support collaboration between mathematics and career and technical education faculty work
- **Faculty Technology Center Grant Recipient**, to attend the Educause Learning Initiative Annual Meeting, February 2012
- **Alaska Council for Teachers of Mathematics Professional Development Grant Recipient**, September 2011, to participate in the 2012 Association for Mathematics Teacher Educators Annual Meeting
- **Tenth International Congress on Mathematics Education National Science Foundation Grant Recipient**, 2004
- **Union Plus Scholarship Recipient** 2007, in recognition of outstanding academic achievements, personal character, and social commitments.
- **Delta Kappa Gamma Leader in Education Grant Recipient**, 2004, to support an integrated, hands-on lesson on inverse functions in Algebra II.
- **National Education Association Leadership Grant**, 2003 – 2005, to support Bartlett's professional learning team on the national mathematics standards in the areas of geometry and data analysis.
- **Alaska Mathematics Consortium Professional Development Grant Recipient**, 2002 – 2003, to support Bartlett High School's professional learning team on the national mathematics standards in the areas of algebra and geometry.
- **Alaska Mathematics Consortium Manipulatives Grant Recipient**, 2003, to support basic math instruction.
- **Alaska Mathematics Consortium Classroom Research Grant Recipient**, 2003, to conduct research in a second-year algebra course with graphing calculators and calculator based laboratories.
- **American Society for Training and Development Grant Recipient**, September 1993

Professional Organizations

Alaska Council of Teachers of Mathematics (ACTM), member since 1998
American Federation of Teachers (AFT), member since 2002
Association for Mathematics Teacher Educators (AMTE), member since 2009
Association of American University Professors (AAUP), member since 2002
Association of Curriculum Supervision and Development (ASCD), member since 2011
Council of Presidential Awardees in Mathematics (CPAM), member since 2005
Kappa Delta Pi, Rho Zeta Chapter, initiate since 1994
National Association of Secondary School Principals, member since 2013
National Council of Teachers of Mathematics (NCTM), member since 1993
National Peace Corps Association (NPCA), member since 1998
University of Alaska Anchorage Alumni Association, member since 1994
Women and Mathematics Education (WME), member since 2003