8-2015

The Relationship Between an Affective Instructional Design, Children's Attitudes Toward Mathematics, and Math Learning for Kindergarten-Age Children

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The Relationship Between an Affective Instructional Design, Children's Attitudes Toward Mathematics, and Math Learning for Kindergarten-Age Children

A thesis

presented to

the faculty of the Department of Teaching and Learning

East Tennessee State University

In partial fulfillment

of the requirements for the degree

Master of Arts in Early Childhood Education

by

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August 2015

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Keywords: Affect State, Core Affect, Environmental Affect, Math Learning, Math Attitudes,

Affective Instructional Design, Kindergarten, Universal Design for Learning

ABSTRACT

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This study explores the relationship between an Affective Instructional Design (AID), children's attitudes toward math, and math learning. Participants included 15 kindergarten children at a university K-12 laboratory school located in East Tennessee. This quasi-experimental study employed a pretest-intervention (AID)-posttest design. Data, including pretest/posttest attitude surveys, and baseline and intervention non-participant video observations of math learning and math attitudes, during 13 math lessons were coded and analyzed. As hypothesized, a significant positive correlation ($r = 0.936$, $p = 0.000$) was found between attitude and math learning. Additionally significant differences were found between the baseline (pre-intervention) mean score and the final intervention lesson for both math attitude, $t(14) = -12.39$, $p = 0.008$, and math learning, $t(14) = -8.40$, $p = 0.002$.These findings suggest AID could be one route to supporting educators in establishing quality learning environments that promote positive attitudes and meaningful learning in mathematics.

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CHAPTER 1

INTRODUCTION

Introducing Affect

What drives some children to become involved and invested in the learning process? Why do some enjoy learning? What inspires and motivates children? Why do some children decide to persevere in a problem, or express opinion in a debate?

For each child the answer to these questions is likely different and uniquely individualized based on personal experiences, but they are all a result of positive affective development.

Affective development happens within an individual, and can be positive or negative. It leads to the formation of attitudes, beliefs, and values that a person possesses (Fleckenstein, 1991). Affective development is influenced through experiences. Environment, social interactions, and reflection all contribute to a person's affective development (Fleckenstein, 1991; Hinett, 2002; Littlefield-Cook, Cook, & Bee, 2005; Schoenfeld, 1992; Vygotsky, 1987). Affective development begins at birth, when, with their earliest experiences, the feelings young children have lead to the formation of attitudes which can influence future learning (LeDoux, 1997; Schlöglmann, 2003).

Educators and psychologists through the 20th and 21st century express knowledge and understanding of the importance of affective development (Berridge & Kringlebach, 2013; Clark, 1999; Craig, Arthur, Graesser, Sullins, & Gholson, 2004; Krathwohl, 2002; Miller, 2005; Schlöglmann, 2003). However because it cannot be easily measured, educators have had difficulty incorporating affect in teaching and learning across content areas (Griffith & Nguyen, 2006).

Mathematics is a good example of one content area that has traditionally omitted affective development as a part of the teaching and learning process. In mathematics teaching, instructional designs have relied on direct instruction, with the intention of achieving cognitive development

(Pearse & Walton, 2011; Sparrow & Hurst, 2010; Schoenfeld, 1992). It is also a content area many children express negative attitudes about (Organization for Economic Co-operations and Development (OECD), 2003; Schoenfeld, 1992; Sparrow & Hurst, 2010).

This thesis project explores the relationship between an affective instructional design and young children's attitudes toward mathematics, and their mathematical learning.

Background of the Problem

Affective development is interconnected with cognitive and psychomotor development (Brett, Smith, Price, & Huitt, 2003; Goleman, 1995; Miller, 2005; Plutchik, 2001). Unlike the latter two, affective development is difficult to measure because it is development that happens within a person. Traditionally, it has been valued as a necessary feature in education, essential to the development of good character, beliefs, and values, leading to positive citizenship (Beane, 1986; Noll, Newton, & Oswald, 2010; Zins, 2007).

As a result, educators and psychologists have worked to try to find ways to design curriculum that promotes positive affective development. Intermittently through the 20th century, special curricular programs were introduced to promote affective development: religious teachings, social-emotional programs, reward and punishment systems (Beane, 1986; Brett et al., 2003; LeDoux, 1996). However, these programs were add-ons, independent of the content areas, with an emphasis on establishing positive behavior rather than the development of positive attitudes toward learning (Griffith & Nguyen, 2006).

Historically, affective development has not been made a part of instructional designs for individual content areas. It has been pushed aside to make way for objectives promoting cognition and psychomotor development. Growth in these areas is measurable and tangible, making them the preferred routes to instructional design because they chart measurable attributes (Kirk, 2007; Martin & Briggs, 1986; Pierre & Oughton, 2007; Noll et al., 2010).

Affective development should be considered the driving force behind cognition and psychomotor development, as it is the vehicle through which children first encounter a learning experience (Vygotsky, 1987). In any learning experience there are a number of affect states – feelings - that emerge within an individual (Kort, Reilly, & Picard, 2001). If a child's experience involves an affect state such as frustration or boredom there is potential for a negative attitude to form, followed by low levels of attention, and consequently limited cognitive growth (Akey, 2006). If, on the other hand, the experience inspires affect states such as curiosity, or enjoyment, a positive attitude is likely to emerge, leading to deeper learning (Baker, D'Mello, Rodrigo, & Graesser, 2010; Craig et al., 2004; Koballa, 2007).

Through these affect states arise attitudes essential for meaningful, long-lasting learning. They are expressed through behaviors such as attentiveness to task, self-regulation, purposeful social interaction, and task persistence, all of which lead to increased cognitive growth (Craig et al., 2004; de Lourdes Mata, Monteiro, & Peixoto, 2012).

In their work, Kort et al. (2001) designed an affective learning model, which proposes every learner experiences a range of affect states during the learning process and in doing so, form positive attitudes toward learning (see Figure 1.1).

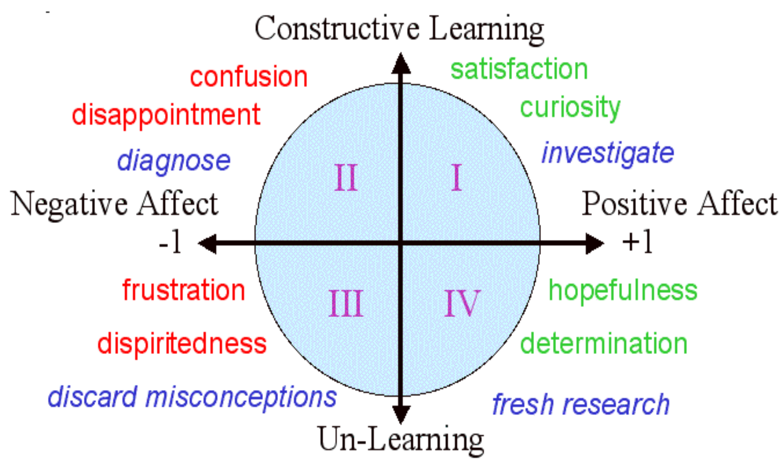

Figure 1. Emotion Learning Model. The model shows the range of affect states experienced during the learning process from "Cognition, Affect, and Learning," by Kort, 2008. Retrieved, with permission from https://sites.google.com/site/barrykort/home/cognition-affect-and-learning)

In their four-quadrant model, learners move from positive to negative and back to positive affect states as they journey through the learning process. Kort (2008) suggests experiencing this range of affect states supports the development of positive attitudes toward learning and is an essential component to constructing knowledge. Further, Kort and colleagues suggest that learners may, at times, experience a mix of affect states such as curiosity and frustration, and that both, when acted upon appropriately by a responsive and supportive adult, promote the process of learning (Kort et al., 2001, Littlefield-Cook et al., 2005).

Based on the supporting research on affect, attitude and achievement (Akey, 2006; Bodovski & Farkas, 2007; Grootenboer & Hemmings, 2007; Ladd & Dinella, 2009), Kort et al.'s, (2001) model of affective learning could be a purposeful way of studying the relationship of an instructional design, children's attitudes and their learning (Akey, 2006; Craig et al., 2004; Vygotsky, 1987). In particular, this model could be helpful in the early years, where children encounter their first experiences with different learning environments, which could influence attitude development and future learning.

Mathematics is a content area that has traditionally relied on instructional designs rooted in didactic and explicit instruction centered on cognitive development (Pearse & Walton, 2011; Sparrow & Hurst, 2010). In their mathematical instruction teachers have followed behaviorist models, where the teacher controls the learning, has pre-determined goals, structured lessons with specific outcomes and children are passive participants in the learning process (Cunningham et al., 2007; Simon, 1995). The teacher gives the students a method to use to find a solution without any thought or discussion as to why or how a solution may be discovered, or the feelings students experience in this learning process (Pearse & Walton, 2011). Within this context, affect has had no purposeful place in the teaching and learning process, and has instead promoted in learners the idea that mathematics involves memorizing rules and formulae with little meaning or purpose. From this have emerged negative attitudes toward mathematics – with individuals feeling it is a subject beyond their scope and without meaning or relevance in their daily experiences (Grootenboer & Hemmings, 2007; Pearse & Walton, 2011; Sparrow & Hurst, 2010).

Therefore, there is good reason to investigate the relationship between an affective instructional design, children's attitudes toward mathematics, and mathematical learning in the early years. Intervening in the early years could promote positive attitude formation, leading to improved mathematical learning, which is indicative of future academic success (Bodovski & Farkas, 2007; National Research Council Mathematics, 2001).

Statement of the Problem

Affective development is key to promoting positive learning attitudes (Claxton, 2012; Fleckenstein, 1991; Sparrow & Hurst, 2010; Vygotsky, 1987). Positive learning attitudes result in behaviors conducive to cognitive development (Bodovski & Farkas, 2007; Claxton, 2008; Grootenboer, 2003). Cognitive development is the focus in education, with test scores being the primary way of measuring development (Griffith & Nguyen, 2006; OECD, 2012; Schoenfeld, 2002). The majority of American children score at, or below average in mathematics with only a 1 point improvement since 2011, and when surveyed, score less than average on positive mathematical attitudes (Nations Report Card (NRC), 2013; PISA 2003). One element missing from instructional designs in mathematics is the intentional and purposeful use of strategies that promote positive affective development (Bodovski & Farkas, 2007; Pearse & Walton, 2011; Sparrow & Hurst, 2010).

Furthermore, research on affective development has focused on character development, and in mathematics on anxiety reduction (Beane, 1986; Bodovski & Farkas, 2007; Brett et al., 2003; LeDoux, 1996; Zins, 2007). Therefore, there is a need for research investigating the relationship between an affective instructional design, children's attitudes toward mathematics, and their mathematical learning.

The Purpose of the Study

The purpose of this study is to explore the relationship between an affective instructional design, children's attitudes toward mathematics, and mathematical learning.

A quantitative design has been chosen to gain an understanding of the relationship between an affective instructional design, learner attitudes toward mathematics, and math learning. The study will take place in a kindergarten classroom at a K-12 laboratory school located in East Tennessee. Using an adaptation of Thomas and Dowker's (2002) Primary Mathematics Survey (see Appendix E) empirical data will be gathered to determine pre and post measures of attitude. Attitude is one measure of affect which includes an individual's engagement, resourcefulness and resiliency in learning mathematics (Chapman, 2009; Dalton, Hegedus, Brookstein, Moniz, & Tapper, 2011). During the 10-lesson intervention phase, the teacher will plan lessons using an affective instructional design (AID) (See Appendix H and I). This design incorporates the use of instructional strategies (see Appendix K) that promote positive affective development, while teaching toward content objectives. During this phase video recordings will be used to gather data for two purposes. First, the study aims to identify emerging patterns of attitude that may develop as a result of the affective instructional design during mathematic lessons. Second, the study seeks to determine the relationship between attitude and mathematical learning. Through analysis, these data can provide a better understanding of the relationship between an affective instructional design and children's attitudes toward mathematics and mathematical learning.

Significance of the Study

Mathematics is a subject that permeates everyday life. It includes problem solving, numbers, shapes, measurement, data handling, and algebra. Using technology, media, in our jobs, or everyday tasks, we encounter and are required daily to use components of mathematical thinking (National Research Council of Mathematics, 2001; Pearse & Walton, 2011). Like reading or writing, the more skilled children are with it, the more likely their success in later life (National Research Council, 2001; Pearse & Walton, 2011).

The foundation for mathematical learning begins before kindergarten. Children as young as six months of age show a beginning understanding of numbers and concepts such as less or more (Kilpatrick, Swafford, & Findell, 2001). The emotions children have in these early mathematical experiences are important to their long-term learning (Bodovski & Farkas, 2007; National Research Council for Mathematics, 2001). It is through these emotions that children develop their interest, curiosity or value for a topic, which lays the foundation for deeper thinking (Vygotsky, 1987). However, based on traditional teaching, children's emotional experiences with mathematics – their puzzlement, interest, wonder, or frustration - have been stifled (Cunningham et al., 2007). Instead they have been taught how to answer a question and then to repeat the process by robotically memorizing steps (Pearse & Watson, 2011). This has not inspired long-term interest in mathematical learning (Cunningham et al., 2007). Furthermore, following his study interviewing 45 primary age students for their views of mathematics, Grootenboer (2003) found students' attitudes toward, and beliefs about mathematics are rooted in their school experiences. Therefore, there is great value in researching ways to purposefully incorporate affect within an instructional design so that teachers are facilitating the development of children's understanding of the various emotions involved with learning mathematics. By doing so, children are more likely to become confident, motivated and invested learners, able to manage the range of emotions experienced in learning while developing cognitive abilities (Kirk, 2007; Pearse & Watson, 2011).

Vygotsky, (1934/1987) wrote that affect is what underpins deep cognitive development. This includes learning to think critically, creatively, and to use language effectively to debate and/or reason. Supporting this idea is research by Diamond and Lee (2011), who found that through affective development, individuals gain the necessary skills for accessing executive functions, which are necessary to achieving higher mathematical learning such as problem solving. Furthermore, research indicates that attitude is related to academic achievement, and it is through affective development that positive attitudes and a long-lasting interest in learning arise (Akey, 2006; Chavarat, 2012; Claxton, 2008; de Lourdes Mata et al., 2012; Koballa, 2007; Ladd & Dinella, 2009; Sparrow & Hurst, 2010; Zembylas, 2004).

Kort et al.'s (2001) affective model has potential to influence teaching and learning. It can be incorporated into an instructional design that a teacher can use to facilitate a learning environment that stimulates affect states, like those described in the Kort et al.'s (2001) affective model: Emotions and Learning Cycle. Through this approach there is potential for affective development in learners leading to positive attitudes toward mathematical learning while constructing deep mathematical understanding. This has long-term implications for the development of children's mathematical knowledge, understanding, and lasting interest in mathematics.

A study of how an affective instructional design influences mathematical attitudes and learning amongst kindergarten-age children is important for many reasons. First, school is the primary setting for mathematics learning. Second, early learning is indicative of future academic success, and mathematics is an area where children have shown decreased interest and achievement through later primary, middle and high school. Third, it is a subject where students have made less progress when compared to international student achievement (Bodovski & Farkas, 2007; De Corte, 1995; Ladd & Dinella, 2009; National Research Council for Mathematics, 2001). Lastly, research indicates that attitude plays a major role in student success (Grootenboer & Hemming, 2007). Therefore, it is important to investigate the relationship between an affective instructional design, student attitudes and mathematical learning as a possible means of affecting the level and nature of student learning (Heibert & Grouws, 2007).

Through this study the researcher hopes to contribute to the body of knowledge about the role of affect in mathematical learning, specifically, how an affective instructional design might relate to mathematical attitudes and mathematical learning.

Research Questions

Within the study, one overarching question and two sub-questions will be addressed.

Overarching Question. Does an affective instructional design improve children's attitudes toward mathematics and mathematical learning?

Sub-Research Question #1. Is there a correlation between children's attitudes and mathematical learning?

Sub-Research Question #2. What are children's attitudes toward mathematics?

Hypotheses

1. It is predicted that the proposed affective instructional design (AID) adapted from Kort et al.'s, (2001) affective learning model will positively impact children's attitudes toward mathematics and mathematical learning.
2. It is predicted that there will be a significant positive correlation between children's attitudes toward mathematics and mathematical learning.

Limitations

This study will be completed in a small class, with only 15 participants. It is a non-randomized, convenience sample, and will involve only one age group. For these reasons, the findings may not be generalized to other educational settings. However, findings from this small study can guide the direction for future, larger studies with more significant implications.

Due to the age of the children completing the Attitude to Mathematics Survey (see Appendix E), there may be possible issues with self-reporting. For that reason video recording will be used to minimize inaccuracies in self-reporting and to increase validity.

Lastly, the study is being completed over a period of 2 weeks, and changes in attitude may not be evident in so brief a period. Therefore this study is limited by time and scope.

Definition of Terms

For the purpose of this study the following terms will apply:

1. ***Attitude.*** McLeod in 1992 (as cited in Grootenboer, 2007) described attitude as observable, expressed in positive or negative ways, and arising as a result of experiences. For the

purpose of this study, data reflecting positive expressions of attitude will be collected. Such expressions will include learner engagement (on-task, interest in activity, purposeful participation, relevant mathematical conversation); resourcefulness (willingness to seek support/resources, question asking, listening to develop a new line of inquiry); and resiliency (a willingness to try a new line of thinking, taking multiple attempts at working out a problem) in mathematical activities (Dalton et al., 2011).

i. ***Engagement***. On-task behaviors that a child demonstrates during mathematics including: active listening, math conversation (use of mathematical language, gesturing and question asking), purposeful collaboration with peers, and attentiveness to task (Wells & Claxton, 2008).

ii. ***Resourcefulness***. Can be expressed in two ways: personal and social. In this study social resourcefulness will be the observation focus. Social resourcefulness refers to a child's purposeful help-seeking behaviors (asking questions of an interested adult, listening and sharing with peers). Through these interactions learners are able to shape thinking and generate ideas for problem-solving (Zausniewski & Bekhet, 2011).

iii. ***Resiliency***. Any behavior that reflects task-persistence and is beneficial to the student's development of mathematical concepts. For this study, resiliency will be measured by a child's flexibility in thinking as demonstrated by trying new strategies, or responding positively to peer or adult suggestions (Yeager & Dweck, 2012).

2. ***Affect.*** A developmental domain triggering emotional, behavioral, or psychological responses, which shape an individual's attitudes, thoughts, and actions (Claxton, 2012; Martin, 1999).
3. ***Affect States.*** The range of emotions, expressed as feelings that an individual experiences in a given moment, that lead to physiological, cognitive, and behavioral responses (Fleckenstein, 1991).
4. ***Instructional Design.*** The method used by the teacher to present learning material to the students. In this study the instructional design will be organized around two parts: environmental affect and core affect (Martin, 1999; Russell, 2003).
    i. ***Environmental Affect.*** The strategies from the environment that a teacher uses to initiate an affective state in the learner. These might include the teacher's use of language; any range of auditory, visual or kinesthetic strategies; manipulatives; or groupings for an activity. Environmental affect is an external stimulus used to initiate an affective state within the learner (Russell, 2003). In this study, an environmental affect will be stimulated through the use of Universal Design Learning Strategies.

    ii. ***Universal Design for Learning (UDL).*** The UDL model recognizes each student as a unique learner, needing access to information in different ways (auditory, visual, kinesthetic, independently, and in small groups) (Howard, 2004). Through this model children have the opportunity to receive, respond, and engage with new information in a variety of ways which promotes feelings of security and support, while constructing knowledge and understanding (Stanford & Reeves, 2009).

iii. ***Core Affect.*** The internal emotions that an individual experiences that are processed through thought and reflection (Hinett, 2002; Russell, 2003).

iv. ***Reflection.*** A way of promoting deeper thinking and understanding, contemplation, further questioning, and a chance to share feelings and emotions associated with the learning process, as well as how to move learning forward. Used purposefully, this process provides opportunity for understanding and influencing the core affect of the learner (Claxton, 2008; Hinett, 2002).

5. ***Mathematical Learning.*** Learning that leads children toward becoming numerate (Pearse & Watson, 2011).
6. ***Numerate.*** The ability to think deeply about and value mathematics; to reason, evaluate, communicate and apply their knowledge and understanding in everyday life situations through the use of words, pictures or symbols (Pearse & Watson, 2011).
7. ***Mathematical Problem-Solving.*** An opportunity to learn through application of shared mathematical thinking, use of mathematical vocabulary, gestures, symbols, pictures, or manipulatives to convey their understanding (Claxton, 2012; Hiebert & Grouws, 2007; Pearse & Watson, 2011).

Overview of the Study

The overarching goal of this study is to investigate the relationship between an affective instructional design, children's attitudes toward mathematics, and mathematical learning. This study is significant as mathematics is a subject that traditionally is disassociated with affect, and it is a subject that children have made little progress, and express a lack of interest in, or value for. Yet it permeates everyday life. Therefore, it is valuable to investigate ways that may promote the development of positive attitudes toward mathematics, and mathematical learning.

The following chapter contains a review of relevant literature including the history, trends and evolution of the study of affect in education; current research about affect; affect in teaching and learning mathematics in the early years; and the disconnect between research and practice. After the review of literature, the conceptual framework for the study is presented.

CHAPTER 2

REVIEW OF THE LITERATURE

A History of Affect in Education

An Absence of Affective Curriculum

When we trace the evolution of affect in child development and learning in America, we see that through the late 19th and early 20th century, educators focused on content areas (knowledge acquisition) with no consideration of the role affect plays in learning. Teachers were authoritarian in terms of managing the social climate. Class numbers were large; children sat in rows of desks which were bolted to floors; they committed information to memory and were expected to follow the rules, and to act with manners and obedience at all times (Cuban, 1984). During this same historical period, religion played an important role in the evolution of affect, both in and outside of the classroom. Religious zealots regarded affect as something imposed on individuals and learned by following religious teaching, such as being good to your neighbor, being honest and truthful, following the laws or rules of the religion, Bible or classroom. Authoritarian adults in charge imposed punishments of varying degrees on those who failed to follow the rules (Beane, 1986; Martin, 1999).

The Rise of Affective Curriculum

Through the early to mid 20th century, concepts involving child-centered learning, linking knowledge and understanding to the child's world, began to emerge as part of the Progressive movement and with it, philosophers such as Dewey (1939) introduced ideas of developing affect through shared human experiences (Beane, 1986). From this, constructivist models emerged, promoting learning as an active process, where children construct knowledge through interaction with their environment (Littlefield-Cook et al., 2005; Schoenfeld, 1992; Wortham, 2002) and eventually the development of affective education – programs designed to explicitly teach children values, morals and character (Cuban, 1986). Simultaneously, psychologists contributed research that influenced the evolution of affect in education. Skinner (1968) regarded behavior as an outward expression of affect, and as something to be regulated by external influences such as punishment and reward systems. This notion lead to behaviorist models of instruction based on reward and punishment which are often still used in classrooms today (Craig et al., 2004). Others, such as Bloom et al. (1964), identified different classifications, or taxonomies, for learning. Specifically, he defined the affective domain as giving rise to internal emotions related to attention and conscience. In this classification system, affect develops in a 5-step hierarchical manner (Clark, 1999). The steps progress from receiving to responding, followed by valuing, organization and ending with characterization. Through teaching and learning within this model of the affective domain, Bloom and supporters of this taxonomy, believed children would develop desirable dispositions for learning, which would contribute to development of knowledge and understanding in the cognitive domain (Krathwohl, 2002). The publication of Bloom's work has lead to further research into attitude, behavior, motivation and engagement. It had an impact on instructional design through the second half of the 20th century, leading to social-cognitive programs such as Social, Emotional, Learning (SEL) and Providing Alternative Thinking Strategies (PATHs). As a route to supporting the social-emotional development of middle school children, these programs emphasize developing qualities of good citizenship, and a positive school climate. The wide scale implementation of such programs has limitations, as they add to already over-stretched instructional schedules (Protheroe, 2012). Since the initial publication of Bloom's (1956) Taxonomy of the Affective Domain, there have been a number of other taxonomies written in an attempt to more concisely summarize and link the complex nature of affective development to instructional design (Miller, 2005).

Current Research on Affect

During the last decade of the 20th century, and moving into the 21st century there have been breakthroughs in neuroscience that have lead to new views of the role of affect in development.

Neuroscience involves the study of different systems of the brain, their specific and inter-related functions, as well as how these systems relate to cognitive and affective processes (Schlöglmann, 2003). Research in neuroscience suggests that the root of emotional development occurs in the amygdala - a part of the limbic system. This is the area of the brain in charge of memory and emotion (Berridge & Kringlebach, 2013; Gupta, Koscik, Bechara, & Tranel, 2011; Le Doux, 1999; Schlöglmann, 2003). Through their research, scientists suggest that the limbic system, specifically the amygdala, reacts first to sensory information, triggering areas of the brain in the prefrontal cortex, which are responsible for working memory. Based on the trigger, the working memory either stimulates a feeling synonymous with a past experience, or the working memory perceives the nature of the stimulus and draws on long-term memories to determine an emotional response (LeDoux, 1999; Taylor, 1992). That response can be observed through any number of bodily reactions, including facial expressions, sweating palms, or increasing heart rate (Evans, 2006; Schlöglmann, 2003). In turn, cognitive processes impacting concentration, decision making, and attention, are activated (LeDoux, 1999; Schoenfeld; Taylor, 1992).

In his work, Schlöglmann (2003) has investigated the neuroscience behind affect and mathematics education. According to Schlöglmann (2003) children experience a steady stream of stimuli, otherwise known as sensory information, in any learning situation. This sensory information is interpreted first by brain systems connected with affective processes, and then closely thereafter by brain systems connected with cognitive processes. These affective and cognitive responses influence an individual's ability to attend, as well as triggering new memories and attitudes, all which impact learning (Schlöglmann, 2003).

For example, certain physiological responses may arise within a child whose first experience with solving mathematical problems leads to feelings of confusion, frustration, or anger. Such responses may include increased heart rate, inability to attend, irritability, or displeasure, and will interrupt the child's concentration, or creative thinking.

It is the emotions associated with experiences from a young age that are stored and triggered when similar situations arise that eventually influence an individual's attitude (Claxton 2012; Fleckenstein, 1991; LeDoux, 1999). This research suggests that it is through emotional development that the potential for nurturing positive associations with learning resides, and in that, the potential to inspire an affiliation for deep thinking.

Affect in Teaching and Learning Mathematics in the Early Years

The National Scientific Council on the Developing Child (NSCDC, 2007) recognizes that child development is the key to the future success of a society. They define the core concepts of development as including "cognitive skills, emotional well-being, social competence, and sound physical and mental health" (NSCDC, 2007, p. 4). Further, they stress that if these areas of development are fostered in the early years through quality learning environments, nurturing relationships, and engaging social interactions, a foundation will be laid for future successes: positive school achievement, future economic productivity, as well as responsible citizenship (NSCDC, 2007).

An awareness and understanding of affective development is the route toward achieving these goals. The literature suggests that it is through affective development that children gain emotional well-being, social competence, sound mental health, and cognitive skills (Claxton, 2012; Fleckenstein, 1991; Goleman, 2006; Mahn & John-Steiner, 2002; Schlöglmann, 2003).

Affective development begins with an infant's earliest experiences, occurring because of his/her emotional responses to environmental and social stimuli that is interpreted by the brain as sensory information (LeDoux, 1997; Schlöglmann, 2003). A nurturing environment with strong, supportive relationships promotes positive affective development (Bredekamp, 2005; Goleman, 2006; NAEYC, 2009; Smidt, 1989)

In the early years' literature, affect is most often written about as the emotions that a child experiences and expresses as feelings. These feelings lead to the formation of attitudes, which are observable through a child's words or actions (Goldin, 2006; McLeod, 1992; Schlöglmann, 2002; Schoenfeld, 1992; Smidt, 1989; Taylor, 1992). Therefore, attitudes can be defined as an expression of affective development (Breckler & Wiggins, 1989; Grootenboer, 2007; Kort et al., 2001; Lee & Shute, 2009; McLeod, 1992; Russell, 2003; Schoenfeld, 1992; Schlöglmann, 2002). Research on affective development suggests that attitudes are transitory, reflecting affect states, and can be influenced by environment and social interactions (Evans, 2006; Fleckenstein, 1991; McLeod, 1992). This understanding is particularly important in the early years, when children begin to form attitudes for learning that influence their beliefs or values in the long term, and it is adults who are responsible for the environment and social interactions within which the learning occurs (Lee & Shute, 2009; Schoenfeld, 1992; Zan, Brown, Evans, & Hannula, 2006).

Research About the Role of Affect in Teaching and Learning

Supporting this idea is research by Zembylas (2004) who found that emotion and cognition are interdependent components of young children's successful science learning. In her three-year longitudinal study, Zembylas (2004) used a qualitative, ethnographic methodology to investigate the role of emotion in science teaching and learning in a mixed-age classroom of first and second grade students. Zembylas worked closely with the classroom teacher, discussing instruction, reflecting on lessons, and sharing thoughts about curriculum and lesson planning, as the classroom teacher worked to create a learning community based on a "supportive emotional culture" (p. 700). The classroom teacher followed a social constructivist practice, incorporating exploratory, inquiry-based integrated and thematic curricular programming. Classroom organization – design of the learning environment, opportunity for social interaction, and availability of learning materials - was frequently reviewed and changed to meet the needs and interests of the children; this was a way of developing an affective learning environment. Additionally, during science lessons, time was dedicated to providing opportunities for children to share, discuss, and reflect on activities as a way of facilitating a caring community of science learners.

A variety of qualitative data sources were collected and analyzed, including video-taped classroom observations, teacher interview transcripts, field notes, lesson plans, philosophy statements, a diary, children's worksheets, and school records. Open-coding, and constant comparative approach were used to identify and confirm emerging themes from the data (Zembylas, 2004).

Zembylas (2004) reported three findings from the study. First, emotions and cognition play equally important roles in science learning, and that "intellectual growth was synonymous with emotional growth" (p. 716). Second, the aesthetic quality of the learning environment is significant to children's intellectual development. Third, the role of the classroom teacher in facilitating positive emotional interactions is significant to developing a positive emotional tone in the learning environment. This research, although limited based on number of participants, has significance as it suggests emotion has an important role in learning, and highlights factors such as teacher-child interactions, and environmental design as important affective components that promote positive emotional experiences leading to positive learning attitudes.

Research suggests that attitude is predictive of a child's future academic successes (Akey, 2006; Claxton, 2008; Grootenboer & Hemming, 2007; McLeod, 1992; Russell, 2003; Singh, Granville, & Dika, 2002). In their study of 8th grade students, Singh et al. (2002) investigated the effects of affective variables: attitude, motivation, and academic engagement, on students' academic achievement in mathematics and science. The participants consisted of a random sample of 2,958 students in 8th grade. Using structural equation modeling, Singh et al. (2002) assessed "the direct and indirect effects of [the affective variables] on each other and on achievement" (p. 324). They found that there is a direct relationship between the three affective variables and students' mathematical achievement. Specifically, attitude had a direct effect on academic time ($\beta = .21$), which was a measure of motivation, and attitude had a direct effect on academic achievement ($\beta = .23$). From their findings, they also suggest attitude toward mathematics is not fixed but can be influenced by the instructional design or delivery (Singh et al., 2002). Findings from this investigation are significant because they suggest attitude is an important factor in mathematics achievement. Furthermore, this research supports the idea that specific strategies can be used in the instructional setting to "enhance [student] interest in mathematics" (p. 330).

Moreover, Grootenboer and Hemmings (2007) examined affective and demographic factors that contribute to mathematical performance amongst 1,880 third through eighth grade students ($M = 10.6$ years). There were 78 teachers, who participated in the study. The participants came from three types of schools, primary (Year 1-6), intermediate (Year 7-8), and full primary (Year 1-8). The investigators collected survey data from the participants, which included demographic-style questions (gender, ethnicity, and school year level), as well as questions to determine “Kids Ideas about Maths (KIM)”. Performance ratings were collected from the participants’ teachers. Using SPSS (Version 14.0), investigators carried out correlation analyses. Spearman’s Rho was used to determine correlations related to the gender and ethnicity, while Pearson product-moment was used for the socioeconomic status variables, and affective variables. Grootenboer and Hemmings (2007) used a regression analysis to identify which combination of the affective and demographic factors could be used to classify students as below average, average, or above average achievers. They found a direct correlation between affective factors and mathematical performance. Four affective factors were measured, Positive View of Mathematics, $r = 0.361$, $p < 0.001$; Utilitarian Belief, $r = 0.203$, $p < 0.001$; Traditional Belief, $r = -0.190$, $p < 0.001$; Math Confidence, $r = 0.229$, $p < 0.001$. Furthermore, in their regression analysis, they found SES and affective factors to be unrelated. This study is significant because it suggests there is reason for further research, investigating the relationship between affective factors and mathematical performance.

In their longitudinal study of 13,043 kindergarten students, Bodovski and Farkas (2007) investigated the relationship between early math readiness, quality of student engagement, and long-term mathematical achievement. The data for this study came from the US Dept. of Education, National Center for Education Statistics, Early Childhood Longitudinal Study – Kindergarten Cohort (ECLS-K). Investigators constructed a sample group including only those participants who had data available for the fall and spring of kindergarten, and the spring of first and third grade. Data was analyzed in two parts. First, three models were analyzed for achievement gain, and second, mathematical skills at the beginning of kindergarten were analyzed and sorted according to high and low skill level. Investigators then focused on the lowest achievers, their number knowledge, and corresponding achievement gains through to third grade. Bodovski and Farkas

(2007), measured student engagement using the “Approaches to Learning in ECLES – K”. Teachers completed the survey for kindergarten, first, and third grade. Findings from the study suggest that gains in knowledge and understanding by the spring of third grade correlate with achievement levels upon entry to kindergarten. Time spent on instruction corresponded to students’ needs. The lower the student ability, the higher the time given to instruction. A positive and reciprocal relationship was found between engagement and student achievement. Student engagement had the greatest impact on achievement gains versus time on instruction; kindergarten engagement (M = 3.17, SD = .67); kindergarten instruction (M = 1.79, SD = .70); grade 1 engagement (M = 3.07, SD = .67); grade 1 instruction (M = 2.29, SD = .54); grade 3 engagement (M = 3.06, SD = .64); grade 3 instruction (M = 2.36, SD = .53). This study is significant as it suggests that mathematical readiness is indicative of future mathematical achievement, and student engagement is an important factor in student achievement.

It is important in the early years that educators understand the interconnected relationship of affective and cognitive development. Affective development is important to child development; attitude is an expression of affective development; attitude is predictive of children’s future academic successes; attitude, and therefore, affective development, can be fostered through learning environments, strong relationships, and positive social interactions (Claxton, 2008, Dweck, 2007; Mahn & John-Steiner, 2002; McLeod, 1991; NAEYC, 2009; NSCDC, 2007; Schlöglmann, 2008; Schoenfeld, 1992; Seeger, 2011; Taylor, 1992).

A Disconnect Between Research and Practice

Contrary to this approach, an early years’ environment that offers children worksheets, stickers, and checkmarks to reinforce correct answers promotes understanding rooted in memorization and heteronomy rather than autonomy (Kamii, 2000; Schoenfeld, 1992; Seeger, 2011; Taylor, 1993). In such a situation, the point of view promoted in the learning environment is reward for a correct answer and following adult direction, rather than embracing mathematical learning through discovery, exploration, and shared thinking. In such an environment, affective and cognitive development resides around the concept of reward rather than deep learning (Schoenfeld, 1992; Seeger, 2011).

Educators in the 21st century, following the passing of the No Child Left Behind Act (2001), and the “Race for the Top” Initiative (2009), are being held to a higher than ever degree of accountability. Academic achievement standards measured by cognitive outcomes have been set for learners, and schools are expected to meet these standards, or suffer consequences such as reduced funding or eventual job loss (Griffith & Nguyen, 2006). As a result, school systems across the country have experienced vast changes in traditional practice. School days have been lengthened and recess times decreased or eliminated. An emphasis has been placed on single-subject teaching, testing and tracking progress in English and mathematics, as well as following prescribed instructional designs focused on meeting standard-specific objectives (Griffith & Nguyen, 2006; Jones, 2012; Schoenfeld, 1992). This emphasis on prescriptive practice to meet discrete outcomes promotes learning as a product, not a construct. Learning is not regarded as an ongoing process involving challenge, puzzlement, erroneous thinking, as well as discovery, knowledge and understanding (Yeager & Dweck, 2012). Through this product approach, children are more likely to develop performance-oriented attitudes characteristic of fixed mind-sets and lacking in affective development (Bransford, Brown, & Cocking, 2000; Dweck, 2007). The result? Children do not develop an understanding of, or value for, the range of emotions associated with learning – excitement when feeling success, and sometimes confusion or disappointment in the face of failure. Instead they become fearful of failure, anxious to achieve a result, and disconnected with learning as a process (Amrein & Berliner, 2003). As schools race for the top, children's affective development is being left behind (Noll et al., 2010).

These changes to education and resulting practices are problematic because they are not working. The Program for International Student Assessment (PISA), is an international assessment given to students who are 15 years of age. They are tested in three-year cycles on English, Science and Mathematics (OECD, 2012). The results from this international assessment provide information about a country's education system. Currently there are 65-70 countries participating in PISA. The PISA results for 2012, which had a focus on mathematics achievement, show no measureable improvement for American students over past scores, with math and reading both falling below or just average in comparison to the mean scores of the 65 participating nations (OECD, 2012). Additionally, The Nation's Report Card (NRC) uses information collected by the National Assessment of Educational Progress (NAEP) to report findings on the achievement of various subjects from elementary and secondary schools across the United States. The NRC (2013) reports only a 1 point improvement in math competency among fourth graders since 2011, with 83% of children still performing at or above only the basic level of achievement. Furthermore, in the United Nations 2010 ranking of child well-being for the top 29 wealthiest countries, the United States found itself ranked in the bottom 25%. Quantity and quality of education are two areas measured to determine the well-being of children within a nation. In this category, the United States ranks 27th out of 29 countries (Provasnik et al., 2012; Schoenfeld, 1992; UNICEF Office of Research, 2013).

Collectively, these findings suggest that this new educational emphasis, with the corresponding changes to the teaching and learning environment, is not having any measurable impact on developing children's deeper cognitive thinking or value of long-term learning (Griffith & Nguyen, 2006; Jones, 2012).

One component absent in this new educational approach is the purposeful inclusion of affect in instruction. Through affect, children develop positive attitudes toward learning and are more likely to possess growth mind-sets - the understanding that intelligence grows through learning, and is not fixed at birth (Dweck, 2010). Affect is what leads to deeper cognitive thinking and resiliency in learning (Claxton, 2008; Dweck, Walton, Cohen, Paunesku, & Yeager, 2011).

Overall, the research that has been done with respect to affect in teaching and learning has been achieved by looking at isolated components of affective development such as motivation, engagement, character or attunement (Broussard & Garrison, 2004). As well, affect has been taught in isolation, as a discrete subject through character education, religious teaching, or social emotional learning classes (Craig et al., 2004; Miller, 2005). In all cases, the findings suggest that children benefit emotionally and academically when these factors are included as components of teaching and learning. However, they have not been brought together as part of an instructional design for mathematical learning. Therefore the actual impact of emphasizing affective development in teaching and learning may not be fully realized. As Vygotsky (1934/1987) wrote:

> [Thought] is not born of other thoughts. Thought has its origins in the motivating sphere of consciousness, a sphere that includes our inclinations and needs, our interests and impulses, and our affect and emotion. The affective and volitional tendency stands behind thought. Only here do we find the answer to the final "why" in the analysis of thinking. (as cited in Mahn and Steiner, 2002, p. 282).

The Conceptual Framework

An Introduction to the Conceptual Framework

Schoenfeld (1992) states that mathematical learning in the 21st century looks vastly different than the traditional view of mathematics, which saw it as a practice involving memorization and rote rehearsal. According to Schoenfeld (1992), mathematics should be viewed as a social activity, through which development of higher-order mathematical thinking arises. Students of the 21st century need to become numerate, and it is through this view of mathematics as a social activity that this can be achieved (Hiebert et al., 2005; Pearse & Walton, 2011). When children are numerate they have the ability to think deeply about their mathematics: to reason, evaluate, and apply their knowledge and understanding in everyday life situations (Pearse & Walton, 2011). Children who are numerate learn to communicate their mathematical thinking, use mathematic language to convey their understanding, and to connect concepts and ideas laterally as a way of developing solutions to problems (Hiebert et al., 2005; Kostos & Shin, 2010). They show flexibility in thinking, creativity, and perseverance in problem-solving (McLeod, 1992; Schoenfeld, 1992; Seeger, 2011). Achieving these skills requires developing an understanding of the emotions involved in learning. To achieve this end, the role of affect in mathematical learning must be given consideration (Evans, 2006; McLeod, 1992; Schoenfeld, 1992; Seeger, 2011).

The conceptual framework for this study is rooted in social-constructivist and constructivist theories of learning, is an adaptation of Kort et al.'s (2001) model that relates learning and emotions, and is based on research that supports the use of specific instructional strategies to promote positive affective development.

Learning Theories and Affective Development

Social Constructivism. In *Thinking and Speech* Vygotsky (1934/1987) referred to affect as a route to deeper cognitive thinking. It is the child's emotional experience while in the zone of proximal development that underscores his/her thinking and results in meaningful learning (Mahn & John-Steiner, 2002; Taylor, 1992).

Vygotsky (1978) wrote that children learn optimally when in their zone of proximal development (ZPD). This is a learning environment where the child is challenged just beyond his/her independent working ability. According to Vygotsky (1978), the teacher must consider three factors to ensure successful teaching and learning within the ZPD: the quality of mediated instruction; the purposeful use of resources – social interactions, as well as manipulatives - to support learning; and the teacher's ability to recognize and respond to a child's affect states (Mahn & John-Steiner, 2002; Taylor; 1992; Wilson, Teslow, & Taylor, 1993). Vygotsky recognized that a child experiences various affect states while in the ZPD, and the teacher, while scaffolding learning, must consider both cognitive and affective development. Learners need to be appropriately challenged in both areas, and the teacher needs to be able to respond appropriately to both affective and cognitive needs in order to successfully facilitate learning (Cooper & McIntyre, 1996; Lui, 2012; Mahn & John-Steiner, 2002; Taylor, 1992; Vygotsky, 1978; Wilson et al., 1993; Zembylas, 2004). By considering the learning environment, the purposeful use of language, social interactions and choice of teaching strategies, a teacher can mediate the emotions associated with learning, thereby promoting positive affective development and cognitive growth within the child's ZPD (Claxton, 2008; Mahn & John-Steiner, 2002; Taylor, 1993; Thompson, 1991; Zembylas, 2004).

Constructivism. Piaget (1948) stated that the purpose of education should be to support the autonomous social, moral, and intellectual development of each child (as cited in Kamii, 2000). Autonomy refers to an individual's independent thinking skills, self-awareness and regulation, leading to deep thinking and understanding (Kamii, 2000). This approach to teaching and learning mathematics requires opportunity for exploration, discovery, and shared thinking. Such opportunities are rooted in emotional experiences and therefore affective development. Developing mathematical logic, which is essential for deeper mathematical understanding, comes through development in both the affective and cognitive domains (Kamii, 2000; Schoenfeld, 1992).

Piaget stressed the importance of respectful and nurturing relationships to support a child's development of autonomy (Kamii, 2000). He defined three affect states of young learners that, if nurtured, support the development of autonomy: respect, curiosity, and puzzlement (Kamii, 2000). An affect state, also referred to in the literature as core affect, is defined as the emotions that an individual experiences in any moment that are outwardly expressed as feelings (Fleckenstein, 1991; Goleman, 1995; Kort et al., 2001; Russell, 2003; Schlöglmann, 2002; Shen, Wang, & Shen, 2009; Storbeck & Close, 2008).

According to Piaget, children who participate in respectful and affectionate relationships construct their own understanding of how to interact with others, thereby gaining the social-emotional maturity required to participate successfully in group situations. The child, who is respected for his or her thoughts and feelings, learns to respect the thoughts and feelings of others (Piaget, 1965, as cited in Kamii, 2000). From feelings of respect, arise the ability to participate constructively in a cooperative learning environment where exchanges of mathematical knowledge and discussions about mathematical thinking, or reasoning take place, leading to deeper mathematical understanding (Kamii, 2000; Schoenfeld, 1992; Seeger, 2011; Taylor, 1993, Thompson, 1991).

Moreover, Piaget described children as active learners, innately curious and interested in constructing new understanding (Kamii, 2000). Curiosity leads to engaging behaviors and thoughts, which in turn become constructive learning opportunities. The responsibility lies with teachers to offer children engaging, meaningful, and interactive environments. When such an environment exists, children are most likely to immerse themselves in exploration and discovery, thereby stimulating positive affect states, which in turn allow for deep thinking (Kamii, 2000; Russell; 2003; Storbeck & Clore, 2008).

Furthermore, Piaget defined learning as a process whereby the child experiences a sense of disequilibrium, or puzzlement, leading to new learning. Puzzlement is an affect state that leads a child to question, discard misconceptions, and begin to build new, deeper understandings (Kort et al., 2001).

The role of the teacher in all of these processes is to recognize, scaffold, and facilitate the child's affective and cognitive development within the environment, leading to autonomy and deep mathematical learning (Kamii, 2000; Schoenfeld, 1992; Seeger, 2011; Taylor, 1993; Thompson, 1991).

From these learning theories it is possible to see the important role that affective development plays in learning. It is through affective development that higher-order cognitive development is possible (Fleckenstein, 1991; Mahn & John-Steiner, 2002). These are two interconnected systems whereby cognition depends on positive affective development (Brett et al., 2003; Fleckenstein, 1991; Goleman, 1995; Miller, 2005; Plutchik, 2001; Schlöglmann, 2002).

Mathematical Learning and Emotions

Research Relating Learning and Emotion. The view of affect in mathematical learning has evolved since the 1980s through the work of researchers who have expanded the understanding of attitude and emotions in learning (Evans, 2006; Hinton, Miyamoto, & Della-Chiesa, 2008; McLeod, 1992; Zembylas, 2004).

Historically, attitude was considered a measure of affect that was a fixed characteristic, narrow in scope – involving an individual's self-reported liking or disliking of mathematics (Taylor, 1992). Current research suggests that attitude is transitory and related to the deluge of emotions experienced in any learning situation (Evans, 2006; Hinton et al., 2008; McLeod, 1992; Taylor, 1992). Emotions can be positive, negative, or somewhere in between, and consequently impact the quality of learning that occurs (Russell, 2003; Storbeck & Clore, 2008; Zan et al., 2006). Such findings have lead to an understanding of the important role affect plays in learning, as well as how factors such as the learning environment and social interactions within that environment can impact affect, and therefore learning (Mahn & John-Steiner, 2002; McLeod, 1991; Schlöglmann, 2008; Schoenfeld, 1992; Seeger, 2011; Taylor, 1992).

Furthermore, research in neuroscience suggests that affective and cognitive processes are interconnected – in other words, emotion and learning are linked to one another. For example, when affective processes stimulate emotions that give rise to feelings such as fear, or nervousness, a negative relationship with learning exists (Evans, 2006; Storbeck & Clore, 2008). When an individual is overcome by negative emotion, the ability to attend, make decisions, or problem solve is significantly reduced. However, through development of cognitive processes, an individual can learn to regulate, through reasoning, such emotions (Evans, 2006; Hinton et al., 2008; Storbeck & Clore, 2008). This ability to reason allows an individual to gain control over his/her affect state, to make room for learning to occur. However, such cognitive appraisal can only occur if learners have been taught how to recognize their affect states, and to reflect on them to develop the cognitive ability to self-regulate (Evans, 2006; Goleman, 2006; Hinton et al., 2008; Zan et al., 2006).

These new understandings, linking learning and emotion, give rise to the idea that teachers need to be taught how to foster cognitive and affective development in children. An instructional design that supports affective and cognitive development may be one route to achieving this goal.

A Model Relating Learning and Emotion. In their research Kort et al. (2001) support the idea that learning is a process involving cognition and emotion. Furthermore, they reason that children need to be taught about the range of emotions involved in learning in order to become successful learners. They write that a range of affect states, experienced in a certain order, lead to meaningful learning. Affect states, also referred to in the literature as core affect, are defined as the emotions that an individual experiences in any moment that are outwardly expressed as feelings (Fleckenstein, 1991; Kort et al., 2001; Russell, 2003; Storbeck & Clore, 2008).

In support of these ideas, Kort and colleagues (2001) devised a model relating learning and emotion (Figure 1). In their model, they propose four emotion phases, as depicted by quadrants on an axis, that link to different stages of learning. In the initial phase, learners experience positive affect states such as curiosity, which leads to interest and investigation, resulting in constructive learning. In the second phase, understanding is challenged, which leads to negative affect states such as confusion or disappointment. In this phase learners recognize a problem exists between what they currently know and the information they are presented with. This leads to the third phase, which involves affect states such as frustration. It is in this phase that the learner recognizes the need to discard incorrect information, thereby allowing for new learning to take place. In the final phase the learner experiences renewed interest, hope and determination leading to new understanding and meaningful learning.

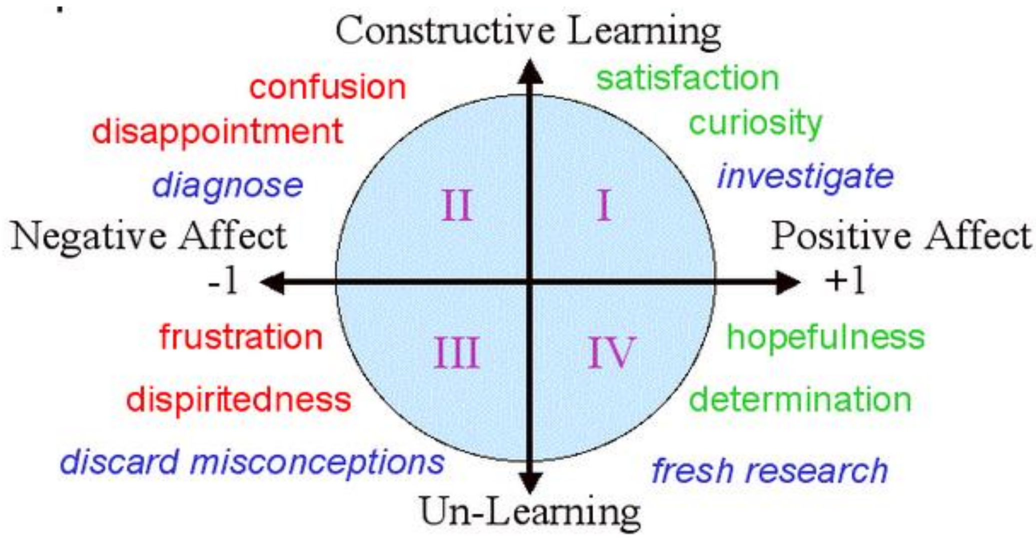

Figure 1. Emotion Learning Model. This model illustrates the range of affect states experienced during the learning process. From "Cognition, Affect, and Learning," by Kort, 2008.
Retrieved with permission, from https://sites.google.com/site/barrykort/home/cognition-affect-and-learning.

Research supporting the ideas proposed by Kort and colleagues, (2001) has been done by D'Mello and Graesser (2011), who used computer technology to measure the decay rate of affect states during learning. They found that college students who participated in a 32-minute Auto Tutor session experienced a range of affect states similar to those described by Kort and colleagues (2001). In their findings, D'Mello and Graesser (2011) report that positive affect states such as delight and surprise decayed more quickly than negative affect states such as confusion and boredom, while the decay rate of frustration fell between the two (D'Mello & Graesser, 2011). Additionally, they found a negative correlation between prior knowledge and engagement, but a positive correlation between acquired knowledge and engagement. This suggests that students need to be challenged appropriately in the learning process; otherwise, they risk being stuck in negative affect states such as boredom, which could lead to negative attitudes toward learning.

While Kort and colleagues' (2001) work is based on the design of a computerized learning companion that recognizes and responds to a learner's affect states, the current study uses the model as the foundation for an instructional design that can be used by teachers to mediate affective and cognitive development through their instructional practice.

The Affective Instructional Design

Design Components. Learning is the overarching goal of every instructional design. Within the instructional design two questions must be addressed – What is the objective of the learning? How will the instruction be delivered? The answer to these two questions depends upon the type of instructional design implemented (Wilson et al., 1993).

In this study, the *what* of the instructional design has been predetermined by the Common Core State Standards, currently in place in Tennessee. The *how* in this study will be achieved using an instructional design adapted from Kort et al.'s (2001) model, relating learning and emotion. The instructional design has been organized to promote affective and cognitive development and is rooted in a social-constructivist framework. The overarching goal of the instructional design is to ensure affective development is given equal weight with cognitive development, and this will be reflected in the title of the design, "An Affective Instructional Design: Promoting Development across Affective and Cognitive Domains." Affective development will be attended to in two ways: through environmental affect and core affect.

Environmental Affect. Based on work by Russell (2003), environmental affect refers to any stimulus within the environment which is perceived by an individual as possessing an affective quality. An example would be an individual who perceives a sunset as beautiful. The perceived affective quality –beautiful - gives rise to an affect state in the learner. From the example provided, the beautiful sunset may give rise to affect states such as joy or contentment. The individual's perception of affective quality influences judgments and decision-making processes (Russell, 2003; Storbeck & Clore, 2008; Walshaw & Brown, 2012). In terms of mathematical learning, this suggests that the environment set by the teacher could play a role in determining learners' affect states, which in turn could influence people's judgments and decision-making regarding their attitude toward mathematical learning. An example may be the students' initial perception of the affective quality of a new mathematical concept. Should the teacher introduce the concept using strategies that promote curiosity, intrigue, or happiness, the learners' perception of the affective quality of the activity will be positive, thereby leading to positive affect states. In turn, learners may judge the concepts in a positive light and make decisions to invest their interest and participation in activities related to the concept.

Brown, Brown, and Bibby (2008) surveyed 1,500 high school students to investigate why participation in mathematics courses decreases once it is no longer a compulsory course. In their findings they report boredom and a dislike of mathematics as a main reason for decreased participation, while enjoyment was stated as the main reason for continued participation. In their conclusion, Brown et al. (2008) suggest there is an interconnectedness of affect and cognition that influences learning. The classroom environment provides stimuli that impact a learner's affect states, which in turn impacts the quality of learning.

Core Affect. Core affect refers to the base emotions, which stir within an individual and are expressed as feelings (Russell, 2003). Core affect can also be referred to as an individual's affect state. According to Russell (2003) perception of affective quality, hereafter referred to as environmental affect, has "capacity to change core affect" (p. 149). Core affect is linked to attitude formation and cognitive processing. Its orientation can be positive, negative, or neutral, and its intensity can be long lasting or short in duration (Russell, 2003; Storbeck & Clore, 2008). According to Russell (2003), "the more positive core affect is, the more positive events encountered or remembered seem" (p. 149). Storbeck and Close (2008) describe core affect as a "guide for cognitive processing" (p. 1). They equate core affect with a green light – a way of initiating deep thinking (Clore & Palmer, 2009). Collectively, these ideas make it is possible to appreciate the importance of environmental and core affect: positive experiences lead to positive attitudes and increased cognitive processing (Russell, 2003).

In her longitudinal study, Walls (2007) found children were most likely to develop increasingly negative mathematical attitudes over time when learning was predominantly traditional rote practice and rule memorization. Walls' (2007) study traced the mathematical learning of 10 children, beginning their third year of primary school and ending at their completion of year eleven. Walls (2007) investigated how young children come to lose interest in mathematics, and as a result, experience declining achievement scores. The participants were chosen from a random sample. They were similar in age and came from diverse learning environments. The investigator used an ethnographic case study approach to gain an understanding of children's mathematical learning experiences. The framework for the study was rooted in the theory of symbolic interaction; a range of data was collected to gain an understanding of participants' social interactions in mathematics. Sources of data included classroom observations, interviews, informal discussions, questionnaires, and workbooks. From these, the investigator looked for emerging themes that revealed how children experienced learning mathematics. Findings suggest that throughout their school experience, the participants experienced math learning as an isolated activity, requiring independent focus, repetitive action, memorization, and silent working environments using activity sheets or workbooks. These attitudes resulted in disengagement, lack of confidence, and lack of meaningful learning. This study is significant as it suggests that children, from a young age are experiencing tedium in how they learn mathematics. The lack of discovery, inquiry, or exploration is having a negative impact on how students view mathematics in the long-term (Walls, 2007).

Alternatively, Norton and Irvin (2007) found in their case study that student affect became increasingly positive when teaching and learning involved the use of concrete learning materials, group activities, shared thinking, and open discussion where students were encouraged to share their mathematical thinking. The study participants included 18 Year 9 algebra students, and their teacher, at a middle to lower socioeconomic school in a suburb of Brisbane. The mathematical intervention involved the use of verbal and concrete instructional strategies to teach algebra and was developed in response to lower than average enrollments in advanced senior mathematics classes. There were 18 intervention lessons, taking place during a six-week period of time. All intervention lessons emphasized the use of verbal and concrete materials as a way of facilitating student understanding of algebraic concepts. Students were involved in discussion groups where they could explain and discuss their mathematical thinking. Data collected included video recordings of lessons and class/group discussions, work samples, tests and examples of scaffolded student learning. The researcher analyzed the data for error patterns. These error patterns were used to inform the planning of each consecutive intervention lesson. The findings from this research suggest a positive relationship exists between the use of concrete materials, including games, student engagement, and in supporting increased understanding of algebraic processes. Furthermore, the use of discussion was valuable as it promoted expression of student thinking, and eventual ownership over the mathematical language and concepts. These findings are significant as they suggest the importance of multiple representational techniques to promote the development of student engagement, knowledge, and understanding.

In this study, the *affective instructional design* (AID) incorporates instructional strategies to promote positive affect states. Through a universal design model, auditory, kinesthetic, and visual strategies will be used to stimulate environmental affect, while reflection, and mediated learning opportunities will be incorporated as a way of promoting core affect.

Instructional Strategies to Promote Positive Affect States

The Universal Design Model. The Universal Design for Learning Model (UDL) promotes positive environmental affect by ensuring each student is treated as a unique learner (Howard, 2004). It is a research-based framework with three main goals: 1) to ensure students have a range of ways to access information; 2) ensure opportunity to express their understanding; 3) offer varied instructional methods to ensure students feel interested, motivated, and challenged in their learning environment (Maryland State Department of Education, 2011).

In her research, Katz (2013) investigated the relationship between a UDL model and student social and academic engagement in inclusive classrooms K-12. This was a quasi-experimental design, using a pre-test and post-test. It involved 661 students with varying ability levels, and grades 1-12 from 10 schools. Participants were from five different school districts in rural and urban areas of Manitoba, CA. There were over 60 languages spoken by the students, with "20% of the population ESL learners. All participating teachers received one day of training on the UDL model, and purposive sampling was used to determine which schools were interested in further training. Those who were interested in further training became the intervention schools and received a further three days of training, while the others became the control groups. Fifty-eight educators were involved in the study. Teachers in the intervention classes worked collaboratively, co-planning using the UDL model and what they had learned through their training sessions to develop integrated unit plans, incorporating multiple intelligence strategies and inquiry-based activities. Data was collected using time-sampling observations and self-report surveys, with the exception of grade 1 children, who were unable to read or comprehend confidently enough to complete the surveys. A MANOVA was used in the data analyses. Katz (2013) found in the pre-test measures that the control group had "higher levels of overall engaged behavior, and active engagement, and lower levels of passive and non-engagement" (p. 170), but after the intervention, it was the experimental group, who had the higher mean scores in these areas; elementary (pre/control) (*M* = 42.97, *SD* = 8.96), elementary (pre/treatment) (*M* = 41.54, *SD* = 10.23, elementary (post/control) (*M* = 53.97, *SD* = 4.22), elementary (post/treatment) (*M* = 54.52, *SD* = 4.00). The pattern of findings regarding student social emotional variables was similar to engagement. In the pre-treatment measures, the control groups scored highest, and following intervention it was the treatment groups who showed the highest scores. Katz (2013) found a positive relationship between an instructional design based on the UDL model and improved student social and academic engagement. Findings from this study are significant as they suggest the importance of the type of instructional framework in promoting social and academic engagement.

By incorporating strategies that are a part of the UDL model in the affective instructional design (AID), children will have opportunity to receive, respond and engage with new information in a variety of ways. Based on the goals of UDL, the AID ensures the use of varied instructional practice offering visual, auditory, kinesthetic strategies; variety in group sizes; and choice in how to demonstrate understanding.

Mediated Learning Opportunities. In mathematical learning, core affect can be influenced through mediated learning opportunities and reflective practice (Russell, 2003). Mathematics of the 21st century is described as a socialization process (Schoenfeld, 1992). Children are encouraged to investigate, explore and discuss ideas as a way of learning to think mathematically and to become numerate (Pearse & Walton, 2011; Walshaw & Brown, 2012). Using meaningful activities with connections to a child's real world, such learning can occur in small groups, teacher-child, or peer-to-peer interactions, as well as in large groups (Astor-Jack, Kiehl Whaley, Dierking, Perry, & Garibayal, 2007; Burton, 2010; Seeger, 2011).

Vygotsky regarded mediated learning as the key to cognitive development. He described mediated learning as a process that occurs while the learner is in the zone of proximal development (ZPD). In the ZPD, children learn from others about concepts they would not otherwise be able to comprehend. According to Vygotsky, in order for learning in the ZPD to be successful, the teacher, or adult in the environment, must have an awareness and ability to respond to a learner's various affect states (Mahn & John-Steiner, 2002; Taylor; 1992; Walshaw & Brown, 2012; Wilson et al., 1993). Learners need to be appropriately challenged affectively and cognitively, and the teacher needs to be able to respond appropriately to both affective and cognitive needs in order to successfully facilitate the learning (Cooper & McIntyre, 1996; Lui, 2012; Mahn & John-Steiner, 2002; Taylor, 1992; Vygotsky, 1978; Wilson et al.,1993; Zembylas, 2004). This requires the effective use of manipulatives, language, and social interactions.

Grouping children for learning is another consideration essential to promoting positive affective and cognitive development. Research suggests there are great benefits of cooperative group work, across domains, when such considerations are made (Gillies, 2003). Groups of 3-4 learners, with activities scaffolded to meet the learning needs of each group, have been found most successful in promoting learning (Gillies, 2003). Additionally, when students are given explicit instruction of how to work cooperatively, the research suggests social and academic engagement increase (Gillies, 2003). Burton (2010) reports that group activities in mathematics offer young children opportunity to develop questioning, reasoning, and prediction skills. It is an opportunity for children to gain an understanding that their emotions, whether puzzlement leading to questions, or joy leading to discovery, are welcome, and essential in the learning process (Burton, 2010; Claxton, 2008; Kort, 2001). Therefore, the AID will incorporate cooperative group work as another way of promoting positive affect.

The Value of Reflection. Hinett (2002), reports that reflection, an active thinking process, can also change core affect. Through reflective practice, an individual can attend to emotions experienced in the learning process. By expressing their feelings, children accept them and begin to gain control over them through cognitive processes (Seeger, 2011). As a result, learners gain an understanding and acceptance of their strengths and weaknesses and an ability to regulate thinking or decision making (Storbeck & Clore, 2008). This is especially important when a learner experiences a heightened and prolonged negative affect state which overwhelms his/her ability to attend to any other information. In this condition, there is no room for cognitive processes to work, and learning cannot occur (Clore & Palmer, 2008; Fleckenstein, 1991; Russell, 2003; Storbeck & Clore, 2008). An example might be the learner who is asked to come to the front of the class to demonstrate how to solve a mathematical problem. That learner may become overwhelmed with negative affect states including fear of failure and/or embarrassment in front of peers. However, if the learner has developed the ability to regulate his/her thinking through mediated, reflective practice, it will be possible to neutralize the negative affect. The learner may remind him/herself that peers are supportive, and no one will laugh if he/she makes a mistake.

Used purposefully, reflection provides opportunity for understanding and influencing the core affect of the learner. It is an effective way of encouraging children to share their thinking, feelings, and attitudes about their learning to bring about positive affect states, as well as developing an understanding of how to manage and accept the range of emotions that arise in the learning process (Claxton, 2008).

Affect and Problem Solving. Problem solving, when utilized as an exploratory process, can be a route to higher-order mathematical thinking and the development of conceptual understanding (Burton, 2010; Pearse & Walton, 2011; Schoenfeld, 1992). Through problem-solving activities children can engage in every strand of mathematics; learn through social interaction; develop mathematical vocabulary; and express and learn to manage negative affect states that may be associated with the challenges presented in problem solving (Hiebert & Grouws, 2007). Moreover, through the process of problem solving, children learn reasoning, prediction, skills in self-expression, as well as an ability to listen to and respect the contributions made by others (Burton, 2010). It is an activity that fosters affective and cognitive development.

Combined, the strategies outlined in this section, provide a structure for the AID (see Figure 2.) that is rich in opportunities for developing environmental and core affect. By considering the learning environment, the purposeful use of language, social interactions and choice of teaching strategies, a teacher can mediate the emotions associated with learning, thereby promoting positive affective development and cognitive growth within the child's ZPD (Claxton, 2008; Mahn & John-Steiner, 2002; Taylor, 1993).

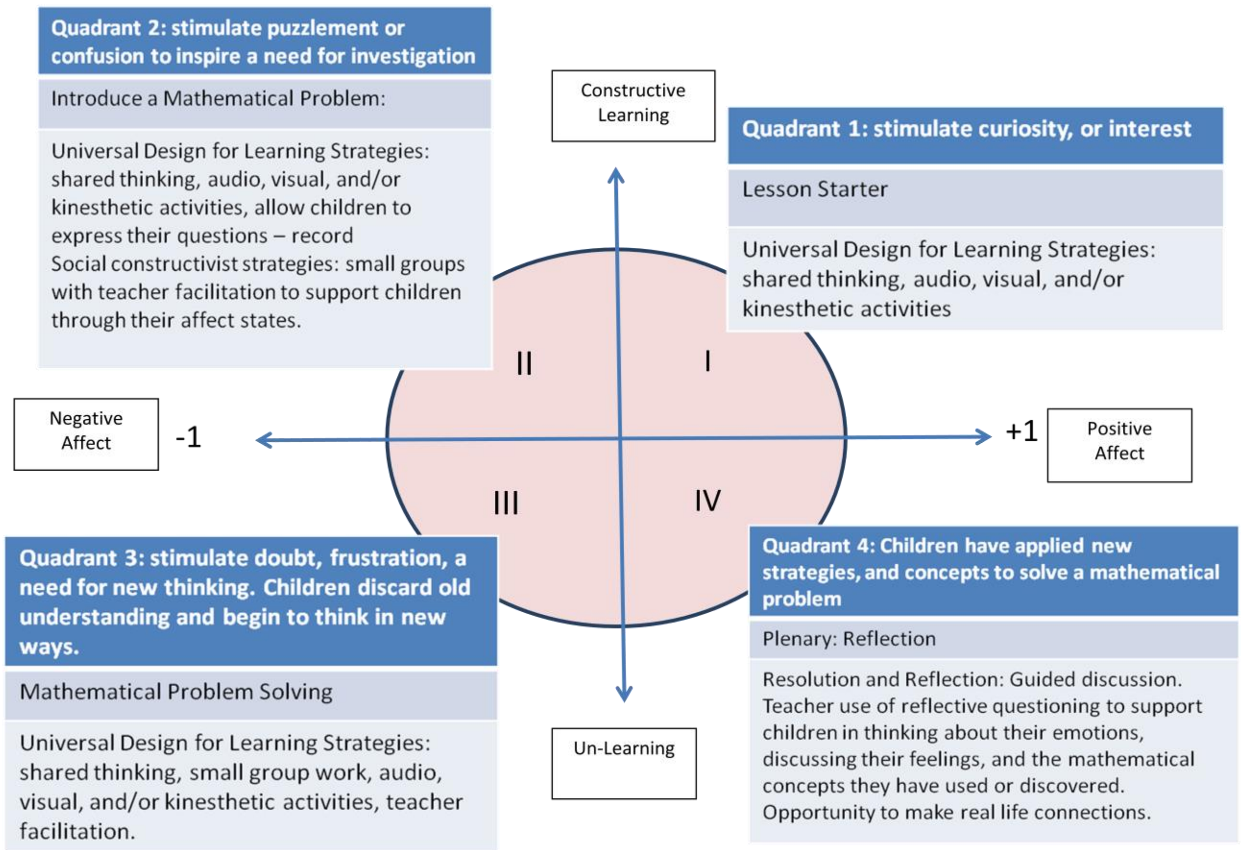

Figure 2. The Affective Instructional Design (AID): An adaptation of Kort et al.'s (2001) model. The AID illustrates how emotion and learning can be purposefully planned for in a four-part math lesson: the starter, introduction to the problem; mathematical problem solving; reflection.

The Affective Instructional Design (AID) ensures the teacher is structuring the lesson to promote affective and cognitive development. Each stage of the lesson is identified, as well as the desired affective states. Pedagogical approaches are built into each stage of the lesson to facilitating affective development.

Summary

The affective domain refers to internal development as a result of emotions and feelings associated with every experience. Development in this domain gives rise to attitudes, which are expressed through words and actions (Craig et al., 2004; Pierre & Oughton, 2007). In the classroom environment, such actions might include commitment to tasks, interest in learning, valuing of information, and an ability to work both cooperatively or independently (Krathwohl, Bloom, & Masia, 1964; Lee & Shute, 2009). It is through the affective domain that an individual gains the internal mechanisms that allow for development of the higher executive functions in the cognitive domain (Beane, 1986; Diamond, & Lee, 2011).

Research suggests that affect and cognition are interconnected (Grootenboer & Hemmings, 2007; Schlöglmann, 2003; Storbeck & Clore, 2008; Walls, 2007; Zembylas, 2004). In their Affective Learning Model, Kort et al. (2001) propose learning is a process involving a range of affect states. How children move through these states impacts their long-term attitude formation (Kort et al., 2001). Further research has found a direct relationship between attitude toward learning and achievement (Mega, Ronconi, & De Beni, 2013). Finally, studies across many countries have found the learning environment, quality of social interactions, and choice of instructional strategies all influence learners' affect states and attitudes toward learning (Grootenboer & Hemmings, 2007; Katz, 2013; Singh et al., 2002; Zembylas, 2004). With these ideas in mind, there is great purpose in investigating how an affective instructional design (AID) relates to attitude formation and learning in the early years.

The classroom learning environment provides experiences, which lead to feelings or emotions that in turn influence learners' thoughts and actions. Adapting the Kort et al. (2001), model for affective learning, it is possible to create an affective instructional design to support children in developing affect.

In particular, the AID could be helpful in teaching mathematics, as it is a subject where teachers have traditionally relied on explicit instruction leading to cognitive development. Furthermore, it is a subject in which children have shown the least long-term interest and achievement. Applying AID to an early years' mathematical environment is purposeful, as it is at this age where children's mathematical learning is indicative of future academic success (Bodovski & Farkas, 2007; National Research Council, 2001; Pearse & Walton, 2011; Sparrow & Hurst, 2010).

Therefore, the purpose of this quantitative, quasi-experimental study is to investigate the relationship between an affective instructional design, student attitude towards mathematics and mathematical learning for kindergarten-aged children.

CHAPTER 3

RESEARCH METHODOLOGY

The purpose of this study was to investigate the relationship between an affective instructional design, children's attitudes towards mathematics, and their corresponding mathematical learning.

There are multiple reasons for choosing to investigate this relationship. First, there is an abundance of research suggesting affective development is essential for learning (Akey, 2006; Chavarat, 2012; Goleman, 1995; Grootenboer & Hemmings, 2007; Mata et al., 2012; Sparrow & Hurst, 2010; Vygotsky, 1934/1987; Zembylas, 2004). Second, mathematics is a subject that has not traditionally incorporated affect into instruction (Hurst & Sparrow, 2010; Pearse & Walton, 2011). Third, American children have made little gains in their mathematical learning since the initial Program for International Student Assessment (PISA) reports in 1999, and therefore investigating affect as a means of improving math learning is worthwhile (NRC, 2013). Fourth, in recent PISA reports, American children express limited enjoyment or interest in mathematics (OECD, 2012). These emotions relate directly to affective development and have a long-lasting impact on learners' attitudes towards mathematics (Craig et al., 2004; Russell, 2003).

This chapter describes the methodology used to explore the relationship between an affective instructional design, children's attitudes toward mathematics, and their mathematical learning.

Research Design

This was a quasi-experimental design using a one-group, pre-test-intervention-post-test study design (O^1 - X - O^2). The independent variable was the affective instructional design, and there were two dependent variables: the participants' attitudes toward mathematics, and their corresponding mathematical learning. The research occurred during structured math time, five times per week, over 2 weeks, in a kindergarten classroom at a university K-12 laboratory school located in East Tennessee. This quasi-experimental research design was organized in four phases: (1) obtaining consent; (2) establishing baseline measures; (3) intervention phase; and (4) post-intervention measures. To ensure fidelity of implementation, the PI and class teacher worked collaboratively planning the lessons using the affective instructional design and planning script (see Appendix I), the mathematical vocabulary resource (see Appendix J) and the affective strategies resource (see Appendix K). Additionally, based on recommendations by Tashekori and Teddlie (1998), the Observations of Mathematical Learning Checklist (OML) was reviewed and validated by an expert in the field of mathematics as a way of ensuring content validity. In order to ensure trustworthiness of the data gained from both the Attitude Checklist and OML Checklist, a secondary coder worked with the primary researcher to establish inter-rater reliability. Each individual used the coding checklists with video from an anonymous kindergarten classroom. The team identified and eliminated inconsistencies through discussion and compromise, and where necessary, checklist modifications were made. Any changes, or explanation of differences were identified and reasons for maintaining the current checklist were noted in the minutes from the meeting (See Appendix O). To ensure ongoing inter-rater reliability, the secondary coder used the checklists to code 30% of the video-taped sessions. The two raters met and discussed the ratings to ensure continued accuracy in the data collection. Any discrepancies were resolved by reviewing the video data, discussion and consensus. Minutes from each meeting were kept, as well as a summary of each rater's codings (See Appendices O and P).

Setting and Participants

The participants in this study were fifteen 5 and 6-year-old students (*M* = 5 years, 8 months) enrolled in the 2014/15 kindergarten program of a university K-12 laboratory school in East Tennessee. The ethnic diversity within the class was comprised of Caucasian (*n* = 13, 87%), Chinese (*n* = 1, 7%), and African American (*n* = 1, 7%). Within the class, there were 7 females and 8 males. Participation in the study was based on administrative, teacher, and parental informed consent, and the identity of participants was kept confidential using pseudonyms. The classroom teacher holds a Master's in Early Childhood Education, and is an experienced teacher with 29 years teaching practice, 19 of which were spent in pre-K, kindergarten or first grade.

The early childhood classroom and participants for the study were chosen for a number of reasons. First, the researcher was familiar with the educational institution. Second the classroom teacher follows a social constructivist philosophy and practice, which was a requirement for the research intervention because of the importance of social interactions in building affect (Mahn & Steiner, 2002). Third, and most importantly, kindergarten children were chosen because mathematical learning in the early years can have a major impact on a child's future success (National Research Council Mathematics, 2001).

Instruments

Attitude Survey

A Pre and Post Mathematics Attitude Survey, consisting of 11 Likert-style questions was used to determine participants' attitudes toward mathematical learning (Appendix E). This survey was adapted with permission from Thomas and Dowker's (2000) survey and utilizes emoticon symbols. These emoticon symbols help young children to understand and interpret the Likert scale (Thomas & Dowker, 2000). Thomas and Dowker's (2000) Maths Attitudes and Anxiety

Questionnaire is a 28-item questionnaire on attitude toward mathematics and self-rated competence. The survey is composed of seven sets of four questions related to seven areas: 1) math in general, 2) written math work, 3) mental math work, 4) easy math, 5) hard math, 6) math tests and 7) understanding the math teacher (Thomas & Dowker, 2000).

In Thomas and Dowker's (2000) investigation, children were asked four different types of questions related to attitude and anxiety. The questions included: 1) how much they liked math (Enjoyment); 2) how unhappy they would feel at being unable to do math (Unhappiness); 3) how good they thought they were at math (Self-Rated Competence); and 4) how anxious they would feel if they couldn't do math (Anxiety).

Thomas and Dowker's (2000) Maths Attitudes and Anxiety Questionnaire was found to have validity and reliability in research with a measure of internal consistency of their scale between 0.83 and 0.91 (Kringxinger et al., 2007).

In this survey, different picture-symbols were used for each grouping of questions. Questions related to feelings used emoticons, anxiety-related questions used a Mr. Worry character, enjoyment-related questions used wasps and sweets, and self-rated competence questions used crosses and checks (Thomas & Dowker, 2000). The emoticons in their scale were used to represent the 1 to 5 Likert rating scale, ranging from very happy/very likeable, to very unhappy/hating. The children's responses were matched to the number scale so that the most negative responses scored 1, and the most positive responses scored 5. The maximum possible score, correlating with the most positive attitude, was 140, and the lowest possible score, correlating with the most negative attitude, was 28.

As the purpose of this research study was to determine children's attitudes toward mathematics, only questions related to attitude were used (see definition of attitude, p. 9). The adapted Primary Mathematics Attitude Survey (see Appendix E) consists of 11 questions focused on determining children's attitudes. Emoticons were used to reflect the 1-5 Likert scale, so that the children could more easily identify and communicate their feelings: ranging from hating, or disliking to liking or really liking. Children's responses were matched to the 1-5 rating scale, with the most negative responses scored 1 and the most positive scored 5. The maximum score possible, correlating with the most positive attitude, was 55, and the lowest possible score, correlating with the most negative attitude, was 11.

Non-Participant Observations

Video recording was used by the researcher to complete observations of child participants during different parts of the mathematics lesson: 1) whole group introduction, 2) small group activity, and 3) whole class reflection. These recordings of structured math time occurred five times per week, over a period of 2 weeks. Each lesson lasted 40-45 minutes, and for each lesson the researcher had video recording equipment set up on tripods around the classroom to capture children's actions, interactions, conversation, and written work. The researcher carried a video recording device to capture interactions and written work during mathematical activities. The researcher analyzed data using two separate checklists, for evidence of changing attitudes toward mathematics, and mathematical learning. The following checklists were used in the analysis process:

A. Attitude Checklist (Appendix F)

B. Observation of Mathematical Learning (OML) Checklist (Appendix G)

To ensure trustworthiness of the data gained from both the Attitude Checklist and OML Checklist, a secondary coder worked with the primary researcher to garner inter-rater reliability. Prior to the research study, the checklists were piloted using video from an anonymous kindergarten classroom.

The primary researcher and a trained research assistant used the coding checklists with the video. Inter-rater reliability was determined using an intra-class correlation. The alpha coefficient was found to be 0.969, suggesting high internal consistency. Through discussion three changes were deemed necessary. First, both raters determined that purposeful social interaction should include both peer and teacher-child interactions. Second, the data for mathematical vocabulary needed to be collected in two ways: as a record of what math words were spoken, as well as the frequency of word use. Third, each lesson segment needed to be partitioned into a beginning, middle, and end, to accurately capture attitude and math learning observations across the entire lesson segment. Checklist modifications were made based on these determinations (See Appendix O). To ensure continued trustworthiness of data collection, the secondary coder rated 30% of the video observations. Discrepancies were resolved through consensus and recorded in meeting minutes (See Appendix O). The results of the inter-rater analysis are 0.999 with $p < 0.001$. As described by Landers (2011) this measure of agreement is statistically significant and suggests a strong degree of agreement between the raters.

Scripted Notes

The researcher designed two scripts to support delivery of the attitude survey and teacher training sessions.

1. To support delivery of the attitude survey, the researcher followed a script (see Appendix L) which contained specific directions for completing the Attitude Survey.
2. To support teacher-training sessions, the researcher followed a script which defined key words and outlined the order of information to be delivered, to ensure accurate and consistent delivery of instruction (See Appendix I)

Field Notes

Finally, as further support to the data collection, the researcher kept field notes for each visit to the research site. These notes were used as a source of reflection, capturing thoughts and feelings about the researcher's experiences as an observer and participant in the planning processes (See Appendix M).

Procedure

The research occurred during structured math time, five times per week, over 2 weeks, in a kindergarten classroom at a university K-12 laboratory school located in East Tennessee. This quasi-experimental research design was organized in four phases, which were implemented after receiving Institutional Review Board (IRB) consent (See Appendix N):

Phase 1: Obtaining Consent

a. Letter 1: Director Permission to Conduct the Study (Appendix A): As a way of seeking permission to conduct the study at the school, the researcher made initial contact by meeting with the director to introduce the study, provide study details, and request permission to conduct the research with the kindergarten class. The director was asked to sign the consent form at this time and was given a signed copy of this form for his records.

b. Letter 2: Teacher Consent to Participate in the Study (Appendix B): A letter was delivered, by the researcher, to the teacher and teacher assistant school mailbox. The letter provided study information and a request for teacher and teacher assistant participation. The researcher followed up this communication with a scheduled meeting to further discuss study details and to request participation. The teacher and teacher assistant were asked to sign the consent form at this time and were given a signed copy of this form for their records.

c. Letter 3: Parental Permission for Child Participation in the Study (Appendix C): Upon receiving director and teacher consent, the parental permission letter was sent home in a sealed envelope with each child. The letters were sent one week prior to the start of the study. A request from the researcher was included with the letter, asking parents to sign the letter as a way of indicating consent, and the consent form was returned to the classroom teacher. All consent forms were returned, with a 100% participation rate.

d. Letter 4: Children's Consent to Participate in the Study (Appendix D): After receipt of consent forms from parents, the researcher met with the children and teacher to provide the children's consent forms.

The researcher explained what the study would involve and how the children would participate. The researcher made it clear to the children that their parents/guardians had granted consent, and their involvement was voluntary. The children had a simplified consent form written in developmentally appropriate language with illustrations that they signed as a way of giving consent. Had they chosen not to consent, they would have been exempt from the data collection component of the study, even if their parents/guardians had given permission for them to be included. However all children consented and therefore participated in the study.

Phase 2: Establishing Baseline Measures

a. Pre-test for child participants - The Primary Mathematics Attitude Survey was used to determine children's attitudes about mathematics. To complete the survey, the children sat in their regular class, at their work tables, each with a copy of the adapted Primary

Mathematics Attitude Survey (Appendix E). The teacher and teacher assistant remained in the class, offering support and reassurance to the children through their presence. The researcher used the SMART Board technology to show children an enlarged version of the survey with the emoticons. The researcher explained to the children what the emoticons on the survey meant, and how the children were to complete the survey. The researcher, supported by the teacher, asked the children to imagine they were in their mathematics lesson, a visualization strategy recommended by Thomas and Dowker (2000). The researcher read each question to the children and provided them opportunity to ask questions for clarity and to circle the emoticon that best matched their feelings. The survey was used to determine student attitudes toward mathematics before the implementation of the intervention.

b. Non-Participant Observations to be completed using video recording. These video recordings were captured by the researcher during three 40-45 minute regularly structured mathematics lessons the week prior to implementing the intervention. The purpose of this was to allow the researcher to establish a baseline for children's attitudes, and mathematical learning, prior to the intervention phase. The researcher used multiple video recording devices on tripods to capture both whole class and small group work. These videos were analyzed for evidence of existing attitudes, and mathematical learning, using two checklists: an Attitude Checklist (Appendix F) and a Mathematical Learning Checklist (OML) (Appendix G). Each of these checklists were piloted with an alternative kindergarten class to check for inter-rater reliability, and as a way of improving construct validity, and trustworthiness of the data. (See the section on Instruments for more information.)

Phase 3: Intervention

a. The Affective Instructional Design for Mathematics (AID) - This instructional design represents the intervention that was used by the classroom teacher while teaching regularly scheduled mathematics lessons during the two-week intervention phase. AID (Appendix H) is an adaptation of Kort et al.'s (2001) Emotion Learning Model, which identifies various affect states a learner experiences in the learning process. The researcher merged this model with an instructional framework for mathematics. Using four, one-hour training sessions, the PI trained the teacher and teacher assistant (TA) in the planning and implementing of AID. During these sessions the teacher and TA learned about the use of (see Appendix K):

i. Universal Design for Learning (UDL) strategies: visual, auditory and kinesthetic supports

ii. Technology: using cameras during lessons, PowerPoints as visual support, and the internet as a tool for interactive learning materials

iii. Language to foster affective development: open questions/statements that allow children to convey their knowledge and understanding (e.g., What do you see? How might we solve this? Explain your thinking.)

Additionally, the researcher planned with the teacher how to use the instructional design to implement each week's mathematics lessons. The lessons were organized into four lesson segments (see Appendix I):

i. ***Starter***: the opening to the lesson. This is an opportunity to gain student attention

ii. ***Introduction to a problem***: generate interest, curiosity, and engagement with an idea or topic.

iii. ***Problem solving***: promotes thinking, puzzlement, and challenges students to take ownership over the mathematical information as they use it to discuss, debate, or reason.

iv. ***Reflection***: provides an opportunity for shared discussion about the topic. In this part of the lesson, students share what they learned, what was difficult, how they felt, and what strategies they used to attempt the problem solving.

These plans were written weekly to align with the Common Core State Standards according to the teacher's unit plans. It was important that the teacher and researcher collaborated in the lesson planning process, as the material being covered was related to the Common Core State Standards and had be taught in a sequence, and the teacher needed support in the use of affective strategies. Furthermore, working collaboratively ensured fidelity of implementation of the intervention.

b. Non-Participant Observations: The researcher used video recording to collect data regarding children's attitude toward mathematics, and changes in mathematical learning. The video recordings were captured by the researcher 5 times per week during mathematics lessons over a 2-week period. The procedure used to capture the video data in this phase was the same as described in phase 2. Likewise, during the data analysis the researcher used the same two checklists: Attitude Checklist (Appendix F) and Observation of Mathematical Learning Checklist (Appendix G), as a way of measuring changes in participants' attitudes toward mathematics, and changes in their mathematical learning.

Phase 4: Post-Intervention Measures

a. Post-test for child participants - The Primary Mathematics Attitude Survey was used post-intervention to analyze changes to children's attitudes about mathematics. To complete the survey, the children sat in their regular class, each with a copy of the adapted Primary Mathematics Attitude Survey (Appendix E). The teacher and teacher assistant remained in the class, offering support and reassurance to the children through their presence. The researcher explained to the children what the emoticons on the survey meant and how the children were to complete the survey. The researcher, supported by the teacher, asked the children to imagine they were in their mathematics lesson, a visualization strategy recommended by Thomas and Dowker (2000). The researcher read each question to the children, and provided them opportunity to ask questions for clarity and to circle the emoticon that best matched their feelings. The procedure was as similar as possible to the procedure used in the pre-test administration of this survey. The survey was given one day after the culmination of the two-week intervention as a way of determining student attitudes toward mathematics.

Data Analysis

In this research study there were two dependent variables: children's attitudes toward mathematics, and their corresponding mathematical learning. Data was collected in two ways, using a pre-test and post-test attitude survey administered one week prior to and one day post-intervention, and non-participant video recordings during the mathematics lessons, from which the researcher used an attitude checklist and math learning checklist to gather data (See Appendices F and G). The researcher entered all data into a database, and data was analyzed (SPSS Version 22.0) using a variety of statistical measures as a means of addressing the research questions, which consisted of an overarching question and two sub-questions.

Overarching Research Question

Does an affective instructional design improve children's attitudes toward mathematics, and mathematical learning?

In order to address the first dependent variable in this question (attitudes toward mathematics) data was collected from video recordings of 13 math lessons, which were coded using the Attitude checklist (see Appendix F). The first lesson, a pre-test lesson, and the last intervention lesson were coded to capture observations of math attitudes for each participant. Then the 13 lessons were coded to capture observations of math attitudes for the group. A paired samples t-test was used to analyze the pre-test and final intervention lesson data to determine changes in math attitudes. The data from the 13 lessons was analyzed descriptively and summarized, as a way of exploring changes in attitudes across the 13 math lessons. From the analyses, visual supports were created, showing the trend of changes across the five measures of attitude, (active listening, attentiveness to task, purposeful social interaction, task persistence, and positive response to peer support), and across each lesson segment: (a) starter; (b) introduction to the problem; (c) problem solving; (d) reflection.

To address the second part of the question, (affective instructional design and children's mathematical learning), a paired samples t-test was used to determine significance of changes between math learning during the first baseline and the final intervention lesson. Descriptive data summarized the mean differences across the 13 math lessons. From this data, visual supports were created, showing the trend of changes across the four measures of math learning, (mathematical vocabulary - words spoken, mathematical vocabulary - frequency of use, mathematical questioning, and mathematical thinking), and across each lesson segment: (a) starter; (b) introduction to the problem; (c) problem solving; (d) reflection.

Sub-Research Question #1

Is there a correlation between children's attitudes and mathematical learning?

To address this question, the researcher coded the non-participant observation data using the attitude checklist and mathematical learning checklist to measure changes in children's attitudes toward mathematics and corresponding mathematical learning over a two-week period of time. Data for each variable was plotted on a scattergram, and the regression line was included as a way of visually representing the relationship between the two variables; this is a data analysis strategy recommended by Robson (2002). Finally, based on recommendations by Fitz-Gibbon and Morris (1987) and Tashakkori and Teddlie (1998) the Pearson correlation (r) was used because of its value in determining the strength of the linear relationship between two variables. A one-tailed test was used to determine if there is a significant ($p < .05$) positive relationship between student attitude toward mathematics and mathematical learning.

Sub-Research Question #2

What are children's attitudes toward mathematics?

To address this question the researcher used the adapted Attitude toward Mathematics Survey (Thomson and Dowker, 2000) (see Appendix E) to collect the data. The scores for each participant were summed to determine an overall attitude score for each children. As a way of determining an overall attitude toward mathematics within the classroom, measures of central tendency (mean, median, and mode) were calculated.

The following chapter presents the findings and results from the investigation.

CHAPTER 4

RESULTS

The purpose of this study was to explore the relationship between an affective instructional design, children's attitudes toward mathematics, and mathematical learning. It further explored children's attitudes toward mathematics and the relationship between attitudes and mathematical learning. This chapter presents the results of the data analyses corresponding to each of the research questions presented in Chapter 1. It concludes with a summary of the results and findings.

Design and Data Analysis Overview

This was a quasi-experimental design of pre-test, treatment, and posttest, involving 15 children (*M* = 5 years, 8 months) enrolled in a kindergarten program of a university K-12 school in East Tennessee. The classroom teacher had 29 years of teaching experience, 9 of which were spent teaching pre-k, kindergarten, or first grade. Data was collected in four ways: a pre-test and post-test attitude survey was completed as a measure of student attitudes toward mathematics (*N* = 15); non-participant observations were made using video recordings of 13 mathematics lessons, each 40-45 minutes in length. Video recording data captured attitude and math learning across the group (*N* = 1). Attitude measures included active listening, attentiveness to task, purposeful social interaction, task persistence, and positive response to peer or teacher support. Math learning measures included mathematical vocabulary (words spoken, and frequency of use), mathematical questioning, and mathematical thinking. Finally, the first and last of the 13 video recordings were coded to capture pre and post attitude and math learning for each participant (*N*=15), as a way of determining the effect of the instructional design on children's attitude toward math and their math learning.

The first three math lessons were recorded prior to the intervention to establish a baseline measure of math learning and attitudes toward mathematics. Ten lessons followed, during which the class teacher implemented the affective instructional design (AID) intervention. As a way of measuring attitude and mathematical learning during the two-week intervention, video observations from the 13 lessons were coded using two checklists: the Attitude Checklist and Observations of Mathematical Learning Checklist (See Appendices F and G). The Statistical Package for the Social Sciences (SPSS Version 22.0) was used to perform the data analyses. For each of the statistical tests used to investigate the three research questions, an alpha confidence level of 0.05 was established. Descriptive statistics (mean, median, mode, and standard deviations) were generated to summarize pretest and posttest instruments and trends for attitude and mathematical learning across the 13 lessons.

To ensure trustworthiness of data collection, a secondary coder rated 30% of the video observations. Discrepancies were resolved through consensus, and recorded in meeting minutes (See Appendix O). The results of the inter-rater analysis are 0.999 with $p < 0.001$. As described by Landers (2011) this measure of agreement is statistically significant and suggests a strong degree of agreement between the raters.

Study Analysis and Findings

Sub-Research Question #1

What are children’s attitudes toward mathematics?

To determine children’s attitudes toward math, data from the pre and post-test Mathematics Attitude Survey were summarized and measures of central tendency were calculated. Each question on the survey was scored on a scale from 1 to 5, with 1 representing children’s most negative responses, such as hating, or unhappy, and 5 representing the most positive responses, such as loving, or happy. Overall findings from the attitude scores in pre-test (*M* = 3.685, *SD* = 0.820) and post-test (*M* = 3.727, *SD* = 0.680) measures were positive, with the mean of post test scores slightly higher, and a decrease in the standard deviation between scores. Median scores increased from pre-test scores (*Mdn* = 3.545) to post-test scores (*Mdn* = 3.818) (See Table 1).

Table 1

Descriptive Statistics Summarizing Scores from Pre/Post Test Attitude Survey

		PRE/MEAN	POST/MEAN
N	Valid	15	15
	Missing	0	0
Mean		**3.6848**	**3.7273**
Median		**3.5455**	**3.8182**
Mode		3.55	3.82
Std. Deviation		**.82097**	**.68030**
Range		2.55	2.36

Note. Pre-test mean scores and post-test mean scores from the attitude survey are presented in each vertical column. *N* = number of participants.

Sub-Research Question #2

Is there a correlation between children's attitudes and mathematical learning?

Using SPSS (Version 22.0) two analyses were performed on the attitude and math learning data as a means of evaluating their relationship. First, an exploratory analysis was used, with each variable plotted on a scattergram, and a regression line included to represent the relationship between the two variables (See Figure 3.).

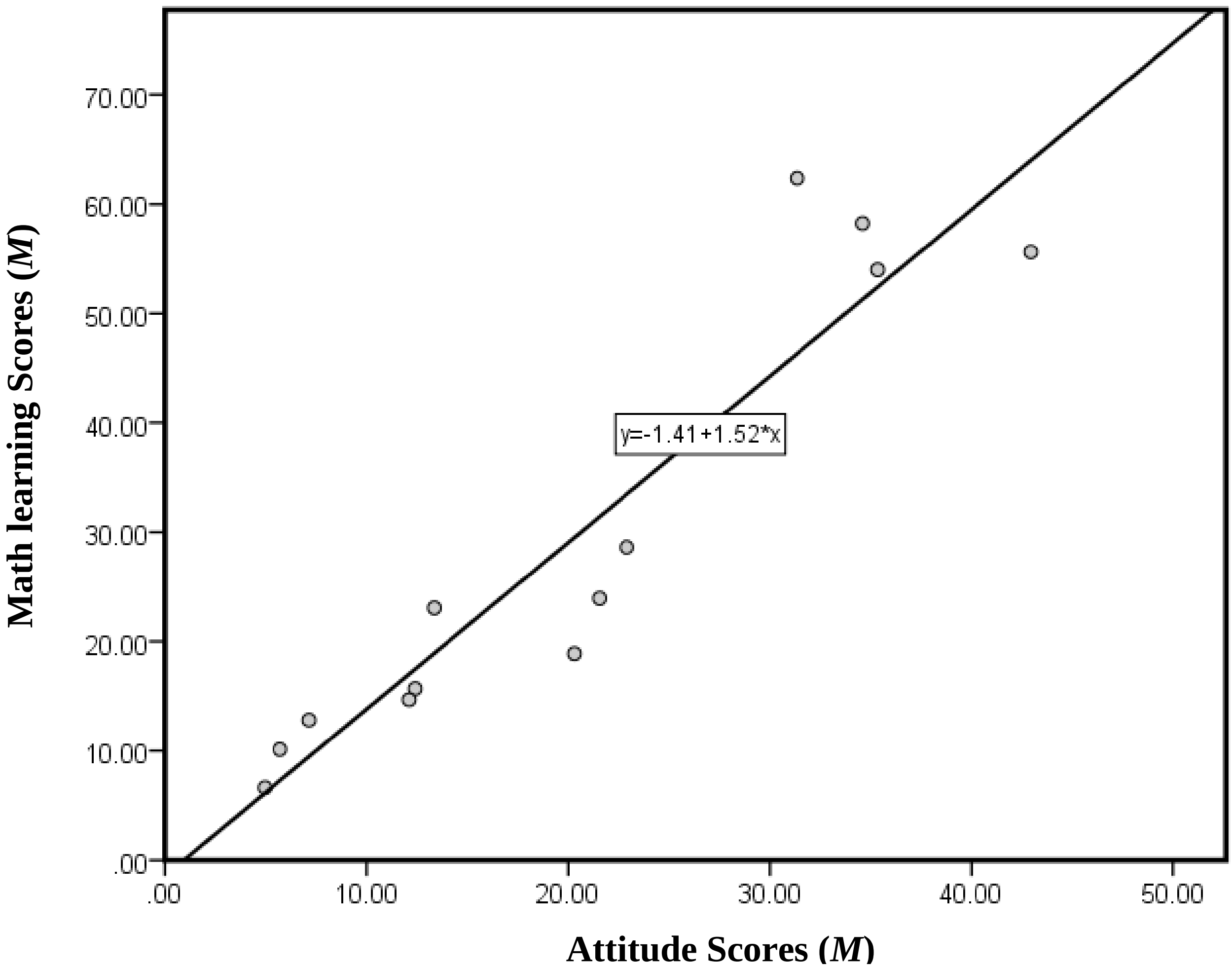

Figure 3. The Relationship Between Math Learning and Attitude Toward Mathematics. The line suggests a strong linear correlation between attitude and math learning. *Note.* *M* = mean scores. The relationship shown is a result of plotting data collected during the 3 baseline and 10 video observations using the Math Attitudes Checklist and Observations of Mathematical Learning Checklist.

Results from the scattergram suggest a positive linear relationship between attitude scores and math learning scores across the 13 math lessons. The Pearson product-moment correlation coefficient was computed to assess the strength of the relationship between attitude toward mathematics and mathematical learning. A strong, positive correlation between the two variables was found, $r = 0.936$, $p = 0.000$.

Overarching Question

Does an affective instructional design improve children's attitudes toward mathematics and mathematical learning?

This question was considered in two parts.

i. *Does an affective instructional design improve children's attitudes towards mathematics?*

During the non-participant observations, video data was recorded during 13 math lessons, each lesson lasting 40-45 minutes. The video was coded using the Attitude Checklist (see Appendix F). Five different measures of attitude were used in coding: active listening, attentiveness to task, purposeful social interaction, task persistence, and positive response to peer and adult support. The first baseline lesson and the final intervention lesson were coded capturing observations of attitude for each participant (N = 15). A paired t-test was conducted to evaluate changes in pre and post attitude scores from the video data. The analysis indicates an extremely significant difference between the baseline mean score (M = 9.40, SD = 3.11) and the final intervention lesson (M = 40.87, SD = 10.49); $t(14) = -12.39$, p = 0.008. (See Table 2).

Table 2

Attitude Observations During Baseline (Pre-test) and Final Intervention Lesson (Post Test)

Attitude	*M*(*SD*)	*t*	*df*	*P*
Pre Test	9.40(3.11)	-12.39	14	0.008
Post Test	40.87(10.49)			

Note. N = 15. Confidence Interval = 95%; M=mean; SD=Standard Deviation

As a way of further evaluating the relationship between the affective instructional design and attitude, descriptive analyses were performed on the 5 different measures of attitude and across the 13 lessons that were videoed. Table 3 summarizes the observations of attitude across the group (*N* = 1), using mean scores and standard deviations for the 3 baseline lessons and the 10 intervention lessons.

Table 3

Mean Scores for the Five Measures of Attitude Across 13 Math Lessons

Attitude Measures:	**Active Listening**	**Attentiveness to Task**	**Purpose Social Interaction**	**Task Persistence**	**Positive Response to Support**
Lesson	*M(SD)*	*M(SD)*	*M(SD)*	*M(SD)*	*M(SD)*
Baseline 1	10.50(6.66)	16.500 (2.38)	5.25 (2.06)	.75 (1.50)	2.750(3.594)
Baseline 2	5.75 (4.65)	12.500 (12.01)	1.00 (1.16)	2.50 (2.38)	3.000(2.449)
Baseline 3	14.75 (9.91)	12.250 (8.54)	1.50 (1.92)	.00 (0.00)	0.000(0.000)
Lesson 1	31.50 (13.10)	16.250 (17.15)	9.00 (11.11)	2.00 (2.45)	3.250(3.594)
Lesson 2	30.50 (13.89)	18.00 (12.68)	9.00 (5.35)	1.00 (1.16)	2.000(1.414)
Lesson 3	38.00 (16.63)	16.00 (11.63)	8.75 (8.62)	1.50 (1.30)	2.500(1.732)
Lesson 4	49.00 (35.75)	26.00 (24.48)	20.50 (15.86)	2.25 (4.50)	3.750(4.500)
Lesson 5	45.50 (20.632)	26.75 (11.983)	31.75 (22.97)	4.75 (7.09)	5.750(5.560)
Lesson 6	44.25 (12.92)	35.2500(21.36)	24.50 (14.53)	1.25 (1.50)	2.500(2.380)
Lesson 7	59.50 (31.59)	53.00 (24.90)	29.75 (27.62)	5.75 (6.95)	8.750(9.777)
Lesson 8	82.75 (18.08)	69.00 (26.77)	43.50 (10.54)	4.75 (1.50)	14.750(5.852)
Lesson 9	78.25 (15.13)	59.00 (40.91)	27.00 (13.88)	4.75 (6.29)	4.000(4.830)
Lesson 10	72.00 (29.86)	55.00 (37.57)	37.25 (27.67)	4.75 (5.74)	7.750(14.175)

Note. *M* = mean attitude score; *SD* = standard deviation.

As a way of visually representing the changes in mean scores for the 5 measures of attitude across the 13 lessons, a cluster graph was created (see Figure 4.).

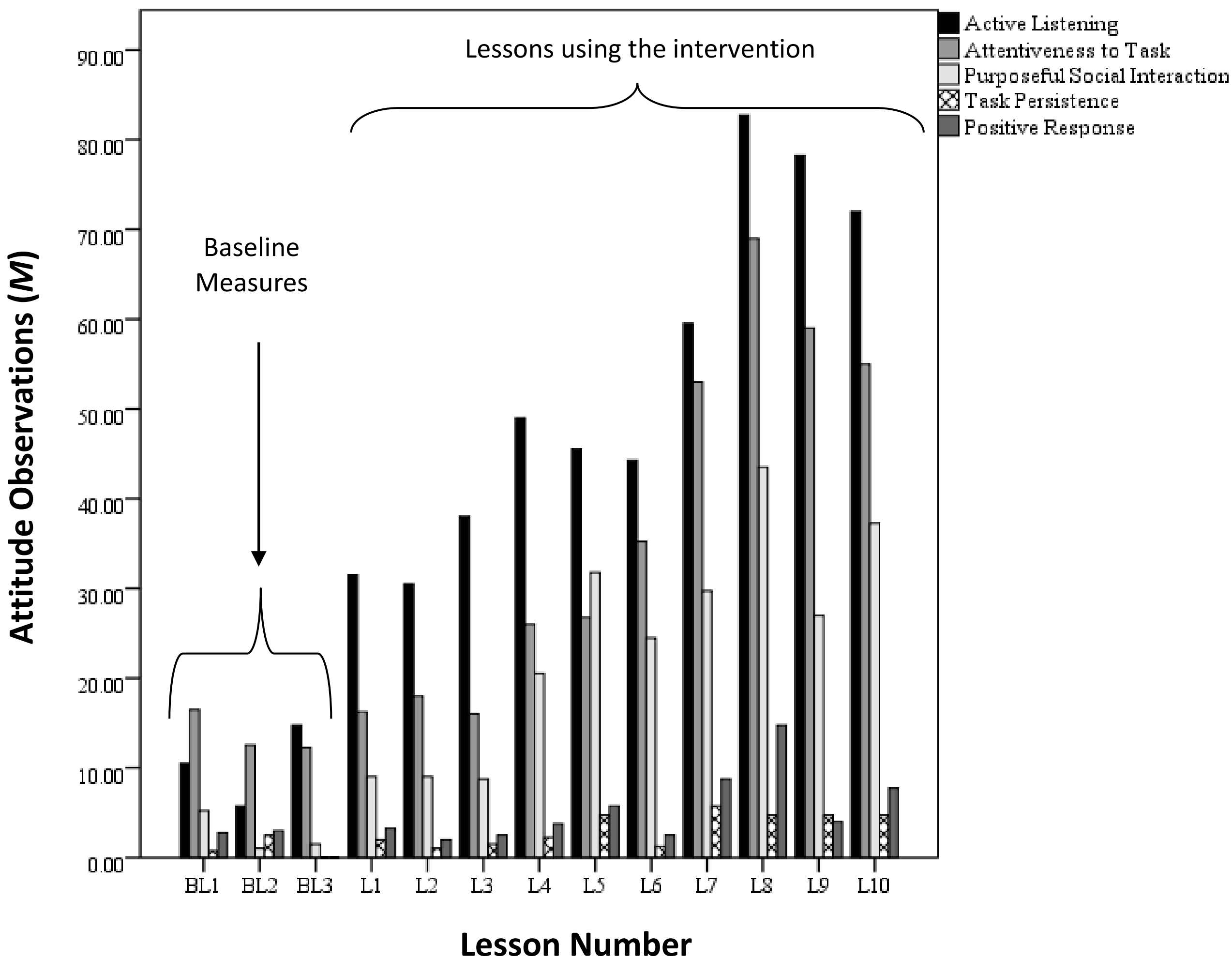

Figure 4. Observations of Five Measures of Attitude Across 13 Math Lessons. Across all of the lessons, the bars suggest improvements in all measures. *Note.* BL=baseline lesson during which no intervention was occurring; L= a lesson using the affective instruction design intervention.

The trends of the bars visually represent the increase in mean scores across the 13 lessons for all measures of attitude, which suggests there is a positive relationship between the affective instruction design and the 5 measures of attitude toward math.

Additionally, as a way of comparing attitude observations prior to the intervention, with attitude observations in the final intervention lesson, the differences in mean scores was calculated for the three baseline lessons and compared to the mean scores for the final intervention lesson. The data has been summarized in Table 4.

Table 4

Differences in Mean Baseline Scores and Final Intervention for Attitude

Attitude Measure	Baseline Scores	Standard Deviation Baseline	Lesson 10 Scores	Standard Deviation Lesson 10
Active listening	10.333	6.272	72.000	29.8555
Attentiveness to Task	13.750	6.076	55.000	37.568
Purposeful Social Interaction	2.583	0.319	37.250	27.669
Task Persistence	1.083	0.569	4.750	5.737
Positive Response	1.917	1.664	7.750	14.175

Across all measures of attitude, mean scores increased from baseline to the final intervention, however the largest increases were found for active listening, attentiveness to task, and purposeful social interaction.

As a final way of exploring the relationship of the affective instructional design with attitude toward mathematics, attitude data was analyzed according to the lesson segments. The cluster column chart is a way of visually representing total observations of attitude captured during each lesson segment: (a) starter, (b) introduction to the problem, (c) problem solving, and (d) reflection, across the 3 baseline lessons and 10 intervention lessons (See Figure 5.)

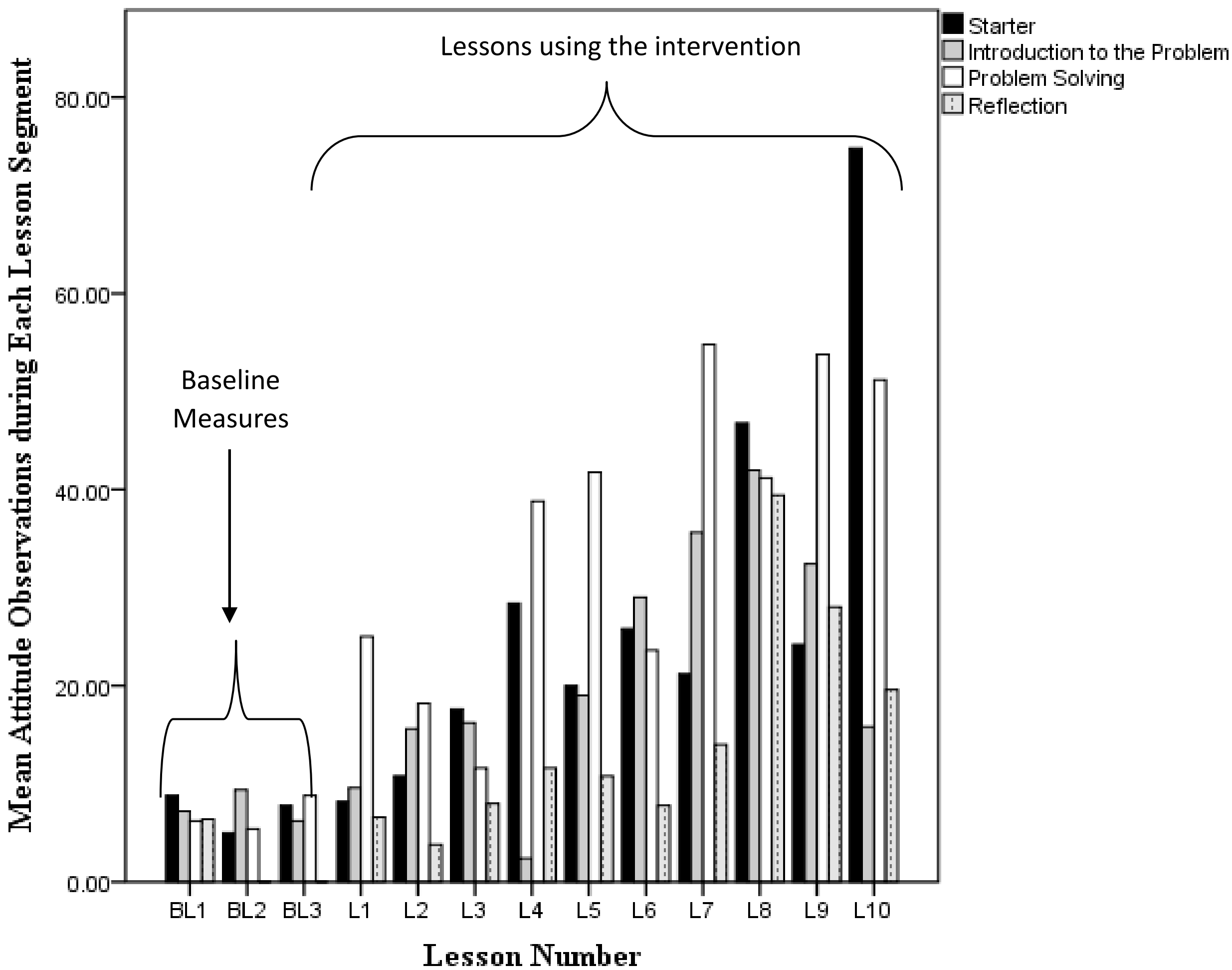

Figure 5. Observations of Positive Attitude Captured During Each Lesson Segment. During the Introduction for L4, L8, L10, lower scores reflect the fact that children were listening to a story as the activity to introduce the problem solving segment, so there were limited observations. *Note*. BL=baseline (pre-test) measures; L=lessons using the affective instructional design intervention; Lesson segments are defined as Starter, Introduction to the Problem, Problem Solving, and Reflection.

The general trend of the bars suggests attitude toward mathematics improved during each lesson segment across the intervention, with the greatest gains captured during the starter and the problem-solving segments of the lesson.

ii. The second part of research question 3 was *"Does an affective instructional design improve children's mathematical learning?"*

The data captured from the video recordings of each mathematics lesson was analyzed to evaluate changes in children's mathematical learning. The video was coded using the

Observations of Mathematical Learning Checklist (OML), which consists of four measures: (a) mathematical vocabulary - words spoken; (b) mathematical vocabulary - frequency of use; (c) mathematical questioning; and (d) mathematical thinking (see Appendix G). The first three recorded lessons were coded to determine a baseline for mathematical learning. Then 10 intervention lessons were videoed and coded for mathematical learning. To determine pre and post changes in mathematical learning, the first baseline lesson and last intervention lesson were coded to capture math learning for each participant (N = 15). A paired samples t-test was conducted to evaluate pre and post math learning scores from this data. The analysis indicates an extremely statistically significant difference between math learning during the first baseline lesson (M = 18.07, SD = 7.37) and the final intervention lesson (M = 53.53, SD = 19.33); $t(14) = -8.40$, $p = 0.002$. (See Table 5).

Table 5

T-test: Math Learning: Baseline (Pre-test) and Final Intervention Lesson (Post Test)

Math Learning	*M*(*SD*)	*t*	*df*	*P*
Pre Test	18.07(7.37)	-8.40	14	0.002
Post Test	53.53(19.33)			

Note. N = 15. Confidence Interval = 95%; M = mean; SD = Standard Deviation

As a way of further exploring the relationship between the affective instructional design and math learning, descriptive analyses were performed on the 4 different measures of math learning and across the 13 lessons that were videoed. Table 6 summarizes the mean scores, and standard deviations for the 3 baseline lessons and the 10 intervention lessons.

Table 6

Mean Scores for the Four Measures of Math Learning Across 13 Math Lessons

Attitude Measures:	**Math Vocabulary/W**	**Math Vocabulary/FU**	**Math Questioning**	**Math Thinking**
Lesson	*M(SD)*	*M(SD)*	*M(SD)*	*M(SD)*
Baseline 1	5.25(3.95)	17.25 (17.46)	.25(0.50)	28.50(30.39)
Baseline 2	5.75(4.65)	8.25(5.91)	.00(0.00)	12.50(8.66)
Baseline 3	7.75(5.91)	9.50(7.77)	.00(0.00)	23.25(21.93)
Lesson 1	11.00(7.75)	16.75(13.15)	2.00(2.45)	33.00(27.54)
Lesson 2	11.75(5.56)	23.50(11.49)	1.00(1.41)	22.50(11.79)
Lesson 3	9.50(5.20)	27.75(14.66)	.75(0.96)	54.25(41.40)
Lesson 4	4.50(3.51)	21.50(17.75)	1.00(1.41)	48.50(45.54)
Lesson 5	20.75(12.42)	47.00(33.25)	.75(0.50)	46.00(38.55)
Lesson 6	13.25(9.12)	25.25(21.79)	.75(1.50)	56.50(49.01)
Lesson 7	15.25(5.32)	83.00(34.38)	2.25(2.87)	149.00(62.48)
Lesson 8	27.00(10.10)	81.25(23.40)	2.25(1.26)	112.00(9.59)
Lesson 9	19.00(4.55)	73.75(16.46)	2.00(1.41)	138.25(44.24)
Lesson 10	15.75(11.24)	66.25(61.28)	1.00(1.41)	133.00(128.03)

Note. W = math words spoken; FU = frequency of use of the math words spoken; *M* = mean score; *SD* = Standard Deviation.

The mean scores across the 13 lessons for all measures of math learning show positive increases, suggesting there is a relationship in the positive direction between the affective instruction design and the measurers of math learning. As a way of visually representing the changes in mean scores for the 4 measures of math learning across the 13 lessons, a cluster graph has been created (see Figure 6.).

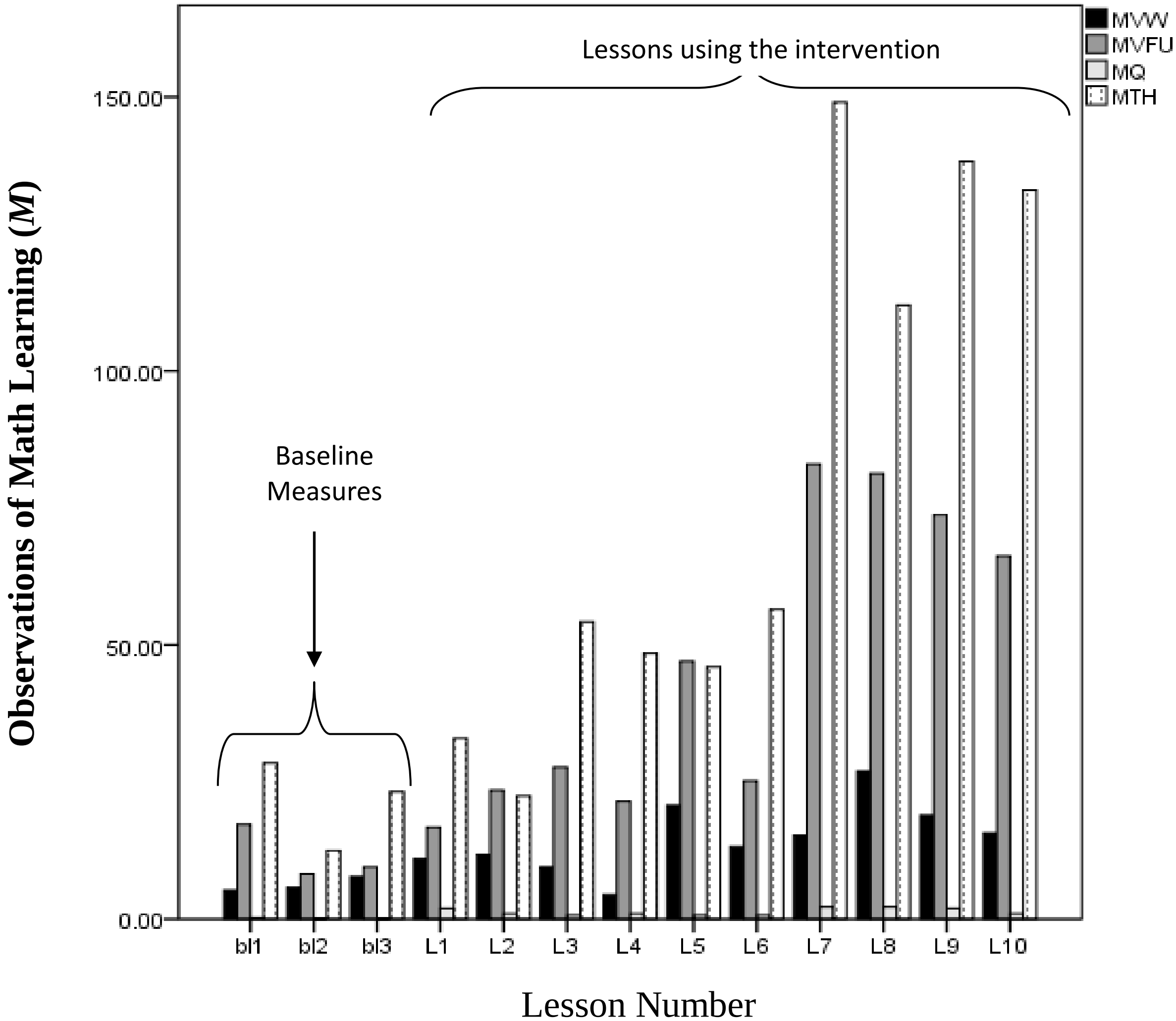

Figure 6. Observations of the four Measures of Math Learning Across 13 Math lessons. MQ was low across all lessons. The findings suggest this may be a skill that needs to be taught discretely. *Note.* MVW=Math Vocabulary Words; MVFU=Math Vocabulary Frequency of Use; MQ=Math Questioning; MTH=Mathematical Thinking

The trends of the bars visually represent the increase in mean scores across the 13 lessons for all measures of math learning, which suggests there is a positive relationship between the affective instruction design and the 4 measures of math learning. As a way of further comparing math learning observations prior to the intervention, with math learning observations in the final intervention lesson, the differences in mean baseline scores were computed and compared with the mean scores from the final intervention lesson. These scores have been summarized in Table 7.

Table 7.

Differences in Mean Baseline Scores and Final Intervention for Math Learning

Math Learning Measure	Baseline Scores	Standard Deviation Baseline	Lesson 10 Scores	Standard Deviation Lesson 10
Math Vocabulary (W)	6.250	4.834	15.750	11.236
Math Vocabulary (FU)	10.479	10.379	66.250	61.277
Mathematical Questioning	0.083	0.167	1.000	1.414
Mathematical Thinking	21.417	20.327	133.000	128.034

Note. W = math words spoken; FU =frequency of use of the math words spoken

Across all measures of math learning, mean scores increased from baseline to the final intervention. This suggests a positive relationship exists between the measures of math learning and the affective instruction design.

As a final way of exploring the relationship between the affective instructional deign and math learning, a cluster column chart was used. The cluster column chart is a way of visually representing observations of math learning captured during each lesson segment: (a) starter, (b) introduction to the problem, (c) problem solving, and (d) reflection (See Figure 7.).

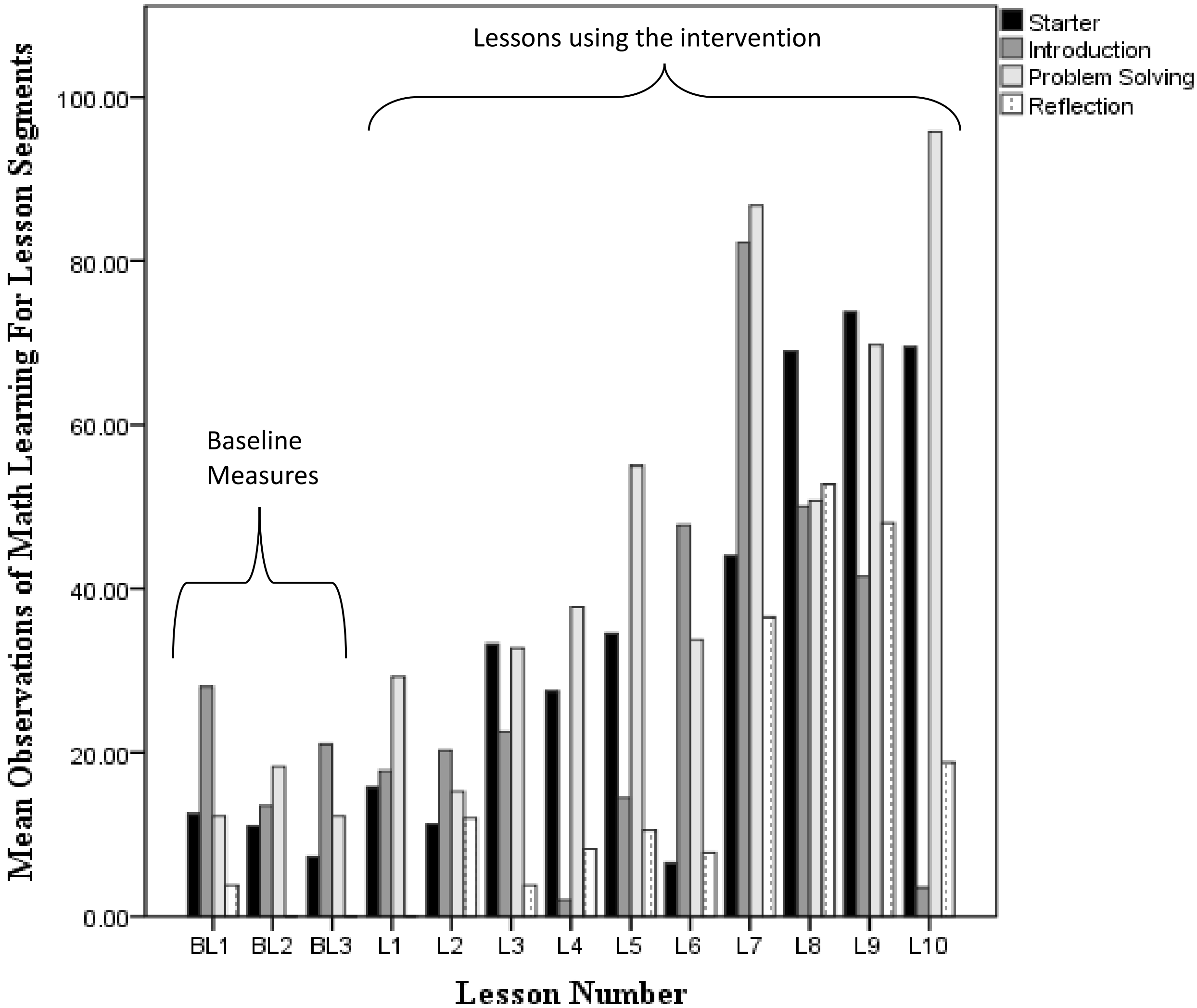

Figure 7. Observations of Math Learning Captured During Each Lesson Segment. Lower scores during the introduction segment for L4 reflect the teacher's decision to omit most of this segment from the lesson; Low scores in the starter for L6 reflect the fact that a story was read, so limited observations could be made for math learning; lower scores in the introduction of L10 reflect the fact that a story was being read, and therefore limited data could be collected for math learning. The participants were very attentive during these times but were not required to verbalize any thinking or use of math vocabulary. *Note*. BL=baseline (pre-test) measures; L=lessons using the affective instructional design intervention. Lesson segments are defined as Starter, Introduction, Problem Solving, and Reflection.

The general trend of the bars suggests math learning improved during the intervention, across all lesson segments, with the greatest gains captured during the starter and the reflection.

Summary

The findings and results presented in this chapter give insight about children's attitude, toward mathematics and the relationship between attitude and mathematical learning. The descriptive data revealed children in the study had an overall positive attitude toward mathematics prior to intervention, and these attitudes improved following the intervention. The scattergram showed a positive relationship between attitudes toward mathematics and mathematical learning, with the Pearson product-moment coefficient confirming a strong, positive correlation between the two.

Regarding the overarching question, "*Does an affective instructional design improve children's attitudes toward mathematics and mathematical learning?"* the results and findings reveal insight about the relationship between the affective instructional design, attitude toward mathematics, and mathematical learning. Comparisons on pre and post-test attitude data show an extremely statistically significant relationship between the affective instructional design and both children's attitudes and math learning. These findings are supported by the descriptive data, which summarizes and visually presents the mean scores for observations of math learning across the 3 baseline lessons and 10 intervention lessons, as well as for each lesson segment.

The following chapter provides a summary of the findings; their implications; and a discussion including limitations, conclusions, and recommendations.

CHAPTER 5

DISCUSSION

In the current educational climate, the role of affect in teaching and learning is often overlooked. Instruction places emphasis on the use of outcome-based measures and is rooted in memorization, rote rehearsal, and paper-pencil activities. Mathematics is one subject area where such practice is routine, and affect has had little purposeful place in the teaching and learning process. A shift in perspective that seeks to identify the relationship between affect, attitude, and learning in mathematics has the potential to contribute to the body of research about instructional design and the nature of student learning.

This study was undertaken to determine the relationship between an affective instructional design, children's attitudes toward mathematics, and their mathematical learning. It further sought to determine the relationship between attitude and mathematical learning. Before this research could be undertaken a number of goals needed to be met. First, a thorough understanding of the current research about affect was required. Following this, it was essential that an instructional design be created that allowed the classroom teacher to teach to mathematics objectives, while purposefully stimulating different affect states. Finally, an attitude survey and two checklists were developed to allow for accurate attitude and math learning data collection. With these goals met it was possible to proceed with the quasi-experimental design employing a pre-test, treatment, and post-test, with non-participant observational data collected during the treatment phase. As a means of answering the research questions, the data sources were analyzed using descriptive and inferential statistics.

Summary of Findings

Three questions drove this investigation. Analyses of the findings presented in chapter 4 delivered the following results:

Sub-Research Question #1

What are children's attitudes toward mathematics?

- The pre-test and post-test Math Attitude Survey results suggest that children had positive attitudes toward mathematics prior to the investigation, and these positive attitudes further increased during the intervention phase.

In general, the participants held positive views of mathematics, leaving little room for improvements. However, it is interesting to note that within the short duration of the intervention, a slight gain was found, with a corresponding decrease in the standard deviation. This suggests that overall, more children experienced increased feelings of positivity toward mathematics post-intervention than prior to the intervention.

Sub-Research Question #2

Is there a correlation between children's attitudes and mathematical learning?

- A highly statistically significant positive correlation was found to exist between attitude and math learning.

It appeared, from observing the 13 lessons, that small group interactions, with opportunities for purposeful social interactions between children and adults was one of the key strategies that promoted improved attitudes, with corresponding improvements in math learning. Prior to the intervention, the lesson structure was with whole class, direct instruction, or independent activity involving worksheets, or art activities. In the whole group settings, the video observations suggest that participation involved only a small percentage of the group, or children disengaged from the activity while waiting for a turn to share. Then, during independent work, the observations suggest children and staff rarely interacted, and purposeful math conversation was very restricted. However, during the intervention lessons, the structure was whole group, small group, or independent with sharing. The video observations suggested that this lead to a significant increase in active listening, attentiveness to task, purposeful social interactions, task persistence, use of mathematical vocabulary, and mathematical thinking.

Overarching Question

Does an affective instructional design improve children's attitudes toward mathematics and mathematical learning?

- A statistically significant positive relationship was found between the affective instructional design and both attitude as well as math learning.

In comparing the video footage from the baseline and intervention lessons, observations suggest that the affective instructional design provided two components that may have contributed to improved attitudes and learning. First, it ensured the classroom teacher and support staff were all involved in the instructional process, and in that process were using various affect strategies: small-group interactions, variety of manipulatives, use of technology, choice in materials, and open-ended questioning. Second, the affective instructional design may have led to improved lesson cohesion. Prior to the intervention, the lesson structure involved a direct instructional phase and a working period. Through training in how to implement the affective instructional design, the classroom teacher gained knowledge and understanding of the lesson segments: a) starter, b) introduction to the problem, c) problem solving, and d) reflection. She stated during intervention 2 that she felt she was gaining new understanding of how to create a child-lead math-learning environment based on the use of the lesson segments. As each lesson progressed, from starter, to introduction, to problem solving, the teacher, or supporting staff member gradually turned the ownership of the math concepts over to the children, who took on the vocabulary, knowledge, and understanding. Then, through the reflection, they had the opportunity to demonstrate this ownership. Based on teacher feedback and observations, the reflection was a significant part of the lesson which had not previously been practiced, and which led to opportunities where children could share their excitement and joy in the learning process, as well as conveying their knowledge and understanding of mathematical concepts.

A final, and unexpected piece of data supporting the positive relationship between the affective instructional design, children's attitudes toward math, and their math learning, is the social validity survey, which was completed after the classroom teacher requested a formal means of reporting her thoughts on the intervention process. Although there is no baseline survey for comparison, the strength of the teacher comments warrants reporting (see Appendix R). In brief, the teacher reports an "electric" learning environment, where children "discuss concepts, and make connections to prior concepts." Furthermore, the teacher describes the children's newly developed eagerness to "share observations using language, gesturing, body language, as well as drawings and demonstrations". Finally, the class teacher states, "I have searched for a long time for professional development in teaching mathematics. While a day or two of lectures and demonstrations, or reading articles is beneficial, THIS experience has been transformational." She goes on to recommend, "If this experience could be offered in the classroom by a Teacher Peer Tutor for at least a week, it could transform math teaching. It would change math into an exciting experience and increase children learning." While this is only anecdotal evidence from one classroom teacher, it speaks strongly to the impact of the AID on not only the students but the teacher as well.

Limitations

Use of Survey with Young Children

It was important to allow children the opportunity to convey their feelings about math as one measure for determining attitudes. However, self-report data can be unreliable. With young children, there is always a possibility that they do not understand the questions being asked, or they feel compelled to answer a certain way. Any number of other factors may impact their answers in a given moment. Furthermore, young children often express positive attitudes in any learning situation, even before an intervention, so measuring gains in attitude can be difficult. Therefore, a second measure, non-participant video observations, was used as a way of addressing the limitations of self-reporting.

Study Design

One important limitation is the non-randomized, single group design used for the study. This was a small sample of convenience involving one class and no control group. This design, along with the small sample size, limits the generalization of the findings. In order to overcome these limitations an experimental design involving a control and experimental group is required. Should positive findings emerge in such a case, the next phase would involve a randomized, control trial across multiple schools and/or grades to determine if the findings from this study have efficacy.

Context of Findings

Neuroscience research suggests the brain's initial response to sensory information stimulates emotional responses, which in turn influence attitude formation, as well as the activation of cognitive processes such as attention or concentration (Evans, 2006). Through his study, Schloglmann (2003) investigated the neuroscience behind affect and mathematics education. He found that students experience a steady stream of sensory information that leads to emotional responses, which in turn impact attitudes and cognition. In the current study, environmental affect and core affect were stimulated through various affect strategies (varied instructional approach, use of manipulatives, varied groupings, use of technology, shared thinking, open questioning). These strategies promoted various emotional responses, which, from the video data suggested an increase in positive attitude toward math, and increased mathematical learning.

Further research by Zembylas (2004) investigated the relationship between emotion and cognition. Findings from this longitudinal study suggest cognition and emotion are interdependent components of young children's successful science learning. In particular, Zembylas (2004) highlighted the importance of teacher-child interactions, and environmental design as a means of promoting positive emotional experiences. Likewise, the current research study incorporated small group, shared thinking, and purposeful social interactions between teacher and child, as well as between children as a means of promoting affect. Purposeful social interaction was one measure used to determine children's attitudes toward mathematics. Observations of attitude across the 13 lessons showed an increase in purposeful social interactions. In keeping with Zembylas (2004), these finding suggest there is a connection between children's social experiences, learning environment, and attitude. Findings from the current study suggest purposeful social interactions are an important part of positive attitude formation and mathematical learning.

Additionally, research by Grootenboer and Hemmings (2007) found a direct correlation between attitude and academic achievement. Although the current study did not investigate academic achievement, it did investigate mathematical learning, and findings suggest there is a direct correlation between positive attitudes toward math and an increase in mathematical learning.

Conclusions and Implications

Collectively, the synthesis of literature and the findings from this study suggest there is a positive relationship between affect, attitude, and learning (Claxton, 2012; Grootenboer & Hemmings, 2007; Schloglmann, 2003; Zembylas, 2004).

This study extends the research about affect and its relationship to attitude and math learning in that it investigates the relationship of an instructional design that purposefully incorporates affect as a central component of the teaching and learning process in mathematics. This is significant in the current educational climate, where the importance and inclusion of affect is most often overlooked to make room for direct instruction leading to measureable learning outcomes. Through use of the affective instructional design, affect becomes an inherent part of the teaching and learning process and still allows the teacher to teach toward the measurable learning outcomes that have become an educational focus. Findings from this research suggest that when affect is made a central component of an instructional design, there is an increase in children's positive attitudes toward math, and math learning. These findings are significant in the contributions they could offer to the general teaching practice.

Moreover, the National Scientific Council on the Developing Child (NSCDC, 2007) recognizes that child development is the key to the future success of a society. They define the core concepts of development as including "cognitive skills, emotional well-being, social competence, and sound physical and mental health" (NSCDC, 2007, p. 4). Further, they stress that if these areas of development are fostered in the early years through quality learning environments, nurturing relationships, and engaging social interactions, a foundation will be laid for future successes: positive school achievement, future economic productivity, as well as responsible citizenship (NSCDC, 2007). The affective instructional design could be one route to supporting teachers and schools in establishing the quality learning environments and engaging social interactions that promote future successes.

Recommendations

The findings from this small study serve as a foundation for future studies guided by the recommendations provided in this section. Future studies should include a change in the research design to a randomized, control group design as a way of building scientific rigor and efficacy of the findings. Second, future research should use statistical techniques that permit analysis of change over time for each participant, rather than looking at change across the entire class. Third, studies should investigate the relationship between the affective instructional design, attitudes, and learning in mathematics across different age groups, particularly middle school, where current research suggests two relevant findings. First, it is during this phase of education where students express declining interest in mathematics, and express growing feelings of negativity toward the subject. Second, affect states are transient, and related to both the quality of instructional design and students' achievement in mathematics (Grootenboer & Hemmings, 2007; OECD, 2003; Singh et al., 2002).

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APPENDICES

Appendix A

Principal's Permission to Conduct Study

East Tennessee State University
Department of Teaching and Learning
423 Warf Pickel, Box 70548, Johnson City, TN 37614-1707

Permission to Conduct Study
(Director's Consent for 2015 School Year)

12/2/2014
Director Doyle
University School
East Tennessee State University
100 CR Drive
Johnson City, TN 37614

RE: Permission to Conduct Research Study

Dear Director Doyle,

I am writing to request permission to conduct a research study at your institution. I am currently enrolled in the Early Childhood Education program at East Tennessee State University and am in the process of writing my Master's Thesis. The study is entitled, The Relationship between an Affective Instructional Design, Children's Attitudes toward Mathematics, and Children's Mathematical Learning.

I hope that the school administration will allow me to complete my investigation with the kindergarten class, their teacher, Mary Myron, and the teacher assistant. Should participation be granted, the student participants will be asked to complete a pre-investigation and post-investigation survey (copy enclosed). The survey results will be kept confidential and only used by the researcher for the study. Second, students will be required to participate in a 4-week intervention that will take place 3x/wk during the regular math lesson. The classroom teacher and teacher assistant will be asked to participate in 4x30minute training sessions, where they will be introduced to the intervention and trained in how to apply affective strategies during their instructional time. During the lessons, the teacher and teacher assistant will incorporate affective strategies as a part of the regular instruction. The researcher will use video recording equipment to capture the actions, and interactions of the children during their math lesson. The videos will be analyzed for child participant emerging attitudes and math learning. Like the survey data, all results will be pooled, and individual results will remain absolutely confidential. All video footage will be stored in a locked office in Warf-Pickel 516 (Dr. Amy Malkus' office, who is the chair of this research study). All video footage will be destroyed after a period of 3 years, according to the ETSU Office of Information Technology (OIT) department guidelines. At no time during the recording session will the researcher be interacting or engaging with the participants, and the recording process will be as unobtrusive as possible. A consent form will be given to the parents or guardian (copy enclosed) to be signed and returned to the primary researcher at the beginning of the survey process.

If approval is granted, student participants will complete the survey in their classroom during school, at a time designated by the classroom teacher. The survey process should take no longer than 7 minutes. The survey results will be pooled for the thesis project, and individual results of this study will remain absolutely confidential.

Should this study be published, only pooled results will be documented. The school, classroom, and the individual students will not be identified.

Your approval to conduct this study will be greatly appreciated. I will follow up with a telephone call next week and would be happy to answer any questions or concerns that you may have at that time. You may contact me at my email address: whitewb@goldmail.etsu.edu

If you agree, kindly sign below and return the signed form in the enclosed self-addressed envelope. Alternatively, kindly submit a signed letter of permission on your institution's letterhead acknowledging your consent and permission for me to conduct this survey/study at your institution.

Sincerely,

Wendee White
Master's Candidate Early Childhood Education
Department of Teaching and Learning
ETSU

Enclosures

cc: Dr. Malkus, Research Advisor, ETSU

Approved by:

____________________ _______________________ _______________

Print your name and title here Signature Date

Appendix B

Teacher Consent to Participate

East Tennessee State University
Department of Teaching and Learning
423 Warf Pickel, Box 70548, Johnson City, TN 37614-1707

(Teacher Consent for 2015 School Year)

12/2/2014
University School
East Tennessee State University
100 CR Drive
Johnson City, TN 37614

RE: Teacher Permission to Conduct Research Study

I am writing to request permission to conduct a research study in your classroom. My name is Wendee White, and I am currently enrolled in the Early Childhood Education program at East Tennessee State University. I am in the process of writing my Master's Thesis. The study is entitled, <u>The Relationship between an Affective Instructional Design, Children's Attitudes toward Mathematics, and Children's Mathematical Learning.</u>

This informed consent will explain about being a participant in a research study. It is important that you read this material very carefully and then decide if you wish to be a volunteer.

Purpose:

The purpose of this research study is to investigate the relationship that exists between an affective instructional design and student attitudes, and math learning. The investigation will take place over a 4-week period, 3 times/wk during regular math programming. In this study teachers will be asked to monitor the children as they complete a pre and post Primary Math Attitude Survey (see enclosed). Second, teachers will be asked to participate in four, 30-minute lesson planning, and training sessions to learn how to implement the affective instructional design for mathematics. This is a design that the teacher will use, which utilizes specific teaching strategies – audio, visual, and kinesthetic, as well as small group interactions, problem solving and reflection – that stimulate children's emotions during the learning process. Third, teachers will be asked to apply affective strategies during their mathematics instructional time. During each of these math lessons the primary researcher will video participants. The video will later be analyzed for emerging attitudes and math learning. Fourth, teachers will be asked to gather student demographics (e.g. age, ethnicity, gender), as well as report their own demographics (e.g., years of school, degree earned) to the researchers.

All results yielded from the data collected, (surveys and video), will be pooled, and individual results will remain absolutely confidential. Should this study be published, only pooled results will be documented. The school, classroom, and the individual students will not be identified.

Duration:
The study will take place during the spring term. It will take place over a 4-week period, 3 times/wk during regular math programming.

Procedures:

Your participation will last approximately one month and will include training in the use of the affective instructional design. During designated math lessons (4 weeks, 3 times/wk) you will be required to use the affective strategies (e.g. The use of a manipulatives, video or audio technology, small group interactions, problem solving, and reflection), which will be presented in training sessions.

Alternative procedures/Treatments:

There are no alternative course of treatment/procedures that might be available or advantageous to you.

Possible Risks/Discomforts:

There are no foreseeable risks associated with this research study.

Possible Benefits:

The results of this study could be used to inform teacher training innovation to improve mathematics teaching and learning, which could directly benefit the children.

Financial Costs:

There will not by any costs to participants that may result from participation in the research.

Voluntary Participation:

Participation in this research study is voluntary. You may refuse to participate. You can withdraw at any time. It you withdraw, or refuse to participate, the benefits or treatments to which you are otherwise entitled will not be affected.

Contact for Questions:

Your approval to conduct this study will be greatly appreciated. If you have any questions or concerns about the actual project, or study, please contact the primary investigator, Wendee White (Master's Candidate in Early Childhood Education, ETSU) at 423-234-0255, or at the following email address: whitewb@goldmail.etsu.edu , or contact Dr. Pamela Evanshen, Teaching and Learning Dept. Chair, at 423-439-7694. If you have any questions or concerns about the research and want to talk to someone independent of the research team, or you can't reach the study staff, you may call an IRB coordinator at 423-439-6055 or 423-439-6002.ETSU wants to make sure that you and your child are treated in a fair and respectful manner. We are eager to ensure that anyone in a research study is treated fairly and with respect. Thank you very much for helping us with this important study.

CONFIDENTIALITY

Every attempt will be made to see that all study results are kept confidential. A copy of all records from this study, along with all video footage will be stored in a locked office in Warf-Pickel 516 (Dr. Amy Malkus' office, who is the chair of this research study). The results of this study may be published and/or presented at meetings without naming you or your students as participants. Although your rights and privacy will be maintained, the Secretary of the Department of Teaching and Learning, the ETSU IRB, and personnel particular to this research (Wendee White, Dr. Amy Malkus) have access to study records. Your records will be kept completely confidential according to current legal requirements. They will not be revealed unless required by law, or as noted above. All video footage will be destroyed after a period of 3 years, according to the ETSU Office of Information Technology (OIT) department guidelines.

By signing below, you confirm that you have read or had this document read to you. You will be given a signed copy of this informed consent document. You have been given the chance to ask questions and to discuss your participation with the investigator. You freely and voluntarily choose to be in the research project.

____

Signature of Participant Date

____

Printed Name of Participant Date

____

Signature of Investigator Date

Appendix C

Parental Permission for Child’s Participation in Research

East Tennessee State University
Department of Teaching and Learning
303 Warf Pickel, Box 70548, Johnson City, TN 37614-1707

ETSU Parental Permission for Child’s Participation in Research
(Parent Consent for 2015 School Year)

Study Title: The Relationship between an Affective Instructional Design, Children’s Attitude toward Math, and Children’s Math Learning.

Researcher: Wendee White, Master’s Candidate in Early Childhood Education, ETSU

This is a parental permission form for research participation. It contains important information about this study, as well as what to expect if you agree to your child’s participation.
Your child’s participation is voluntary.

It is important that you read this material carefully. Please feel free to discuss it with friends or family before making your decision whether or not to permit your child to participate. If you permit your child to participate, you will be asked to sign and return this form, care of your child’s classroom teacher, to the researcher.

Purpose:

There is a growing body of research supporting the idea that children’s attitudes, learning and long-term academic success are related to the feelings they experience in any learning environment. This study aims to investigate the relationship between an affective instructional design and children’s attitudes toward math, as well as their mathematical learning. This means during the children’s regular mathematics lessons, the classroom teacher will implement strategies that allow children to share their thoughts and feelings about the learning process. The researcher will be collecting video data, looking for how these strategies relate to children’s attitudes and mathematical learning.

Duration:

The length of the study will be 4 weeks, and I will be visiting the children during their regular math lesson three times per week to collect video data.

Procedures:

The procedures which will involve your child as a research participant include:

1) Completing a Primary Math Attitude Survey at the beginning and conclusion of the study

   a) In order to complete the survey, the children will sit at their tables in the classroom, and the researcher will read 11 questions for the children to respond to. An example of one of the questions that appears in the survey is, "Show me how much fun it is to do math activities". The children then mark, or color in one of 5 emotion characters:  to represent their answers. The classroom teacher and teacher assistant will be present to support the children and to ensure they feel comfortable.
   b) The children will repeat this same process at the conclusion of the study.

2) Children will be videoed participating in their regular mathematics lessons

   a) The lesson objectives will follow the teacher's regular planning according to the state requirements.
   b) The lessons will include various teaching and learning strategies - technology, hands-on learning, visual and auditory resources, and group activities.
   c) Children will have opportunity to reflect on their learning at the conclusion of each lesson.
   d) During the lesson, video footage will be collected in as unobtrusive a manner as possible.

Alternate Procedures/Treatments

Should you choose not to have your child participate in this study, he/she will not be asked to complete the Primary Mathematics Attitude Survey and will participate in regular mathematics programming that does not involve video recording.

Possible Risks/Discomforts

There are no foreseeable risks associated with this research study.

Possible Benefits

The results of this study could be used to inform teacher training innovation to improve mathematics teaching and learning, which could directly benefit the children.

Financial Costs

There are no costs to participants that may result from participation in this research study.

VOLUNTARY PARTICIPATION

Participation in this research study is voluntary. You may refuse your child's participation. You can withdraw your child from participation at any time or refuse for your child to participate at no cost to the benefits or treatment to which your child is otherwise entitled.

Contact for Questions

If you have any questions about the study, please feel free to contact the primary investigator, Wendee White (Master's Candidate in Early Childhood Education, ETSU) at 423-234-0255, or Dr. Pamela Evanshen, Teaching and Learning Dept. Chair, at 423-439-7694. If you have any questions or concerns about the research and want to talk to someone independent of the research team, or you can't reach the study staff, you may call an IRB coordinator at 423-439-6055 or 423-439-6002.

ETSU wants to make sure that you and your child are treated in a fair and respectful manner. We are eager to ensure that anyone in a research study is treated fairly and with respect. Thank you very much for helping us with this important study.

CONFIDENTIALITY

Every attempt will be made to see that your child's study results are kept confidential. A copy of the records, and video footage from this study will be stored in a locked office in Warf-Pickel 516 (Dr. Amy Malkus' office, who is the chair of this research study). After a three year period, the records and video footage will be destroyed according to the ETSU Office of Information Technology (OIT) department guidelines. The results of this study may be published and/or presented at meetings without naming your child as a participant. Although your child's rights and privacy will be maintained, the Secretary of the Department of Teaching and Learning, the ETSU IRB, and personnel particular to this research (Wendee White, Dr. Amy Malkus) have access to study records. Your child's records will be kept completely confidential according to current legal requirements. They will not be revealed unless required by law, or as noted above.

By signing below, you confirm that you have read or had this document read to you. You are confirming consent to allow your child to be videoed, and upon completion, you will be given a signed copy of this informed consent document. You have been given the chance to ask questions and to discuss your participation with the investigator. You freely and voluntarily choose for your child to be in the research project.

____

Printed Name of Child Date

____

Signature of Parent/Guardian Date

____

Signature of Investigator Date

Appendix D

Children’s Consent to Participate Form

In this project, here is what you will do:

1. You will answer some questions about how you feel when you do math.

2. This will take about 5 minutes. 

3. Whatever you say, we won’t share what you told us with anyone. 

4. If you want to stop, you can. 

5. Your parents/caretakers said that it is okay for you to do this.  

Do you understand what we want you to do?

☐ **YES** ☐ **NO**

If you want to take part in our project, write your name here:

____

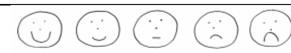
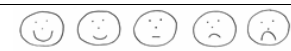
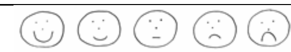
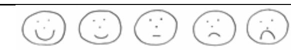
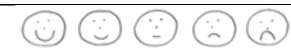
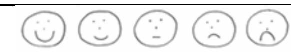
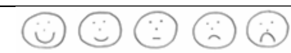
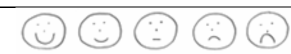
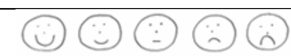
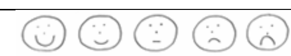
Researcher’s Name: Wendee White

Date: ____

Appendix E

Primary Mathematics Attitude Survey

Children will color in, or put a cross through the face that represents their answer.

Primary Mathematics Attitude Survey	
Show me how important you think it is to learn math	
Show me how much fun you think it is to do math activities	
Show me how much you like or hate math	
Show me how happy or unhappy math makes you feel	
Show me how good or bad you think you are at writing about math	
Show me how much you like or hate to write about math	
Show me how easy or hard you find math	
Show me how much you like to do math compared to every other school subject	
Show me how good or bad you think you are at difficult math	
Show me how much you like or hate to do difficult math	
Show me how happy or unhappy you would feel if you did something wrong in math	

Note. Primary Mathematics Attitude Survey adapted, with permission, by the researcher from Thomas & Dowker's (2000) Maths Attitudes and Anxiety Questionnaire.

Appendix F

Checklist for Observations of Positive Attitude

Momentary Time Sampling: **CHECKLIST FOR ATTITUDE (AC)**

DATE: _____________ WEEK: ☐ B* ☐ 1 ☐ 2 ☐ 3 ☐ 4 LESSON: B ☐ i ☐ ii ☐ iii Int ☐ 1☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ 11 ☐ 12

OBSERVER: ________________________________ **Tally marks should be used to indicate the number of events**

CHARACTERISTICS OF ATTITUDE	**LESSON STARTER**			**INTRODUCTION TO THE PROBLEM**			**PROBLEM SOLVING**			**REFLECTION**			**TOTAL FOR EACH ROW**
ON-TASK/ENGAGED (Claxton 2008)													
	B	**M**	**E**	**B**	**M**	**E**	**B**	**M**	**E**	**B**	**M**	**E**	
Active listening (Student concentrates on the speaker's words and actions, makes pertinent comments, and asks relevant questions) (Jalongo, 1995)													
Attentiveness to the task (Student shows effort in problem solving, sharing ideas, seeking support: peers, teacher, appropriate use of manipulatives.) (Namukasa, Gadanidas, & Cordy, 2009)													
PURPOSEFUL SOCIAL INTERACTION (Zausniewski & Bekhet, 2011)													

Purposeful interaction/ collaboration with peers (Student exchanges ideas with others, uses body language/ language/gesturing to convey ideas.)													
FLEXIBILITY IN THINKING (Yeager & Dweck, 2012)													
Task-persistence (Student tries new strategies, offers suggestions, seeks advice)													
Responds positively to peer or adult suggestions (Student shows in body language or conversation an appreciation of a new idea, interaction stimulates new thinking.)													
TOTAL FOR EACH COLUMN													**(Rows + Columns)**

Note. *B = Baseline i = 1st Lesson Baseline ii = 2nd Lesson Baseline iii = 3rd Lesson Baseline; B=beginning of the lesson segment; M=middle of the lesson segment; E=end of the lesson segment

Appendix G

Checklist for Observations of Mathematical Learning (OML)

Momentary Time Sampling: **OBSERVATIONS OF MATHEMATICAL LEARNING (OML)**

DATE: ___________

WEEK: ☐ B* ☐ 1 ☐ 2 ☐ 3 ☐ 4 LESSON: Baseline ☐ i ☐ ii ☐ iii

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ 11 ☐ 12

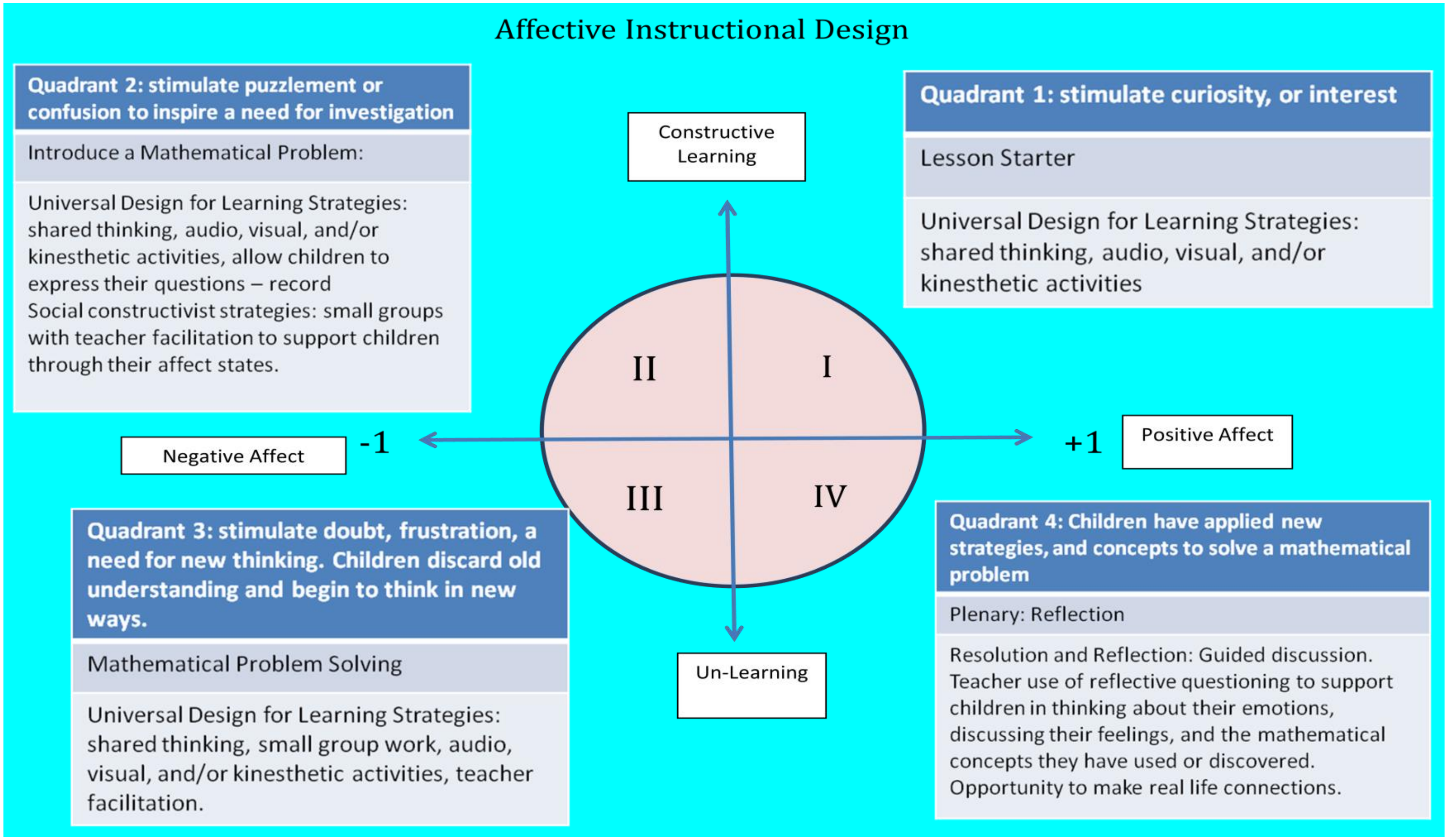
OBSERVER: ____

Tally marks should be used to indicate the number of events

MATH LEARNING CHARACTERISTIC	**STARTER**			**INTRODUCTION TO THE PROBLEM**			**PROBLEM SOLVING**			**REFLECTION**			**TOTAL FOR EACH ROW**
	B	**M**	**E**	**B**	**M**	**E**	**B**	**M**	**E**	**B**	**M**	**E**	
Use of mathematical vocabulary – words spoken													
Use of mathematical vocabulary- frequency of use													
Mathematical questioning													
Mathematical thinking as demonstrated through use or words, pictures, symbols													
TOTAL FOR EACH COLUMN													**ML** **(Rows + Columns)**
Notes/Observations													

Note. *B = Baseline i = 1st Lesson Baseline ii = 2nd Lesson Baseline iii = 3rd Lesson Baseline; B=beginning of the lesson segment; M=middle of the lesson segment; E=end of the lesson segment

Appendix H



Note. Affective Instructional Design (AID) adapted, with permission, by the researcher from Kort et al.'s (2008) Emotions and Learning Cycle.

Appendix I

Teacher Training Script and Lesson Planning Sheet

Training Script	Check Complete	Notes
1. Explain/ Review the purpose of the training session. The purpose of this research is to determine if there is a positive relationship between an affective instructional design, students' attitudes in mathematics, and mathematical learning. The researcher has designed an Affective Instructional Framework, to be used during the math lesson, as a way of promoting different affect states in learners. Today, we are going to review the framework and together use it to plan a math lesson. Before we can begin, there are three terms we need to be familiar with.		
a. Introduce/Review the terms: affect states, core affect, environmental affect i. *Affect States*: The range of emotions that a learner experiences. These emotions can be positive or negative, and in any learning experience, various affect states can be triggered (Russell, 2003). Affect can be developed in two ways: ii. *Core Affect*: the emotions that a student experiences through reflective practice, or social interactions (Russell, 2003). iii. *Environmental Affect*: Stimulus provided in the environment, which gives rise to affective states in the learners (Russell, 2003). iv. We will refer to Appendix K: *Affective Teaching Strategies Resource* to aid our planning of how to promote positive environmental and core affect.		
b. Introduce/Review the *Affective Instructional Design Framework* (Appendix H) i. Quadrant 1: This is the **Lesson Starter**, and UDL strategies will be used to promote affect states such as curiosity, interest, wonder…etc. ii. Quadrant 2: This is the **Introduction to the Problem**. In this part of the lesson, UDL strategies, technology, and social constructivist strategies will be used to promote affect states such as puzzlement, inquisitiveness, confusion…etc		

iii. Quadrant 3: This is the **Problem Solving** part of the lesson. In this part of the lesson children will feel challenge, be required to construct new ways of thinking, communicate their thoughts and feelings, and it will require use of UDL strategies, as well as social interactions and reflection. During this phase children may experience a range of affect states such as frustration, excitement, bewilderment, and/or discovery. The language employed by the teacher and TA will be important in helping children to comprehend the range of affect states. iv. Quadrant 4: **Reflection** comes as the lesson concludes. The purpose of this part of the lesson is to promote shared thinking and to stimulate positive core affect. Children can identify how they felt in learning; what strategies they used to construct their understanding; what they thought went well; and what they found difficult. The teacher will need to use open-questioning and cooperative communication to support children. The purpose is to foster feelings of discovery, and acceptance that the learning process is a positive experience, even if it is difficult at times.		
2. Explain how the lesson planning sheet and the affective instructional design framework link together: The Starter, Introduction to the Problem, The Problem-Solving Activities; Reflection		
a. **The Starter**: is the beginning of the lesson. In this part of the lesson the objective is to choose activities and teaching strategies that will promote positive affect states such as interest, joy, or curiosity. The teacher will know his/her children best and can plan an activity based on those interests. Appendix K: *Affective Teaching Strategies Resource* offers ideas of how to stimulate affect states, and the teacher can choose from the list.		
b. **The Introduction to the Problem**: In this part of the lesson the objective is to promote challenging affect states such as puzzlement, or confusion. From these initial affect states some children will move into positive affect states such as excitement or enthusiasm, while others may feel nervous or unhappy.		

	The teacher and teacher assistant will need to be aware of how different children may react and use teaching strategies to promote positive environmental and core affect states. In this part of the lesson, open-questioning, and supportive language that fosters a cooperative, rather than competitive, environment will be important. We will review Appendix K: *Affective Teaching Strategies Resource* for examples of how foster positive environmental and core affect.		
	c. **Mathematical Problem Solving**: In this part of the lesson affect states will vary. Some children will feel confident and happy to explore different ways of solving a problem, while others may feel frustrated, bored, or disillusioned. The teacher will use the planning sheet to record his/her planning of different strategies for supporting children in their learning. Much like during the introduction to the problem, the teacher and TA need to offer strategies or resources that promote positive affect states. Again, Appendix K: *Affective Teaching Strategies Resource* will serve as a source for choosing activities to foster positive environmental and core affect states. The teacher must be aware of the importance of supportive language and active listening during this part of the lesson.		
	d. **Reflection**: This is the final part of the lesson. In this part, core affect is the focus. Allowing children to come back together as a whole group to share their thoughts and feelings about the problem-solving activity will promote positive affect states. The teacher guides the discussion, promoting child conversation. Allow children to identify strategies they used and discuss how they worked. This is an opportunity for the group to identify how they felt in the process and what they learned. The teacher must promote open-questioning and cooperative discussion. Appendix K: *Affective Teaching Strategies Resource* provides examples of language that can be used to foster positive affect states.		

3. Introduce/Review the Lesson Planning Sheet		
a. Identify the different parts of the planning sheet i. Purpose/Objective ii. Different components of the lesson iii. The Horizontal Headings: Affective Strategies		
b. Identify the Domain (e.g., Counting and Cardinality), from the Common Core State Standards (CCSS), and record on the lesson plan.		
c. Identify the Standard (e.g., Know the number names and count in sequence) and cluster topic (e.g., Count to 100 by ones and by tens) for the lesson. Record this information on the lesson-planning sheet.		
4. Plan Affective aspects of the lesson, by completing the boxes on the planning sheet for each component of the lesson.		
a. Using the *Math Vocabulary Resource* (Appendix J), and with input from the teacher, review, and list mathematical language relevant to the lesson.		
b. Refer to the *Teaching Strategies Resource* (Appendix K), and with input from the teacher, choose activities to use for each component of the lesson.		
c. Refer to the *Teaching Strategies Resource* (Appendix K), and with input from the teacher, identify question/ language that will be used during the lesson.		
5. Record Resources Required for each component of the lesson		

Lesson Planning Sheet: Kindergarten Mathematics

DATE: ______________ WEEK: ☐ 1 ☐ 2 ☐ 3 ☐ 4 LESSON: ☐ 1☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ 11 ☐ 12

Domain: Counting & Cardinality ☐ Operations & Algebraic Thinking ☐ Number and Operations ☐ Measurement & Data ☐ Geometry ☐

Standard: **Cluster Topic:**

Objective/Purpose:

Affective Teaching Strategies Used : UDL ☐ Technology ☐ Questioning & Language ☐ Social Interaction ☐ Reflection ☐

Lesson Components	Key Mathematical Vocabulary	Teaching Strategies to promote Affect	Teacher Questions/Language to promote Affect	Resources
Starter				
Introduction to the Problem				
Mathematical Problem Solving				
Reflection				
Notes				

Appendix J

Kindergarten and First Grade Mathematical Vocabulary

The following list of mathematical vocabulary was taken from the Spelling City website and is a compilation of the mathematical vocabulary from the Common Core that children learn in kindergarten and first grade. This is not an exhaustive list, and can be added to with input from the classroom teacher. The first grade list of words has been included to ensure coverage for advanced learners.(Math Vocabulary (2014). Retrieved from https://www.spellingcity.com/math-vocabulary.html)

KINDERGARTEN MATH DOMAINS	**MATHEMATICAL VOCABULARY**
Counting and Cardinality	
a. Comparison	e.g., big, equal, more, between, less, before, after, opposite, small, compare…etc.
b. Counting	e.g., hundred, count forward, even, number, odd, numeral, quantity, small, big…etc.
c. Grouping	e.g., pair, table, add, equal, ten, one, count, forward, tally, group…etc.
d. Money	e.g., coin, money, cent, penny, dime, quarter, count, dollar, nickel…etc.
e. Sequence	e.g., first, second, third, fourth, fifth, number line, sequence, order, tens, ones, even numbers ,even, odd, odd numbers…etc.
Operations & Algebraic Thinking	
a. Algebraic thinking	e.g., different, alike, input, output, sort, outside, object, match, size, similar…etc.
Number and Operations in Base Ten	
a. Number and Operations	e.g., minus, value, behind, sum, above, difference, add, compare, zero, below, subtract, under, ones, tens, beside, between, addition, sort…etc.
Measurement and Data	
a. Measurement and Data	e.g., measure, long, estimate, longest, shorter, small, size, big, short, biggest, today, time, minute, calendar, hour, second, yesterday, morning, afternoon, date, minute hand, first, second hand, clock, year, equal parts, month, day, week…etc.
Geometry	e.g., square, shapes, pattern, triangle, rectangle, cylinder, halves, cone, in front of, cube, inside, middle, sphere, corner, curves, slide, right, graph, circle, left…etc.

DOMAINS	MATHEMATICAL VOCABULARY FIRST GRADE
Operations & Algebraic Thinking	
a. Algebraic thinking	e.g., alike, similar, object, match, size, output, sort, input, different…etc.
Number and Operations in Base Ten	
a. Graphing	e.g., data, non-standard unit, horizontal, vertical, standard unit, graph, estimate, symbol, sort, group…etc.
b. Counting	e.g., skip-counting, count, numeral, even, odd, whole number, pattern, integer…etc.
c. Comparison	e.g., compare, less, equal, near, less than, more than, half, opposite, before, after…etc.
d. Sequence	e.g., order, number line, pattern, number, more, rule, less, sequence, sort…etc.
e. Operations	e.g., solve, addition, total, add, numeral, subtraction, equals, operation, minus, less, more, number sentence, sum, subtract, plus, difference…etc.
f. Place Value	e.g., half, place value, fourth, double, whole, tens, ones, digit…etc.
g. Digits	e.g., digit, count, zero, ten, one, hundred, thousand, whole number, integer…etc.
Measurement and Data	
a. Measurement and Data	e.g., month, calendar, day, week, year, leap year, season, chart, picture graph, bar graph, input, measurement, table, data, measure, length, foot, ruler, long, inch, shorter, thermometer, temperature, measure, length, foot, ruler, long, inch, shorter, thermometer, temperature, less likely, impossible, equally likely, tally, certain, equal parts, estimate, even, chance…etc.
b. Money	e.g., money, dollar, coin, cent, half-dollar, quarter, nickel, penny, dime, currency…etc.
c. Time	e.g., time, second, hour hand, minute, second hand, half-hour, clock, first, hour, minute hand…etc.
d. Weight/Volume	e.g., measure, gram, scales, cup, pint, quart, pound, size, balance, kilogram…etc.
Geometry	e.g., square, shapes, pattern, triangle, rectangle, cylinder, halves, cone, in front of, cube, inside, middle, sphere, corner, curves, slide, right, graph, circle, left…etc.
a. Description	e.g., size, longer, small, longest, smallest, intersect, characteristics, side, parallel, describe…etc.
b. Direction	e.g., corner, slide, curves, turn, right, above, below, left, direction, line…etc.
c. Location	e.g., location, in front of, between, under, inside, outside, behind, middle, over…etc.
d. Prisms	e.g., geometry, prism, sphere, cylinder, cube, three dimensional, fourths, halves, cone…etc
e. Shapes	e.g., geometry, rectangular, line of symmetry, circle, square, triangle, shape, rectangle, two dimensional, sides…etc.

Appendix K

Affective Strategies for Kindergarten Mathematics Resource List

AFFECTIVE STRATEGY	
Universal Design for Learning (*Environmental Affect*)	• Differentiation – pitch the problem at the appropriate ability level • Provide multiple representations of information • Varied groupings • Choice in activity • Station learning • Varied instructional approach: visual, auditory, kinesthetic strategies • Supports – key words, pictures, symbols, diagrams • Scaffolding • Variety of manipulatives • Variety of writing implements (mini-white boards, pens, pencils, paper, crayon)
Technology (*Environmental Affect*)	• Model, inspire children to explore calculators • Use of PowerPoint, SMART Boards, Software, Internet sources to engage with information • Music, or video to support engagement
Questioning and Language Ideas (*Core Affect*)	• Open questions: How did you know? What can you tell me about that? Explain what you think might happen? What resources might we need? How will you figure this out? How would you…? What do you see? Can you think of another way? Which way do you think? How could we do this? What do you see? Are there any clues that might help us? Can you spot any interesting words? • Use words that inspire cooperation, not competition: "What are some good ways we could…"; "How might we…" (Avoid phrases that start with "Who can…") • Use language that promotes students' explanation of their thinking. • Through language choice, adults promote and value effort, persistence and concentration ("You are clearly thinking this through…", "I heard you say…", "I see you are making another attempt; tell me what you are doing differently…")

Social Interaction (*Core Affect*)	• Promote shared thinking • Promote respectful discussion • Opportunity to communicate understanding or reasoning to others • Collaboration through mixed ability, snowball activities, around-the-room sharing. • Use activities that require thought, and exploration, rather than practice. • Adults draw out key mathematical ideas as the lesson progresses • Adults promote the use of mathematical vocabulary through modeling, or discussion • Scaffold support • Flexibility in learner choice (use of materials, choice of activity) • Vary instructional approaches (visual, auditory, kinesthetic) • Use of technology: images, sounds, videos
Reflection (*Core Affect*)	• Opportunities to listen, evaluate others' mathematical thinking/ideas • Sharing of thoughts, feelings, beliefs • Whole class *three stars and a wish* (The teacher states three things done well during the lesson – e.g., the use of mathematical vocabulary (with examples), use of resources, cooperation, perseverance, etc. Then the teacher states one thing to improve next time. This process is modeled by the teacher, and then in the following lessons it is taken over by the children).
Other	• A clear focus • Link mathematical experiences in meaningful ways to the real world • Vary the use of resources for investigating problems • Offer choice in how to solve a problem: choice of tools, recording methods (words, pictures, symbols) • Promote shared thinking • Adults listening carefully to children's thinking, build on thinking through exchange of ideas, posing thought-provoking questions, or offering clarity, if the child seeks it. • Independent learning opportunities

(Kamii, 2000; McDonough & Clarke, 2003; Myren, 1995; Pearse & Walton, 2011; Pisha & Coyne, 2001; Schoenfield, 1992; Sparrow & Hurst 2010; Taylor, 1993)

Appendix L

Primary Mathematics Attitude Survey: Script for Delivery

Resources: Interactive Whiteboard

1. Introduce myself.
2. Explain the purpose of the activity, and that no one is going to know their answers because they will not put their names on the survey.
3. Show the children an image of the survey on the interactive whiteboard. Point to the faces, and tell the children that I will explain the purpose of these faces.
4. Show children an image of a smiling face on the interactive whiteboard (taken from the survey) 
5. Ask children what they think it shows. Then tell them it means “super happy”
6. Show them an image of the unhappy face. Ask them what they think it might mean. Explain it means “super unhappy”
7. Show the children an image all the faces. 
8. Explain that I will ask them questions about how they feel about math. If they feel super happy, they need to color in or mark the super happy face. If they feel super sad, they color or mark that face. If they feel okay about it, they color in or mark the middle face… and for the final faces, sort of happy, or sort of unhappy.
9. Practice a question: Tell the children I will practice how to answer a question, but my question won’t have to do with math.
“How do you feel about eating ice cream?” - I then color in the face that represents my feeling. Ask the children to tell me what the face means.
10. Explain I will ask them to think about being in their math lesson. Then I will ask a survey question, and if they do not understand, they can raise their hand for support. The teacher and teacher assistant will remain in the room to support the children. But no one can tell them what face to color or mark; that is up to them.
11. Allow for final questions.

12. Begin the survey. Moving through each question, pause, ask children if they have questions. The teacher and TA support by walking around the room and ensuring children are following the instructions of coloring in or marking one face for each question.

13. At the end, collect all survey papers and thank the children for their participation.

Appendix M

Field Notes

Reflections on administering the pre-test attitude survey

- The PowerPoint presentation was a very effective tool in gaining, and holding children's interest and attention about the survey.
- The use of visual supports in the PowerPoint were effective in helping children to understand the purpose of the survey
- The questions on the survey should have been numbered to support children in navigating down the page.
- A seating plan could have been requested ahead of time, and survey sheets should have been numbered ahead of time for efficiency of delivery.

Observations during survey delivery

- Some children answered quickly, confidently, while others seemed uncertain, and looked uncomfortable, glancing at the teacher just before bubbling in their answer.

Baseline Lesson #1 – Time, and Reading Analogue Clocks

- Figuring out camera placement was tricky during each segment. Cameras needed to be moved multiple times to capture evidence of all aspects of the lesson. It was a good strategy to have multiple cameras.
- Unanticipated lesson structure. There was no introduction, and the problem solving segment was mostly independent sheet work, where children worked in isolation, filling in answers on a worksheet. There was little to no communication between anyone during this phase of the lesson. The class teacher and TA walked around the room, looking over children's shoulders, and children worked without conversation. There was not a reflection. Instead the class teacher introduced a new activity. Later, she stated that the math time was not up, so she needed to add something to fill the time. I think the teacher training session, and introduction to the reflection has potential to be very impactful. It will be interesting to see how the class teacher progresses with use of lesson time, once the lesson structure is firmly established based on the affective instructional design.

Baseline Lesson #2 – Review of Subtraction and Number Sentences

- This lesson was spent on the carpet as a whole group. The teacher told subtraction stories, and the children worked on their whiteboards to solve the questions. The teacher facilitated a conversation with the children about different ways to solve subtractions sentences. Work was independent, sharing happened after everyone had the work on their own whiteboard, and each child shared how they come up with the solution to the question. About half way through many children lost interest, until it was their turn to talk in front of the class. There was no support for children who were struggling. Again, no reflection. The lesson ended with the teacher announcing it was time for lunch.
- The support staff in the class have a very restricted role during lesson time. The majority of the first and second lesson, the teacher has used direct instruction with all of the children, or children worked independently. The TA's role has been limited to handing

out materials, or supporting with art-like activities such as assembling clock faces for children.

Baseline #3 - Subtraction

- More subtraction sentences with wb. Children enjoy using the wb. Then, worksheets – again in isolation. No sharing, no reflection. Limited engagement, very teacher focused. Questions are direct. Children see the worksheets as something to get done quickly, so they can play. Again, no teacher/TA and child interactions during independent work. Hard to know what children really understand, or who is struggling.

Intervention Lesson #1 – Subtraction

- There was an immediate obvious – even drastic difference in the number of children sharing ideas, and participating in math conversations just through the use of small groups, and involving the support staff in the instruction delivery process. Children had better focus, and because they were in small groups, they could all share ideas, use math vocabulary, and by the end it was obvious who had grasped the concepts presented, and who was in need of support. The class teacher made a comment at the end of the lesson about not realizing some of the children were struggling.
- The class teacher attempted the reflection segment today. She used 3 stars and a wish – and used too much teacher talk, but is grasping the idea that this is opportunity to share ideas about the lesson, revisit key concepts, share feelings about the challenges of learning, and celebrate successes. There was good attention during this phase.
- TA had more difficulty using open questioning. The use of the script is key to ensure correct implementation of the lesson plan. It is obvious the use of open questioning is a new concept for teacher and TA.
- The class teacher commented on how much more content was covered, and how much more fluid the learning process was. She could see during the lesson how the children took ownership over the learning.
- Class teacher expressed a feeling of being exhilarated in the process, and how she felt teaching math today.

Intervention Lesson #2 – Problem Solving with Positional Language

- Great use of open questioning today. Teacher-lead activities were used in the starter, but children very quickly took ownership over the language and enjoyed being challenged to explain their thinking.
- The teacher expressed joy and new understanding of the concept, “child-lead” during math. This is an area she has struggled with for a long time, and today she said she gained new insight.
- Teacher also realized today that lessons don’t need to involve lengthy preparation of materials, but use of the classroom tools, manipulatives is important and impactful.

- Overall, the teacher and support staff used effective language, and open questioning exceptionally well to promote thinking, and math conversation.
- Shows me the importance of purposeful social interactions, and language choice.

Intervention Lesson #3 - More Than, Less Than, Fewer, Most

- Today began brilliantly. I barely got this on film… just before the lesson started, as the children were gathering at the carpet, child 13 says to his teacher, "Ms M, I got to tell you something. Last night I sat **beside** my sister – AND that's a math word!"
- The class teacher's eyes were wide with delight, and after she responded to the little boy, she looked at me and said quietly, "This is amazing. He is thinking about math outside of math time, and he is bringing his life into our math lesson – AMAZING."
- Then, before we knew it, two other children spontaneously started telling stories about dinner the night before, and how their food was 'inside' them, and that was a math word, too. Then they giggled with delight when they announced what word they had used.
- In today's lesson, the importance of effective questioning to scaffold learning became evident. Children struggled with the key words, and adults had difficulty, and discomfort scaffolding the learning through their own language choice and questioning. For example, when discussing fewer than adults were unsure how to demonstrate, describe, or find synonyms to support learning.
- MQ seems to be very low, whereas we are seeing good progress across the other measures of math learning. This does not seem to be a natural ability that comes through purposeful social interaction – I didn't expect this!

Intervention #4 – Problem Solving with Patterns

- High energy today. Children really engaged with manipulatives, and the freedom to create and discuss their own patterns. The use of the camera was effective during the reflection, where children really engaged well with discussing their patterns using the photos, projected on the whiteboard.
- Collaboration, and conversation was very good. Children are making good progress interacting in a purposeful fashion, and sharing their thinking. Teachers are doing a good job facilitating these interactions. It is a striking difference to the initial lessons where everyone worked in isolation.
- Genuine feeling of happiness in the room.
- After the lesson ended, children continued to discuss patterns and made real world connections.
- Child 15 – "Ms. M bumble bees have a pattern." (Holding up a book with a picture of a bumble bee)
- Child 4 – "I have a pattern on my shirt!"
- Child 1 "Hey, you have a pattern there (points to pattern on TA's glasses).

Intervention #5 – Problem Solving with Length

- Teacher was slightly disorganized today. Not feeling well, and lost focus on lesson structure. As a result, parts of the lesson were slightly disjointed.
- Really interesting today, some children were using the word "fewer" in the correct context today. This was interesting since yesterday they, collectively, seemed to struggle with the correct use of the word. I think this supports the idea of reflecting, and even the notion of time to digest learning.
- Manipulatives were effectively used by children, and enabled them to take ownership over the language, as they identified objects longer, or shorter. Also, children engaged with the use of real life objects in comparing, and the opportunity to choose their own objects appeared to bring about an increased interest in math conversation about the length, and shape of the objects.
- Good teacher talk today. The use of open questioning is becoming more natural.

Intervention Lesson #6 - Problem Solving and Capacity

- The beginning of the starter is becoming tedious. The calendar activity is not being utilized effectively. Affect strategies are not being used in the segment. We will need to revisit in the next planning session.
- Today, for the introduction the teacher read a math story to the children that introduced the topic in a child-friendly way. The children were mesmerized during the story, which reinforces for me the importance of cross-curricular programming, and the use of UDL strategies to promote affect.
- With the story reading in the introduction, there will be a lot less data for MVW and MTH, as well as MVFU… I'll have to think of how to explain this in the data!
- Children continue to engage well, and the class teacher is showing good progress encouraging children to support one another, and to share their thinking. The message is becoming one of, "Learning together".

Intervention Lesson #7 – Problem Solving and Missing Numbers

- The teacher told the children someone had bumped the calendar and it had gone to pieces… the children were engaged just like that! It was great.
- The calendar activity was SO MUCH BETTER - children engaged, were involved in the process of looking at, and deciding what information needed to go on the calendar… they shared ideas of how to find the missing information.
- The teacher said afterward, she had no idea some the children didn't understand the calendar, and this session provided valuable formative assessment. Also, she stated, she would like to have another session with this topic, and include differentiation – which she has to this point been reluctant to see the benefit in differentiating when required to support children's learning, both emotionally, and cognitively.

- The children continue to improve in their ability to use mathematical vocabulary, and to help one another when they are not sure how to solve a problem. However, MQ is not really changing to the same degree as the other areas. I wonder if this is age related – children are not yet able to form questions?? OR could this be a skill that needs teaching??
- At the end of the lesson children did a good job saying if they were helped by someone, and how. Then they threw a star. Children responded very positively, and the teacher reinforced the idea that learning together is a great way to learn.

Intervention Lesson #8 – Problem Solving and 3D Shapes

- Prior to this session, I had only ever witnessed one child using 3D shape vocabulary.
- During the lesson, children showed growing confidence using the vocabulary associated with 3D shapes – names, attributes, and real life connections.
- Today, not every instructor covered all of the lesson elements on the script. Although there was a script, some of the adults had modified according to the needs or interests of the children. This is GREAT! Scripts are limiting. It is good to see that the teacher is taking ownership over the affective instructional design, and using the strategies with the children's needs to develop learning.
- By the end of the lesson, children were having good fun giving 3D shape clues to each other, to try to figure out what 3D shape was being described.
- As the lesson came a close the children erupted with ideas, after Child 15 announce, "Hey, look what I found… (he holds up a book with the earth's image) the earth is a sphere." Then four other children joined in… "Guess what? My head is a sphere"; "Look at that, (pointing to the refrigerator), it's a rectangular prism"; "SO is the fish tank (pointing)".
- Also, key to the idea that knowledge and understanding grows with time, application, and reflection… children were using the words more than, fewer than, less than in describing the numbers of 3D shapes they had graphed. This shows great learning since int. lesson 3.

Intervention Lesson #9 – 2D Shapes

- The PPT is an effective use of technology. Children engaged really well with the photos today, and it reinforces for the teacher, that even if her use of technology is limited, she can find easy, and efficient ways to include technology in her lessons.
- The teachers used scaffolded questioning to effectively support children in taking ownership over the names, and attributes of 2D shapes.
- Giving children opportunity to discuss their work during the reflection phase is most effective when open questions are used, that then allow other children to join in the conversation as well. It is never effective when just one child is doing all of the talking!

Intervention Lesson #10 – Problem Solving with Fractions

- A story was used during the introduction – children mesmerized. Lead to excitement to get started in group activities.
- Children enjoyed using the play dough, and being able to share out their cookies.
- Greatest conversation came during the final part of the problem solving when the real cookies came out and children had to work together to decide how to share them out. Great thinking – and excellent formative assessment opportunity.
- The reflection was great today. The class teacher turned it over to the children and they used drawing and conversation to describe, and share their thinking. It was excellent.

Appendix N

IRB Approval

EAST TENNESSEE STATE UNIVERSITY

Office for the Protection of Human Research Subjects • Box 70565 • Johnson City, Tennessee 37614-1707
Phone: (423) 439-6053 Fax: (423) 439-6060

IRB APPROVAL – Initial Expedited Review

March 23, 2015

Wendee White

Re: The Relationship Between An Affective Instructional Design, Children's Attitudes toward Mathematics, and Mathematical Learning for Kindergarten-age Children
IRB#: c0215.8s
ORSPA #: n/a

The following items were reviewed and approved by an expedited process:

- xform New Protocol Submission; Letter to Principals; Teacher Consent (version 2/9/15, stamped approved 3/19/15); Parental Permission* (version 2/9/15, stamped approved 3/19/15); Child Assent* (stamped approved 3/19/15); Teacher Training Script; Math Survey Script; Surveys; Data Sheets; Bibliography; CV

The item(s) with an asterisk(*) above noted changes requested by the expedited reviewers.

On **March 19, 2015**, a final approval was granted for a period not to exceed 12 months and will expire on **March 18, 2016**. The expedited approval of the study *and* requested changes will be reported to the convened board on the next agenda.

Based on the **Review of the Child Advocate** the IRB determined that no greater than minimal risk to children is presented as the activity is part of a class and ICD/parent permission and assent is obtained prior to videotaping. Permission of one parent is sufficient because there is minimal risk to the child. The research is not subject to FDA regulations. Permission will be obtained appropriately and will be appropriately documented. If permission is to be obtained from a guardian, the guardian will be an individual who is authorized under applicable State or local law to consent on behalf of the child to general medical care. The IRB determined that assent is required for each child who is capable of providing assent based on age, maturity, and psychological state: all children in the classroom. Documentation of assent is required by child signature on the assent form.

Accredited Since December 2005

The following **enclosed stamped, approved Informed Consent Documents** have been stamped with the approval and expiration date and these documents must be copied and provided to each participant prior to participant enrollment:

- Teacher Consent (version 2/9/15, stamped approved 3/19/15)
- Parental Permission (version 2/9/15, stamped approved 3/19/15)
- Child Assent (stamped approved 3/19/15)

Federal regulations require that the original copy of the participant's consent be maintained in the principal investigator's files and that a copy is given to the subject at the time of consent.

Projects involving Mountain States Health Alliance must also be approved by MSHA following IRB approval prior to initiating the study.

Unanticipated Problems Involving Risks to Subjects or Others must be reported to the IRB (and VA R&D if applicable) within 10 working days.

Proposed changes in approved research cannot be initiated without IRB review and approval. The only exception to this rule is that a change can be made prior to IRB approval when necessary to eliminate apparent immediate hazards to the research subjects [21 CFR 56.108 (a)(4)]. In such a case, the IRB must be promptly informed of the change following its implementation (within 10 working days) on Form 109 (www.etsu.edu/irb). The IRB will review the change to determine that it is consistent with ensuring the subject's continued welfare.

Sincerely,
Stacey Williams, Ph.D., Chair
ETSU Campus IRB

Appendix O

IRR Meeting Notes and Sample Checklist

Meeting #1: Reviewing the Checklists

a) Clarity of Language

i. Attitude Checklist

- Expand the definition of task persistence to include wording, “after initial teacher input”
- Expand the definition of purposeful social interaction to include, “teacher or peers”

ii. Clarity on term: Moment Sampling

- Collection of data will occur during the beginning, middle and end of each lesson segment: a) starter, b) introduction to the problem, c) problem solving, d)reflection
- The video clips will be named by the PI according to lesson segment, as a way of improving consistency between coders.
- If uncertain as to whether a tally should be awarded, the time will be recorded and the name of the video clip, so PI and secondary coder can preview together to achieve agreement, or discuss changes that may be required to the checklist.
- Where large inconsistencies exist between coders, the video footage for said section will be reviewed in an attempt to identify and clarify the inconsistency.

iii. Observations of Math Learning Checklist

- Re: mathematical vocabulary – this section needs to become two separate data points. Words spoken should be tracked, as well as frequency of words spoken.
- Vocabulary is a reflection of mathematical thinking, so when coding, if a tally is given for mathematical vocabulary, it should also be given for mathematical thinking.
- The PI will ensure the secondary coder has a list of potential mathematical vocabulary for the recorded session.

IRR Meeting 2 – Review of Baseline #1

a) Awarding Tallies

- The main point of discussion was around how to accurately code observations of mathematical thinking when children are completing worksheets. We decided it was only consistent if we gave tally marks for each question, as that matches other aspects of the collection. For example, when children are at the carpet, if the CT asks a range of questions (show me 6 O’clock, 4 o’clock…) they get a tally for each time they demonstrate their thinking. We reasoned that the questions on a sheet of paper reflect this same kind of thinking, and therefore need to be acknowledged.

- Within each lesson segment (e.g. starter: beginning/middle/end) if 2 activities are presented to children (e.g. sorting objects, then describing rules for sorting) tally marks are awarded for attentiveness to task, and active listening for each activity.

b) Discrepancies

- Discrepancies were found for vocabulary and mathematical thinking during the starter. Review of the video footage, revealed the discrepancy occurred because not all time words were not being accounted for. After reviewing the footage, the PI and secondary coder were in agreement.

IRR Meeting 3– Intervention Lesson #1

a) Discrepancies

- Frequency of word use during the starter – differences were resolved by reviewing the video footage, and establishing how many children were speaking words during choral speaking moments.

- Mathematical Thinking during the starter – differences were identified resolved with review of footage and minute notes from meeting #1, where it was determined that use of math vocabulary was also evidence of mathematical thinking.

IRR Meeting 4– Intervention Lesson #5

- No significant discrepancies
- Both coders finding tallying observations very time consuming in order to capture all observations. Consistency in coding continues to improve, as kinks have been worked out with the checklists.

IRR Meeting 5– Intervention Lesson #7

a) Discrepancies

- Use of Mathematical Vocabulary – differences arose because one coder tallied math words not related to the topic, and the other coder did not. After previewing the video footage, the definition on the checklist, and notes from meeting #1, it was determined that the tally marks should be awarded.
- Mathematical Vocabulary, frequency of use – this discrepancy was resolved by reviewing the video together.
- Active listening – we established in meeting #2 that each activity within a segment should be counted. There was so much activity in this session that it was a challenge to count each observation. After reviewing the footage an agreement on the number of observations was achieved

Inter-rater Reliability Tracking: CHECKLIST FOR ATTITUDE/ ACTIVE LISTENING (Sample)

LESSON:	**DATE:**		
Event	PI	Secondary Coder	Notes
Starter/B			
Starter/M			
Starter/E			
TOTAL			
Intro to problem/B			
Intro to problem/M			
Intro to problem/E			
TOTAL			
Problem Solving/B			
Problem Solving/M			
Problem Solving/E			
TOTAL			
Reflection/B			
Reflection/M			
Reflection/E			
TOTAL			

Appendix P

Checklist for Observations of Attitude by Participant

Momentary Time Sampling: **CHECKLIST FOR ATTITUDE** **Tally marks should be used to indicate the number of events**					
CHARACTERISTICS OF ATTITUDE	**Participant**	**LESSON STARTER**	**INTRODUCTION TO THE PROBLEM**	**PROBLEM SOLVING**	**REFLECTION**
Active listening (AL) (Student concentrates on the speaker's words and actions, makes pertinent comments, and asks relevant questions) (Jalongo, 1995)	1				
	2				
	3				
	4				
	5				
	6				
	7				
	8				
	9				
	10				
	11				
	12				
	13				
	14				
	15				
Attentiveness to the task (ATT) (Student shows effort in problem solving, sharing ideas, seeks support: peers, teacher, appropriately uses manipulatives.) (Namukasa, Gadanidas, & Cordy, 2009)	1				
	2				
	3				
	4				

	5				
	6				
	7				
	8				
	9				
	10				
	11				
	12				
	13				
	14				
	15				
Purposeful interaction/ collaboration with peers (PSI) (Student exchanges ideas with others (teacher or peers), uses body language/ language/gesturing to convey ideas.)	1				
	2				
	3				
	4				
	5				
	6				
	7				
	8				
	9				
	10				
	11				
	12				
	13				
	14				

	15				
Task-persistence (TP) (Student tries new strategies, offers suggestions, seeks advice after initial teacher input)	1				
	2				
	3				
	4				
	5				
	6				
	7				
	8				
	9				
	10				
	11				
	12				
	13				
	14				
	15				
Responds positively to peer or adult suggestions (PR) (Student shows in body language or conversation an appreciation of a new idea, interaction stimulates new thinking.)	1				
	2				
	3				
	4				
	5				
	6				
	7				

	8				
	9				
	10				
	11				
	12				
	13				
	14				
	15				

Appendix Q

Observations of Mathematical Learning by Participant

Momentary Time Sampling: **OBSERVATIONS OF MATHEMATICAL LEARNING (OML)**

DATE: _____________ WEEK: ☐ B* ☐ 1 ☐ 2 ☐ 3 ☐ 4

LESSON: Baseline ☐ i ☐ ii ☐ iii Intervention ☐ 1☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ 11 ☐ 12

OBSERVER: ____

Tally marks should be used to indicate the number of events

MATHEMATICS LEARNING CHARACTERISTIC		**STARTER**			**INTRODUCTION TO THE PROBLEM**			**PROBLEM SOLVING**			**REFLECTION**			**TOTAL FOR EACH ROW**
		B	**M**	**E**	**B**	**M**	**E**	**B**	**M**	**E**	**B**	**M**	**E**	
Use of mathematical vocabulary words spoken (MVW)	1													
	2													
	3													
	4													
	5													
	6													
	7													
	8													
	9													
	10													
	11													
	12													
	13													
	14													
	15													
Use of mathematical vocabulary frequency of use –(MVFU)	1													
	2													
	3													
	4													
	5													

	6					
	7					
	8					
	9					
	10					
	11					
	12					
	13					
	14					
	15					
Mathematical questioning *(MQ)*	1					
	2					
	3					
	4					
	5					
	6					
	7					
	8					
	9					
	10					
	11					
	12					
	13					
	14					
	15					
Mathematical thinking as demonstrated through use or words, pictures, symbols *(MTH)*	1					
	2					
	3					
	4					
	5					
	6					

	7													
	8													
	9													
	10													
	11													
	12													
	13													
	14													
	15													
TOTAL FOR EACH COLUMN														

Appendix R

Social Validity Survey

Using the following scale, where 1 represents no impact, and 5 represents excellent impact, please rate the impact you feel the intervention has had on children's mathematical learning, and attitudes toward mathematics. At the end of the survey, there is an option to add any other thoughts, or reflections you wish to share with the PI regarding the investigation.

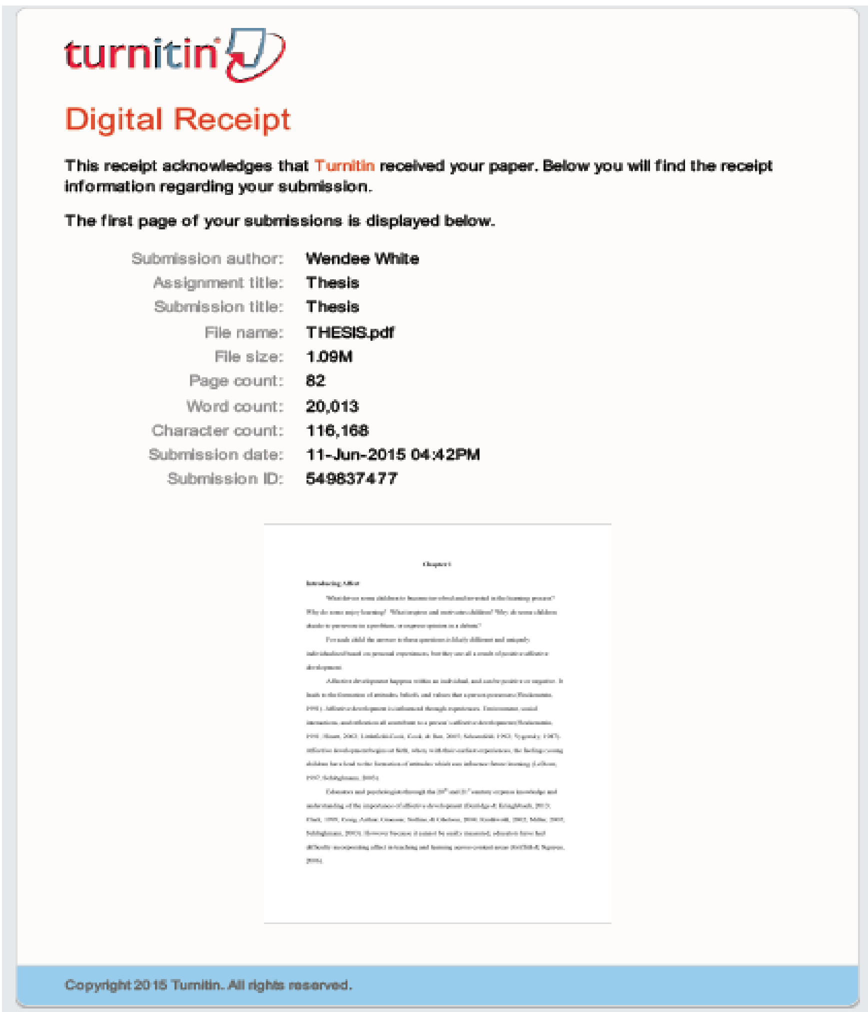
Attributes of Learning and Attitude	1 **–no impact** 2**-some** 3**-good** 4**-very good** 5**-excellent impact**
1. Children's use of mathematical vocabulary	1 2 3 4 5
Comment:5 **5:** The children delight in using the vocabulary not only during math but make connections through the day in other subject areas.	
2. Children's ability to ask mathematical questions	1 2 3 4 5
Comment: 5 **5:**This experience has made them far more cognizant of the math concepts around them and therefore they do come up with questions about which might be longer or shorter…which might hold more or less.	
3. Children's use of mathematical thinking (as demonstrated through use or words, pictures, symbols)	1 2 3 4 5
Comment:5 **5:** The children do use mathematical thinking in their drawings and point out that they drew flowers in order of their growth height, cars in order of how long they are, etc.	
4. *Active listening* (Student concentrates on the speaker's words	1 2 3 4 5

and actions, makes pertinent comments, and asks relevant questions)					
Comment:5 **5:** The consistent use of the vocabulary throughout the lesson by the teacher results in the children doing the same. I have noticed that instead of saying…"Are we supposed to color this one?"...or "What are we to do?" the children listen for and use the vocabulary in asking their questions.					
5. *Attentiveness to the task* (Student shows effort in problem solving, sharing ideas, seeks support: peers, teacher, appropriately uses manipulatives.)	1	2	3	4	5
Comment:5 **5:** The students have displayed increased interest in and ability to share and help each other using all materials including vocabulary.					
6. *Purposeful interaction/ collaboration with peers* (Student exchanges ideas with others (teacher or peers), uses body language/ language/gesturing to convey ideas.)	1	2	3	4	5
Comment:5 **5:** They are so excited by the connections they see at home and around them that they shout out what they have seen and discovered. They are very eager to share with their peers and the adults their observations using language, gesturing, body language as well as drawings and demonstrations.					
7. Flexibility in Thinking as demonstrated by: ***Task-persistence* (Student tries new strategies, offers suggestions, seeks advice after initial teacher input)**	1	2	3	4	5
Comment:5 **5:** The students make connections to prior concept lessons and look for connections to the new one for the day. They can make changes in their thinking using vocabulary and/or manipulatives.					

8. Flexibility in Thinking as demonstrated by: *Positive response* ***to peer or adult suggestions*** **(Student shows in body language or conversation an appreciation of a new idea, interaction stimulates new thinking.)**	1	2	3	4	5
Comment:5 **5:** It is electric in the classroom. The students are discussing the concepts during science, literacy and discovery activities….throughout the **curriculum.**					
Any other comment: I have searched for a long time for professional development in teaching mathematics. While a day or two of lectures and demonstrations, or reading articles is beneficial THIS experience has been transformational. If this experience could be offered in the classroom by a Teacher Peer Tutor for at least a week, it could transform math teaching. It would change math into an exciting experience and increase children learning.					

Appendix S

Turnitin Report



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