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The Impact of Interdisciplinary Project Work on Student Engagement in Mathematics Learning

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THE IMPACT OF INTERDISCIPLINARY PROJECT WORK ON STUDENT ENGAGEMENT IN MATHEMATICS LEARNING

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CERTIFICATE OF APPROVAL

This is to certify that the Action Research Project of

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ABSTRACT

THE IMPACT OF INTERDISCIPLINARY PROJECT WORK ON STUDENT ENGAGEMENT IN MATHEMATICS LEARNING

KRISTIN SONQUIST

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Action Research Project

This study examines the impact of interdisciplinary project work on student engagement in mathematics learning. Students in a multiage first and second grade classroom participated in both interdisciplinary and traditional math work. Data were collected through observation, field notes and student work and were analyzed to determine whether student engagement improved during the interdisciplinary project work. Indicators of engagement were identified, and found to coincide with connection, a social context, active learning and challenge. Interdisciplinary project work was found to be likely to include those elements of engagement. Finally, embedded and standardized assessments indicated a strong correlation between interdisciplinary project work, engagement, and achievement in mathematics learning.

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CHAPTER 1

Introduction

It's math time in my multiage, first and second grade class in a popular "progressive" magnet school in a middle-class, Midwestern, urban neighborhood. I begin a "math meeting" with a game of "What time is it?" I spin the numbers on a teaching clock to show 4:30 and ask "What time is it?" The kids shout out "4:30!" or "5:30!" "How do you know?" is my reply. Someone recites the rule we have developed: When the big hand points straight down, it means you say "30;" "If the big hand is between two numbers you say the smaller number."

Many students respond, but I wonder again whether this is the best way. Our curriculum suggests this routine for first and second graders and we do it. As a teacher of 22 years and a mother of 36 years, I know that developmentally, telling time on an analog clock is too abstract for most first graders, and that most second graders are almost, but not quite ready for deep understanding of the process. Why are we doing an activity that amounts to learning a rule by rote, and has little relevance behind it, given the prevalence of the digital clock? When I give a written assessment to see how we are coming along with telling time, about half of the second graders and three fourths of the first graders circle the problems, indicating that they don't know what to do.

On a different day, I watch as my second grade student Jackson whips through page 72 of his math workbook. Our job is to use a "number string" protocol to solve the problems. Jackson just writes the answer and it is correct. "Go back and show me how you solved the problem." He verbally rattles off the answer. "It just came to me!" he says. My experiences with many students, lots of reading, and multiple math curricula tell me that he has achieved automaticity with equations to 20, and may not be able to explain his thinking. There are several ways to express your thinking correctly in the workbook, and flexible thinking is encouraged. But wow! This little guy is ready for some complex work, and is developing some unproductive habits from doing work that is too easy. He's racing through carelessly, finishing quickly, and then messing with his friends for something to do.

At the next table, Michelle stares at her work. She can't read it, and isn't sure what to do with it anyway. The number strings protocol has too many steps for her, and looks different than what she does in the resource room. She asks to use the bathroom and take a long, long time to come back.

I teach a strategy for solving a "peas and carrots" problem. "Jenny has 14 vegetables on her plate. Some are peas, some are carrots. How many of each might there be?" I look out at my students. Of the 28, four are on their backs looking at the ceiling, four are poking each other with unbent paper clips, and two are quietly tracing patterns in the carpet in polite disengagement. I feel like they are staying quiet until the adult is done talking. I bring the lesson to a close and put them to work. There is an immediate group around me. "What are we supposed to do again?" Jackson and Michelle and Mimi are walking quickly around a table, smiling, hands out. They are playing tag! The peas and carrots work is mixed. Some kids scribble big numbers on their sheets. Some draw careful diagrams with multiple circled drawings of peas and carrots in combinations. Others set up an information table, and quickly, systematically generate all possible answers, hoping that they'll be allowed to play with math games or build with math blocks when they are finished.

Importance of Mathematics Education

In 1989 there was a national call for reform in math teaching. After exhaustive study, the National Council of Teachers of Mathematics developed new standards for teaching math:

"Knowing mathematics means being able to use it in purposeful ways. To learn mathematics, students must be engaged in exploring, conjecturing, and thinking rather than only in rote learning of rules and procedures. Mathematics learning is not a spectator sport. When students construct personal knowledge derived from meaningful experiences they are much more likely to retain and use what they have learned. This fact underlies teachers' new role in providing experiences that help students make sense of mathematics, to view and use it as a tool for reasoning and problem solving." (NCTM, 1989 p. 5)

The NCTM math standards have been reviewed and revised since their debut, but the quest for engagement, meaningful experiences and the construction of personal knowledge has neither changed, nor been completely successful.

In a rapidly changing world, the need for mathematics understanding is critical, and is not being met. Doug Arnold, Director of the Institute for Mathematics and its Applications at the University of Minnesota, addressed graduates on the topic of importance, and the problem attached: "What makes the math sciences so central? As Galileo put it, 'The great book of nature can be read only by those who know the language in which it was written. And that language is mathematics.' Math is the way to understand all sorts of things in the world around us. But only about 1 in 100 undergraduate degrees in this country is given in math and statistics and only a small portion of the population has any facility with that mathematical language Galileo spoke about."

Current Levels of Mathematics Achievement

In my school, high levels of student achievement, measured by test scores and other means, are the norm. Yet math scores don't measure up, especially for students of color. Among third graders in 2010, 77.5% of all math students were in the "proficient" range on the

Minnesota Comprehensive Assessment (MCA). Two years later, among those same students as fifth graders 71% were proficient in math. It's painful to see this general downward trend, but the scores are still above the district average, until you look at the data for our African American students. In 2010, 23.3% of African American students were in the proficient range. As fifth graders, 21.4% of those students were proficient- another downward trend. The situation for eighth graders is about the same. In 2010, our proficiency rate for all eighth graders was 80.3%. For African American students in eighth grade, only 18.2% scored in the "proficient" range in mathematics on the MCA. (MPS Scorecard 2011-12)

Engagement and Interdisciplinary Activities

As a teacher of first and second graders, I lay the groundwork for the success or failure of all of my students, across the curriculum. With my teaching partner I create interdisciplinary units of study based on Dr. Ernest Boyer's "Human Commonalities." (Boyer, 1995, p.89) We weave science, social studies, literacy and the arts together, helping our students discover the connections that make our learning rich and meaningful. It's nearly always a satisfying way to teach and to learn.

The exception is during mathematics instruction. I scan the room during math time and see pencils flipping, hair twirling, and doodling; indicators that my students are engaged in something, but not in math learning. Other students rush through their work and announce, "I'm done- what's next!" before carefully checking their arithmetic or explaining their thinking. During reading, writing, science, art or social studies lessons and work periods, engagement is different. Students have developed personal interest in their work, believe in its relevance, and carry on independently while teachers work with small groups or individuals. During math lessons and work times, behaviors are different. It seems that the work is too hard, too easy, too shallow, too complex, too disconnected. Students disengage, become discouraged, and spend the time allotted for math on other pursuits.

We are required to work with a curriculum that doesn't accommodate a multi-aged classroom. Instruction is designed to be given in grade-alike groups. In a classroom where creating connections between subject areas in the norm, the lessons seem random compared to the rest of our work. With my teaching and learning partner, I have explored the *Investigations* curriculum, and found ways to change the order, find commonalities between first and second grade work, and teach most lessons to the whole class. We have created projects that attempt to connect our math work to the rest of our studies, but we are also required to use the *Investigations* curriculum with "fidelity," so that our students have a consistent background as they move from grade to grade.

Purpose of This Study

The purpose of this study was to look deeply at mathematics learning through the lens of engagement. The guiding questions I explored were:

1.When students are deeply engaged in math instruction, what was happening in the lesson?

2. How do interdisciplinary math activities affect student engagement in mathematics?

3. Will learning from interdisciplinary projects foster general mathematics understanding among the students involved?

My hope is that this study will benefit student engagement and achievement during mathematics learning time in my classroom, and will provide a source of information for teachers who are looking for ways to improve their own math instruction.

CHAPTER II

Review of the Literature

In this literature review, definitions of engagement and relevance in regard to teaching in general, and in mathematics teaching in particular are first discussed. Next, the role of disengagement, and the factors that might lead to students' disengagement with mathematics are explored. In addition, studies in which researchers created relevance and importance in mathematics classrooms are considered. Finally, interdisciplinary project work in mathematics with attention to connections between student engagement and interdisciplinary work are examined.

What is engagement?

According to researcher Phil Schlecty, engagement is the key to student learning. Students who are not engaged may learn, but with a superficial grasp of the content, or a low level of transfer from one situation to another. They may be "ritually compliant," retreat, or even rebel. He names 10 design qualities that lead to student engagement: content and substance, product focus, organization of knowledge, clear and compelling product standards, protection from adverse consequences for initial failures, affiliation, affirmation, choice, novelty and variety, and authenticity. (Schlechty, 2002, p.41)

When looking for a very practical definition, one that would help decide what student engagement looks like, sounds like and feels like, the definition from Morse, Christenson and Lehr, of the University of Minnesota, was helpful. They suggest a broader notion that includes students' self-identification as a member of the group and acceptance of school norms and rules. They note four aspects of engagement; academic, cognitive, behavioral and psychological. (Morse, Christensen & Lehr, 2004, p.69)

Educational researcher Robert Marzano characterizes the definition of "engagement" as controversial, and notes that …"a variety of constructs seem to overlap in meaning and use- specifically motivation, engagement, attention, interest, effort, enthusiasm, participation and involvement." (Marzano, 2011, p.17) He suggests that attention to engagement should be specific and consistent. Marzano's model includes classroom practices and lesson design that attends to emotions, interest, perceived importance and perceptions of efficacy. (Marzano, 2011, p.17)

In the National Research Council's publication *Helping Children Learn Mathematics,* the authors characterize "engagement" as an essential element in mathematics learning. Understanding mathematical concepts, computing accurately and efficiently, applying math knowledge to solve problems, and using reasoning to logically explain and justify math thinking must be entwined with engagement. This is defined as "seeing mathematics as sensible, useful, and doable-if you work at it- and being willing to do the work. " (Kilpatrick & Swafford, 2002, p.14) These five strands are interwoven and interdependent, rather than sequential.: "U.S. school mathematics today often assumes that children must master certain skills before they can understand the procedures and apply them- as if children cannot play a tune before they have mastered all the scales." (Kilpatrick & Swafford, 2002, p.17)

James Appleton and Frances Lawrenz gathered data from 159 teachers and 1,663 students in several states. Their study titled *Student and Teacher Perspectives Across Mathematics and Science Classrooms: The Importance of Engaging Contexts*, looked at whether student, teacher, and outside observer perspectives of engagement were different. Their questions addressed areas of student voice in learning, connections to other fields of study, and prior knowledge. Their data showed that the students' ideas of "real world /practical" knowledge differed from that of their teachers, and what appeared as engagement to teachers may have been merely compliance. The study concludes with the caution that it is important, when looking at student engagement with the goal to improve student achievement, to attend to student perspectives.

In her study *Student Engagement in Instructional Activity: Patterns in the Elementary, Middle and High School Years*, Helen M. Marks defines engagement as "a psychological process, specifically the attention, interest, investment, and effort students expend in the work of learning. Defined in this way, engagement implies both affective and behavioral participation in the learning experience." (Marks, 2009, p.155) She found that there were certain influences affecting engagement in school, including personal background, gender, orientation toward school based on previous school success, authenticity of the work, and social support for learning. The students' perception of authenticity of the work is of particular importance to this study, since it is the most under the control of the classroom teacher. She finds, "authentic instructional work contributes strongly to the engagement of all students. Tapping standards of intellectual quality- higher order thinking, depth of knowledge, substantive conversation, and connectedness to the world beyond the classroom- the salience of authentic work stands in contrast to alienating work….as sources of disengagement" (Marks, 2002, 173).

Disengagement

When studying student engagement in mathematics, it is useful to look at circumstances in which students become disengaged. What is it like when students are disengaged in mathematics? Disengagement from mathematics can be a deliberate, almost political choice. Socioeconomic status plays a large part in engagement with mathematics; sometimes students disengage because they are expected to by peers, family members, or inequitable institutional leaders.

Lisa Sanbanmotsu addressed the issue of students from lower socio-economic neighborhoods who have moved to schools with slightly higher achievement data. Although they refer to an MTO, or "Moving to Opportunity" program in several large cities, in each case, there was little evidence of improvement in math or reading scores, student behavior, or engagement in school. (Sanbanmotsu, 2007, p. 62) School engagement in the higher performing schools was not replicated by the students moving in. (Sanbanmotsu, 2007, p.64) There was little indication that a simple change in socioeconomic status would make a difference in student engagement.

In his study titled *Perhaps the Decision of Some Students Not to Engage in Learning Mathematics in School is Deliberate.*, Peter Sullivan and colleagues, refer to a study group of Australian Aboriginal students, who are the victims of a very polarized society. He refers to a "noticeable arrest in the progression of learning" (Sullivan, Tobias & McDonough, 2006, p.81) during the primary years. He refers to Carol Dweck's work on intelligence, and her thesis that perceptions of intelligence cause students to focus (or not focus) on learning goals. Looking at Dweck's work, Sullivan collected data in four schools. (Sullivan, 2006, p.85) In the end, the researchers were surprised to find out that all students persevered in all tasks, even when the task was perceived as too difficult. What affected achievement and engagement was peer–pressure. The aboriginal students were under pressure from friends *not* to achieve in school.

Disengagement is also sometimes a predictable result of ineffective teaching methods. Victoria Hand of the University of Colorado at Boulder looked at how teachers and students co-create a culture of disengagement based on perception of ability. (Hand, 2010) She talks about perceptions of oppositional behaviors being based on students' personalities or predispositions. Oppositional behaviors are also associated with socioeconomic status. Her work indicates that the interactions in the math classroom, both teacher/student and student/student, actually cause disengagement. Hand refers to a perception that math learning is "culture- free," even though students bring their cultural norms to the mathematics classroom as well as any other. Social contexts lead to behavior norms that may not be deemed acceptable, and may lead to a false presumption of math incompetence. Hand talks about "polarized and flexible" participation structures. In the polarized model, there was a "high level of engagement among a very small number of students, and active resistance among others."(Hand, 2010, p.101)

Researcher David Sousa, in his book *How the Brain Learns Mathematics,* takes a neuro-scientific approach to the question of disengagement. He draws on recent research involving brain-scanning technology that reveals the cognitive processes behind learning mathematics. Sousa traces the change that characterizes math learning in young children: "Children often say, 'I can't do math!" But you never hear them say, "I can't do language!' Why the difference? One reason is that spoken language and number sense are survival skills: abstract mathematics is not. In elementary schools we present complicated notions and procedures to a brain that was first designed for survival in the African savanna. Human culture and society have changed a lot in the last 5,000 years, but the human brain has not. So how does the brain cope when faced with a task, such as multiplying a pair of two digit numbers, for which it was not prepared? (Sousa, 2008, p.1) He suggests that, although many early arithmetic tasks come naturally to children, the more abstract math learning can be frustrating to children and adults:

"Despite years of practice, most people have great difficulty with the multiplication tables. Ordinary adults of average intelligence make mistakes about 10 percent of the time…Why do we have such difficulty? Several factors contribute to our troubles with numbers. They include associative memory, pattern recognition, and language. Oddly enough, these are three of the most powerful and useful features of the human brain." (Sousa, 2008, p. 40)

When disengagement occurs, Sousa concludes, the isolated, abstract tasks are presented in a way that does not leverage the powers of the human brain.

Relevance

An important factor in student engagement is a sense of relevance. Do students believe that the lessons, activities, or information are important to them? In *The Quality School Teacher*, William Glasser (1993) characterizes relevance as essential to creating a quality school, as well as a key to management. He suggests that information taught should always be related to a life skill; those skills that are taught should be practical and needed frequently. The teacher should also listen for, and take advantage of students' expressed desires for their own learning. Lessons, activities, and whole units of study can be created in response to the interests of the student. The teacher's own belief in the usefulness of information is also an important factor. If the teacher can communicate the value of some learning, it is likely that the students will agree it is valuable. The passion that a teacher brings to a subject is a predictor of the engagement of the student. Finally, special information that will be helpful for a specific purpose, like passing a test or getting into college, is useful in a different way. Teachers can create relevance by honestly characterizing the usefulness of certain kinds of vocabulary work, or specialized knowledge.

Both Robert Marzano and John Dewey echo the call for relevance in education. Marzano differentiates between "attention" and "engagement," the first being a shorter term phenomenon, 'Engagement" lasts beyond a class period; the student develops a longer- term interest in the subject that carries over to future learning and becomes part of life experience "Attention" is an important step toward achieving engagement. Marzano suggests that four questions, "How do I feel?" "Am I interested?" "Is this important?" And "Can I do this?" provide a framework for developing a highly engaging classroom. The second and third questions are related to relevance. If students do not believe the material offered is important to them, they will not be engaged in learning. Dewey, in his pioneering work *Democracy in Education*, discusses the differences between early education, in which children observe and practice the habits of their elders, and formal education. Dewey believed that formal education was necessary for the transmission of all kinds of knowledge, and for sharing of experiences not available to young people, but that there should not be a major difference in the way students were expected to learn. Learning through authentic, practical experience was most effective both in and out of school. The danger was that formal education, "easily becomes remote and dead- abstract and bookish." (Dewey, 1915, p.9) Dewey's extensive, long-term research was an important part of the constructivist, progressive movement, which emphasizes relevance, experience, and the individual construction of knowledge and meaning.

Daniel Sousa also talks about the importance of relevance as the brain decides which information to house in long-term memory. He says that information that has survival value, and an emotional impact, is stored most rapidly in the brain. (Sousa, 2008, p.55) The emotional "hook" that can be provided by interdisciplinary math work has brain-based advantage to learning, as does provision of context and acquisition of prior learning. Personal choice also has a place in determining relevance, and therefore a spot for math learning in long-term memory storage: "The question to ask is, 'Does it have meaning?' This question refers to whether the item is relevant to the learner. For what purpose should the learner remember it? Meaning is a very personal thing and is greatly influenced by an individual's experiences." (Sousa, 2008, p.55) Finally, children need to predict that they are "able to use that knowledge in a variety of different settings that students see as relevant." (Sousa, 2008, p.55)

Educator Linda Crawford suggests that the arts in particular can provide relevance and engagement for elementary students. "The arts offer multiple, effective ways to explore and understand concepts, master content, memorize facts, solve problems, and express important thoughts and deep feelings about the world. They make facts and figures lively and help the abstract take on shape and color. Children are likely to remember and use what they have learned with such zest." (Crawford, 2004, p. 2)

Creating Relevance and Importance in the Classroom

Studies of classrooms in which a sense of relevance and importance were achieved through careful and thoughtful "project work" can give examples of student engagement. Perham and Perham describe a high school math club's study that centered on current events on Mars. Students used Johannes Kepler's method of astrological study, record keeping and data analysis to make a new study based on data from the Jet Propulsion Laboratory. In doing so, they appreciated Kepler's process and effort, and gained mathematical insight as well. This led to further in-school learning, in which "the mathematical richness of the math club topic as well as the enthusiasm of the students led to the creation of a geometry unit. " (Perham & Perham, 2011, p.344) In this case the importance of the students' voluntary work let to changes in math curriculum for the school.

William Bintz and Sara Delano Moore describe how a team of teachers used children's literature pieces to present different math concepts to students in second and fourth grade, in an attempt to increase engagement and achievement. The school had suffered falling test scores on high-stakes achievement tests, and was looking for ways to improve "rigor" and student engagement. When teachers and students were interviewed about the preference and success of each lesson separately, teachers preferred the lessons with "practice" rather that "problem solving." They liked to see a direct correlation between what was in the story and what was on the test. Students, on the other hand, preferred the more complex stories, because of they could "do more stuff" with the numbers- they were personally involved and had a stake in the success of the activities that followed the stories. "Rigor happens with meaningful inquiry. Practice is not rigor because it does not include inquiry. Inquiry helps students to be more rigorous problem solvers." (Bintz & Moore, 2010, p.295) In this case, teacher preference for a clear-cut, targeted lesson directly tied to assessments actually interfered with engagement and rigor.

Kerri Embrey and Mary Murray describe a pre-K class in which students were engaged in a collaborative building project. Students constructed an elaborate, cardboard, two- story dollhouse. The inquiry based-project suggested curriculum that grew from the students' own interests and "prompted the children to work with and develop sophisticated geometric concepts." Teachers supported the students learning by providing suitable materials, and playing games to assess knowledge about the properties of the shapes. Sharing constructions gave students a forum for discussion of construction strategies and peer collaboration. A carefully constructed experience that included a cycle of expert input, student work time and student sharing created a mathematics experience that was meaningful, authentic, and grounded in the students' interests and enthusiasms. Students brought their own experiences, questions and concerns to sharing sessions at the end of each work period. Since the students in the class created a product that emerged from their own interests they maintained their sense of ownership, and "sustained their attention and commitment. " (Embrey & Murray, 2010, p.284)

Adam Kalman describes another kind of relevant, compelling math problem in his case study *Fixing Ganache: Another Real-Life Use for Algebra.* His students were motivated to work complex algebraic equations to solve a practical problem: how much chocolate should he add to repair some failed ganache and produce a palatable chocolate truffle? Even without the physical presence of the chocolate, Kalman's students gained "motivation and appreciation for studying proportions and equation-solving." (Kalman, 2011, p. 419) This kind of relevance, (which did result in repaired truffles and were shared with the students the next day) enhanced student engagement and created an atmosphere of perseverance among students.

Interdisciplinary Project Work

Teachers can create opportunities for students to find relevant, engaging "math" work in contexts that are not isolated as mathematical. This is known as thematic teaching, integrated teaching, or interdisciplinary teaching. Heidi Hayes Jacobs defines interdisciplinary learning as "a knowledge view and curriculum approach that consciously applied methodology and language from more than one discipline to examine a central theme, issue, problem, topic, or experience." (Jacobs,1989, p.4-5) Dr. Ernest Boyer, in his role as president of the Carnegie Foundation for the Advancement of Teaching, surveyed 350 teachers in each of 12 countries as part of the International Schooling Project. When asked, "which is closer to your view of how to present the curriculum most effectively?" 89% of the teachers answered "integrate subjects," and 11% "teach each subject separately." (Boyer, 1995, p.92) He talks about the nature of elementary education: "Students study the separate subjects. They pick up isolated facts, but what they fail to gain is a coherent view of knowledge and a more integrated, more authentic, view of life. An educational approach that lacks unity will not touch the child's deepest self nor stir within each student a heightened appreciation of the mystery and majesty of the world. Further, studies on the workings of the human mind reveal that learning, at its best, is an integrative function." (Boyer, 1995, p.91)

Boyer goes on to propose a new way to think about "curriculum with coherence, one that moves beyond the separate subjects, helps students see relationships and patterns and apply learning thoughtfully to their own lives." (Boyer, 1995, p.92) He suggests that traditional subjects be rearranged and integrated into "core commonalities." "By 'core commonalities' we mean those universal experiences that are shared by all people, the essential conditions of human existence that give meaning to our lives. These include: *The Life Cycle, The Use of Symbols, Membership in Groups, A Sense of Time and Space, Response to the Aesthetic, Connections to Nature, Producing and Consuming*, and *Living with Purpose*. Within these eight themes, every traditional subject can, we believe, find a home. (Boyer, 1995, p.93)

David's Sousa's research into the neuro-scientific aspects of mathematics study has implications for interdisciplinary learning as well. "Rote rehearsal is used when the learner needs to remember and store information exactly as it is entered into working memory…We use rote rehearsal to remember a poem, the lyrics and melody of a song, telephone numbers, steps in a procedure, and the multiplication tables. Elaborative rehearsal is used when it is not necessary to store information exactly as learned but when it is more important to associate the new learnings with prior learnings to detect relationships. This is a more complex thinking process in that the learner reprocesses the information several times to make connections to previous learnings and assign meaning. Students use rote rehearsal to memorize mathematical facts, but elaborative rehearsal to probe the deeper meanings and interrelationships of mathematical concepts. When students get very little time for, or training in, elaborative rehearsal, they resort more frequently to rote rehearsal for nearly all processing. Consequently, they fail to make the associations or discover the relationships that only elaborative rehearsal can provide." (Sousa, 2008, p.53)

In an example of a simple way mathematics learning can happen in context, Marja van den Heuvel-Panhuizen and Sylvia van den Boogaard did a case study looking at the effect of picture books on kindergarteners' mathematical thinking. They chose a book that was not overtly math- related, and looked at how students' talk about the book reflected mathematical understanding even when not prompted in this direction by the teacher. They concluded that mathematical thinking did indeed evolve. In fact, "…we found that without any prompting by the reader, half the utterances were mathematics related and that all the four children in this study contributed to this result." (van den Heuvel-Panhuizen & van den Boogaard, 2008, 367)

Kathy Hoppe describes a summer program in which the goal was to "provide students with an engaging program and an environment where they will not only have the greatest opportunity for success in summer school, but also become engaged in content with which they had previously struggled." (Hoppe, 2010, p.56) Authentic problems involving skateboarding, parasailing, weather, rocketry, etc, were systematically posed encased in a growing narrative. As students were exposed to more of the stories, they were required to apply mathematical strategies, explain thinking and demonstrate their understanding. The students who passed using the engaging curriculum more than doubled the amount of students who succeeded with the traditional curriculum.

Daniel Belensky and Timothy Nokes looked at whether the type of materials used with math students affected their learning and engagement. They refer to the goal of math instruction as "…the development of adaptive expertise." In other words, can students use their learning in areas other than the current lesson? Can they generalize the skills and knowledge? Belensky and Nokes looked at different learning materials, concrete and abstract, and with learning prompts that were both problem-focused and "metacognitive." (Belensky and Nokes, 2009, p.104) An interesting conclusion was that compelling context with relevance to students was important to engagement. It's better to teach fractions, for example, with pie pieces instead of tiles, because "the pie pieces embody the fraction concept better, and highlight the nature of the part-whole relationship." (Belensky and Nokes, 2009, p.106)

As a cautionary note, Andreas and Gabriel J. Stylianides, connect low achievement and engagement when they address the dangerous side of embedding mathematical tasks into real-life contexts. They note that it is possible to implement math in a real-life context with "low fidelity." They provide a framework for determining whether the math is adequately "exploited" as a part of a task. They caution that even with a well-respected curriculum as a basis, a teacher's attempt to make mathematics more enjoyable or engaging may actually subvert the mathematical knowledge. (Styliainides & Styllainides, 2008, p.871) Certain aspects of the task, including discourse and follow up activities, can't be sacrificed in favor of a fun and engaging activity.

The review of literature suggested direction for the interventions that are described in the chapter on methodology that follows.

CHAPTER III

Methodology

This study explored the impact of interdisciplinary project work on the engagement of first and second grade students during mathematics learning time. Much of the research on mathematics instruction in elementary school explores the effectiveness of various instructional methods. This study centered on the students' engagement in mathematics instruction, and whether certain experiences were more likely to foster student engagement. After a review of literature, it was determined that the students' perceptions of relevance, importance, and personal connection to the mathematics activity were of particular importance when designing learning experiences that would engage student learning. Several interdisciplinary projects that included mathematical learning targets were delivered to students, and the presence of indicators of student engagement were noted. Student work was examined to see if the mathematical learning targets had been reached. Finally, collected data was examined to discover themes that would inform future curricular decision-making.

In this section, the participants and setting of the research were described, as well as the interventions employed during the study, the data collection process, and the procedures used to analyze the data.

Participants and Setting

The study was conducted in a multiage first/second grade classroom as a part of the regular school day. Students spent two years in the classroom, as part of the progressive or "open" philosophy of the school. The class was made up of 28 children. Of these, 19 students were white, and nine were students of color. There were 12 girls and 16 boys, 13 first graders, and 15 second graders. Five received free or reduced lunch, there were three English Language

Learners (ELL) and four students with Individualized Education Plans (IEP) who received special education services. All 28 students in my class were invited to be part of the study. The sample, therefore, was heterogeneous, and not criterion based. Of these, 21 families agreed to have their children participate. (Appendix A) Of the 21 participants, six were first grade boys, three first grade girls, eight were second grade boys, and four second grade girls. 18 of the 21 students in the study were white and three students of color. All students in the class, regardless of their participation in the study, were part of the interdisciplinary "intervention" lessons, but data were collected only from students who were part of the study. Because it may be helpful to have an idea of the students involved in the study, a brief description of each participant follows. In light of the small size of the group, information about ethnicity and special education services was left out of the descriptions. A pseudonym was given to each participant.

Peter was a first grade boy who loved math games and puzzles and played them at home. He found math at school too easy, but finished work was often incomplete or messy. Peter frequently "tuned out" during whole group lessons.

Thomas was a second grade boy who thought of math as "his thing," but struggled with the reading required to do math; therefore, assignments were often incomplete or incorrect.

Kendra was a second grade girl with "perfectionist" habits; Kendra was reluctant to begin working, and checked in for adult approval frequently. She found math work stressful if the learning was unfamiliar or new.

Janie was a second grade girl whose number sense was well developed. She understood everything presented, right away. She was a perfectionist who worried about running out of work to do. "What's next" was her catch- phrase, and her work was usually already neat, complete, and well documented. She said she needed more challenge.

Kellen was a second grade boy who was working hard at learning to read, so sometimes missed the point in math. With individual help and a quiet place to work, Kellen did well. He did not see patterns easily.

Jackson was a super-active, strong-willed first grade boy with sensory integration issues. He understood math concepts quickly, but had a hard time articulating his thoughts in writing, or showing his work in math.

Stephanie was a first grade girl who learned to read early, but was reluctant to take risks in math. Math time was stressful for her.

Billy was a first grade boy who was so anxious to be older that he forgot to do his work. He did not enjoy math work and said it was too easy, but it was really too hard.

Aaron was a first grade boy who worked at home to improve his skills but often jumped from start to finish without working through the middle of a problem.

Joseph was a first grade boy who loved math, enjoyed working with data, and saw patterns in money easily. He was anxious to start doing "hard work."

Tim was a second grade boy who needed more confidence. Tim had a hard time with math work.

Toby was a very bright second grade boy who needed lots more challenge. He had a hard time paying attention in school, and didn't like school very much.

Amy was a first grade girl, cheerfully tried to do everything, loves to help, made her own math worksheets at home.

Margaret was a second grade girl, who was one of the first show in a physical way that she was tired of a lesson. She flopped to the floor and rolled around when her attention was lost. She was comfortable with math.

Brendan was a second grade boy who struggled with writing, so the precision of math was difficult. He preferred to work with his hands, and had some issues with directionality, but when allowed to talk through problems, did well.

Michael was a second grade boy who was an early reader, worked slowly and methodically, saw patterns in numbers easily, and was able to talk about them. Michael needed challenge to stay on task.

Rose was a second grade girl who was slow to learn to read, but made good progress during her second grade year. She lacked perseverance with math work, but was able to ask for help.

Julian was a second grade boy who preferred drawing and fantasy play to math work. He was liable to tune out or become "goofy." He was resistant to math work.

Victor was a first grade boy who liked to do things his own way, didn't like to be rushed or to ask for help, even though math work was a struggle for him.

Heidi was a first grade girl with careful habits. She loved to count and save money, was interested in sewing, knitting, and other handcrafts. She struggled with reading and writing, especially with reversals in letters and numbers.

Isaac was second grade boy who was brimming with confidence, and believed he knew everything. He goofed around when under-challenged, and said math was "amazing!"

The study took place at "Juliet Lowe Open School," a public "magnet" school that served about 750 students in grades K-8. The school was located on the edge of an upper-middle class neighborhood in a large midwestern city, but drew from a wider area because of its magnet status. Although the building itself opened in the early 1900s, the "open" magnet program had been in existence since the early 1970s. During that time, several educational choices, including open, fundamental, language immersion, arts integration, environmental and math and science magnet schools were started as an effort toward desegregation and retention of families who were engaging in "white flight" from core city neighborhoods. By the early 1990s there were 9 "open" magnet schools in the city, including 3 high school programs. As trends shifted toward standardization, many magnet schools were closed or replaced by traditional neighborhood schools. At the time of the study, Juliet Lowe Open was one of two K-8 "open" schools remaining in the city. It was characterized by a yearly waiting list and high stability among students and staff.

As an "open" magnet school, "Juliet Lowe's" special mission was to have multiage classrooms where strong connections between students, teachers and families were nurtured, and coherent, connected, student-centered curriculum was encouraged. All members of the community, including staff, were addressed by their first names. District- approved curriculum was provided, but a high level of teacher engagement in decision-making about that curriculum was expected and encouraged.

The study took place in the classroom, located on the sunny south side of the building, which was equipped with tables for student use, and open shelves for an extensive library of both books and math learning materials. Students gathered for lessons on the carpet, and were allowed to choose to work at tables or on the floor. Two classes sometimes joined for special projects. Small groups often met in communal hallways. These circumstances were typical of "open" school practice.

IRB approval was sought and permission granted for the purpose of conducting this study with elementary aged students and given IRB approval number 2011-2-1. The special permission of the school district's research and evaluation committee was also sought and granted as a part of the IRB process.

Materials

The purpose of this study was to look at the impact of interdisciplinary project work on student engagement during mathematics learning. The study spanned two interdisciplinary units of study, each eight weeks long. During an interdisciplinary unit of study, students participated in lessons and activities that were designed around a theme with science, social studies, art and literacy goals addressed together. Typically, mathematics instruction was not included as part of interdisciplinary work, but was taught in grade-alike groups following the district-approved *Investigations* curriculum.

For this study, a series of lessons and activities were designed to meet mathematics goals and connected with our interdisciplinary work. Based on a review of the literature, activities were chosen that provided opportunities for active, hands-on learning, were of personal importance to the students, and provided practice in skills that would connect to the state standards in mathematics. The *Investigations* curriculum was implemented as well, with approximately equal time spent on interdisciplinary and traditional work. After the lessons were taught and the skills acquired by the students, they were encouraged to practice their new learning during a "math choice time," which lasted one half hour per day and preceded our formal mathematics instruction.

The units of study were based on Dr. Ernest Boyer's concept of "human commonalities" as outlined in *The Basic School (1995)*. (Appendix B) His idea was that there were eight areas of knowledge that should form a coherent core curriculum in elementary schools. The two areas, or commonalities, addressed during this study were "Response to the Aesthetic," with a unit called

Express Yourself, and "Connection to Nature," with a unit called *Eyes to the Sky*. During *Express Yourself,* students learned about ways that people around the world respond to their environments and cultures through art. During *Eyes to the Sky*, students learned about weather, planets, constellations, and birds; all of the elements of nature that occur "above the ground."

In order to explore the impact of interdisciplinary project work on student engagement in mathematics, students were presented with five extended, interdisciplinary projects during math learning time. These were alternated with lessons from the *Investigations* curriculum and each day preceded by a math choice period. (Appendix C) A brief summary of the lessons presented follows:

Sewing- While learning about patterns found in quilts, students studied pattern, measurement and geometry by sewing a pincushion, a nine-patch quilt block, and projects of their choice. (*Express Yourself*)

Balance and Motion- Students created mobiles, balancing toys, spinners and tops. Students explored the science of balance applying weights and counterweights. They also discovered how objects move through space. They used mathematics to compile data and to gain understanding of number concepts. (*Express Yourself*)

Origami- Students learned the complex process of folding origami cranes while immersed in the story of *Sadako and the 1000 cranes* by Eleanor Coerr. Math concepts highlighted included geometry, algebra, pattern, measurement, and number sense, especially place value. (*Express Yourself*)

Data Party- Students practiced gathering, organizing, compiling and presenting data about their classmates during an extended series of experiences involving two classes. (*Eyes to the Sky*)

Weather Stories- As students learned about weather and climate, they created and solved their own story problems that had weather as the context. (*Eyes to the Sky*)

Although the attainment of math learning was important, indicators of student engagement were the focus of this study. Careful observation, field notes, and student work formed the structure for measuring indicators of student engagement.

Procedures

In this study, data were collected regularly over a period of three months, using the method described by Leedy as the "descriptive survey. " The descriptive survey method "looks with intense accuracy at the phenomena of the moment and then describes precisely what the researcher sees…" (Leedy, 1993, p.185) In this case, students were observed during periods of math instruction, described exactly, and noted especially when indicators of engagement were present or absent. Three methods were used to collect data. At times, it was appropriate to make observations as an "active, participant observer," as described by Mills. (Mills, 2011, p.75) Video-recordings were sometimes made of students during math lessons and work periods. Student responses were also recorded during "math conferences," which were informal, ethnographic interviews (Mills, 2011, p.79) during which students were asked to "think aloud" about their math learning. (Appendix D). Video recordings were carefully transcribed, and observer comments and memos were added to the transcripts. Secondly, the role of "passive observer," (Mills 2011, p.75) was taken. The teacher watched lessons and student work periods when a student teacher or other colleague was in charge of instruction. At this time, field notes were taken and observer comments added on the spot. Although the field notes were rich descriptions of all that was happening, the observer comments focused on "bumps" or paradoxes connected with student engagement. (Mills, 2011, p. 77) Finally, student work produced during math periods was examined with special attention given to indications that student engagement had led to the mathematics learning required by the school district and state standards. Student work included daily work produced, informal "conferences" included as part of field notes, and end-of-unit tests recommended by the school district.

Data Analysis

Data was analyzed with the purpose of identification or development of a theory of student engagement during math instruction based on observations of student experience with both the *Investigations* curriculum and interdisciplinary math projects. Glasser and Strauss described grounded theory as "the discovery of theory from data." (1967, p. 1) As field notes and video recordings were sifted and resifted, themes relating to a theory of student engagement emerged. (Mills, 2011, p.129) First, all video recordings and field notes were carefully transcribed into document form, adding a letter code to differentiate each separate entry, resulting in 24 documents. Then, transcribed notes were read to get an overall impression. On a third reading, observer comments were added to the video transcripts, and memos to all of the documents.

After the three readings, emergent themes were noticed in the data. The expanded field notes were examined again, this time noting those themes in the margins of each document. A list of emergent themes was compiled, indicating which had appeared in each document, providing a visual indication of which themes appeared over and over.

Anecdotes and quotes that were illustrative of the emergent theory of student engagement during mathematics instruction were identified in the transcripts. Students' end-of-unit assessments were given according to school district policy. These assessments were helpful in determining whether students had met math-related learning goals during the period of the study.

Recognizing that personal impressions, experiences, and biases are part of the development of a theory of student engagement, (Cole and Knowles, 2000) the findings were compiled to form the next chapter.

CHAPTER IV

Findings

The purpose of this study was to look deeply at mathematics leaerning through the lens of engagement. The guiding questions explored were:

1. When students are deeply engaged in math learning, what was happening in the lesson?
2. How do interdisciplinary math activities affect student engagement in mathematics?
3. Does learning from interdisciplinary projects foster generalized mathematics understanding among the students involved?

This chapter will discuss findings related to each of the guiding questions, including themes that emerged during the process of data analysis. The first section reveals indicators of engagement and disengagement that emerged from the data and outlines four elements that were consistently present during periods of high student engagement. These elements became themes that were helpful in developing a theory of student engagement during mathematics learning. The second section discusses findings from data gleaned from each of the five interventions, or interdisciplinary math projects. The final section of this chapter addresses the question of mathematics understanding among the participants in the study. It looks at whether student's understanding of mathematics concepts improved during the period of the interventions.

Student Engagement in Math Learning

To begin the process of developing a theory of student engagement, it was first important to ask, "when students were deeply engaged in math learning what was happening in the lesson?" Each set of notes had a story to tell; what the students did, said and felt during each lesson were noted as indicators of engagement and disengagement. (Table 1)

Table 1. Indicators of Engagement and Disengagement.

Indicators of Engagement			Indicators of Disengagement		
Looks Like	Sounds Like	Feels Like	Looks Like	Sounds Like	Feels Like
*Eye contact *Leaning forward *Smiling *Working *Independence *Collaboration *Making/doing *Hands raised *Good work *Sustained *On task	*Quiet *A " buzz" *Math talk *Soft laughter *Focused Questions *Directions brief	*Productive *Peaceful *Happy *Challenging *Fun *Active *Fruitful	*Playing with tools *Eyes down *Rolling *Playing with hair *Twisting hair *Picking nails *Drinks *Bathroom *Uncontrolled movement *Pinching/Poking *Off task	*Noisy * Talking out of turn *Whispering *Pencils drumming *Whining *Rising noise levels *Crying	*Frustrating *Chaotic *Off-task *Unproductive *Anxious *Unsafe *Fruitless *painful

Next, field notes were examined to determine the lesson elements that were present at the same time as indicators of engagement or disengagement. Eventually, repeated sifting of the data with these indicators in mind revealed four specific elements that were consistently present during times of high student engagement. These four elements, connection, social context, active learning and challenge, became recurrent themes of engagement during math learning. Each theme was examined in detail, and illustrated with examples from the field notes.

Connection

Students seemed to be more engaged in math learning when they felt some kind of connection to the lesson. Students connected with their learning in several ways. Indicators of engagement were higher when students felt that the lesson was not random, or "the next one in the book," but that they had some reason to feel that the lesson or activity was personally important to learn. As the data were sorted and sifted, four specific kinds of connection emerged as important to student engagement. These were learning, options, value, and ego.

Table 2. Comparison of Interdisciplinary and Traditional Lessons and Engagement

	Four Themes Present in Engaged Learning				
Lesson T=traditional I= Interdisc.	Connections: Learning Options Value Ego	Social context	Active	Challenge	Engagement
Sew a mouse-T	LV	yes	yes	yes	high
Measuring, Fractions-I	none	yes	yes	no	low
Balance & Motion-I	LV	yes	yes	yes	high
Knitting-I	LOV	yes	yes	yes	high
1st Crane-I	LV	yes	yes	yes	high
Stickers-T	E	yes	no	some	medium
Clock-T	none	no	no	no	low
Worksheet-T	none	no	no	some	medium
Questions-I	LOVE	yes	yes	yes	high
Data Party-I	LOVE	yes	yes	yes	high
Choices-I	LOVE	yes	yes	yes	high
Odd/Even-T	none	yes	yes	some	low
Choices 2-I	LOVE	yes	yes	yes	high
Facts-T	none	no	yes	yes	high
PSstrategy-T	none	no	no	no	low
Weather ps-I	LOVE	yes	yes	yes	high
Choice 3-I	LOVE	yes	yes	yes	high

Learning

Students were more engaged in lessons and activities that were connected to other learning. When the math lessons were purposefully and carefully connected to the interdisciplinary unit of study, indicators of student engagement were uniformly high. (Table 2) Excerpts from field notes provide examples of contrast in engagement between traditional and interdisciplinary lessons. In a traditional lesson on identifying key words to note when solving a story problem, students were disengaged: "The whispering, flopping, tickling starts. Brendan hangs his head down and bangs it on the carpet. Jackson retreats to the table and plays loudly with markers. Kids ask for drinks and bathroom: Jackson, Billy and Joseph shout out answers twice and gets two breaks. Joseph comes back and pinches Kellen. Nine students are simply not attending. Instead they look at the carpet." Next, students were assigned to complete sections in their workbooks. Several students had questions about the task, several hung back and some were anxious about their next activity. At the end of the work time, students gathered to discuss their findings. A similarly off-task scene ensued.

The next day, the teacher presented another lesson with the same learning goals. This time the teacher had written problems about the weather, connecting to the thematic unit *Eyes to the Sky*, instead of using the workbook. When the teacher introduced the activity, students were off task: "Aaron is rolling on the floor. Peter is on knees looking at Jackson's fancy watch. Tim and Aaron are playing a hand game. Rose is chatting with Joseph…"

However, when the students were set to work on their task, engagement changed. Students noticed that their work was related to the morning's lesson about fictional weather disasters, and excitedly read the problems aloud:

Billy-" the mayor of the town "Floodsalot" measured the river and found that it was 7 inches higher than normal. "

Julian- "Tape! Tape! Get some tape! (like a carnival barker.)

The teacher notes: "Julian gets the tape. Heidi and a friend have their heads together. Kellen and Margaret are working together. I look for kids who are not working and can't find any…it is fun to see the problems being tackled with vigor."

During both lessons, when students were gathered together to find out what to do, indicators of disengagement were high. During the work time for the traditional lesson, students remained disengaged. The second day, when the teacher had written special problems with dangerous weather as a context, engagement during work time was universal and sustained.

Options

When students were allowed to choose a math activity from several options, there was a high level of engagement (Table 2). Having ownership over work assignments seemed to create a special kind of connection. Students were focused and happy to get right to work: when offered options, they selected activities based on their perception of how much fun they would have doing it. Toby, an advanced second grade boy who often avoided work and professed a dislike of school in general, explained why he chose to learn to fold an origami peace crane, a complex model involving 27 steps: "Well, I just, I just think it's just really fun, cause, I don't really know why, there's not really a reason that makes it fun, but I think it's just fun. It's just fun."

A "quiet math choice time" was instituted in the period after lunch and before the formal math lessons started. During this time, students could choose from a variety of practice worksheets, their *Investigations* workbook, and several math projects that involved handwork, (knitting, weaving, sewing, origami, etc.) Of 27 students present during one choice time observation, 26 were on task, engaged in their work: "There is a little quiet talk to show work, but mostly, everyone is doing their own thing. My lowest kids are working and my highest kids are working. My antsiest kids are working."

Another kind of math choice was offered in a series of lessons on data collection and interpretation. Students worked in groups to decide on a question that they would ask of classmates. They also had a choice of data collection methods; tallying response or writing each response on a student list as well as choice of partner and question. Although the task was complex and required movement and talk, there were no indicators of disengagement during this task. Laughter and loud voices, and expressions of surprise were noted; however, it was also noted that conversations were confined to the math task at hand, and the noisy environment, this time, did not lead to disengagement. No signs of stress or anxiety were noted; in fact, the climate was "peaceful and festive." Having the chance to collect data with authentic options for learning helped students connect with their math task, and work through possible distractions and stressors.

Value

The third way students had of connecting to their math activity was through its value, relevance or importance to them. Would they need the skill for future work? Did they find the project motivating enough to take a risk with something difficult? Did they feel the learning was important? During one traditional problem- solving lesson, a handful of students were obviously disengaged. "Michael and Isaac are whispering in animated conversation centered around something tiny in Michael's hand. Peter is now rocking back and forth. Tim is now engaging his friend, and wiggling around, softly singing 'ba, ba, ba, ba ,ba ,ba, ba.' Rose lavishly rolls her eyes at Julian, who is holding one foot and rocking back hard. Jackson has a highlighter open and is painting a friend's fingernails. Michael and a friend are whispering, and the friend is trying to get everyone engaged in something. The teacher has done a nice job of summing up the lesson, but most kids were just waiting her out." Indicators of disengagement dominated the lesson, and had a negative affect on the classroom climate.

In contrast was an interdisciplinary lesson on how to sew a mouse-shaped pincushion from felt. It was a complex process that involved shapes, pattern, measuring and sewing. The lesson took about ten minutes of "teacher talk." Students were fully engaged during the demonstration of the process, which was given by the teacher, and took about ten minutes. After the demonstration, during which all indicators of engagement were present, the following exchange took place:

Teacher- "What math will we need to make our mouse?"

"One after another, students volunteered everything- from the obscure shape-name "vessica," to line of symmetry, a yard plus six inches of thread, doubling the thread, congruent halves, ¼ inch from the edge, the pattern, (up like a rocket, down like a submarine) 4 pinches of fluff, four stitches to finish. The teacher went through the threading, knotting, and sewing, and then had a couple kids sew up and down on the demonstration mouse. "

Although the task was complex, and required self-control, a step by step processing and lots of problem solving, engagement during the work period remained high. The students were anxious to be sewing and making a mouse of their own. They lacked the knowledge needed and it was important to them to have it. Their engagement, as seen in the quiet room, careful attention to detail, and the math talk at the end was quite different from the engagement during the traditional problem-solving lesson. They could see why they should pay attention to the mouse lesson. They were not so sure about the importance of solving an imaginary problem.

Lessons with a game at its center were also of value to students and created a similar climate of engagement. When playing a "categorizing" game called "picnic basket, " universal engagement seemed never-ending, even though the game required quiet, listening, deep thinking, taking turns and remaining seated. "The whole group is arranged at the feet of the teacher…'I'm going on a picnic and in my basket there is Aaron, Toby, and Janie'...students lean forward, raising hands, "ooh!" grunting and groaning. This is our third day playing the game and they are into it. The teacher's voice is quiet and her face animated. Yes, no, no, no, yes. Soon, someone is allowed to guess the rule. And gets it. 'Students who are wearing white.' Triumph! All 26 are fully present, engaged, straining forward in excitement." The value students placed on success with the game helped them connect to the math activity while they were connecting with one another.

Ego

Engagement spiked when students, literally, saw themselves in an activity. Problems rewritten to include students' names were more engaging than similar work taken straight from the curriculum. Lessons that allowed students to share personal objects while demonstrating math learning were similarly engaging. Following is an excerpt from field notes that illustrates what is meant by "personal connection."

"Recess is over, tables are washed, lunches unpacked; there is a soft clamor of first and second graders taking their first bites. Our routine calls for table three to start the sharing. The topic is shapes. Stephanie has brought a blanket to share. 'The shape is a rectangle. She is very special to me. Her anniversary with me is December 25. Her name is Pinkie. She has some flowers in the corner that makes it special. I am ready for questions and comments.' Hands quietly went up. Questions about the history, shapes and importance of the quilt sustained for several minutes. "

In another example. Jackson was a first grader with special needs relating to attention, sensory processing, and fine motor skills. He was highly competent with math thinking, but usually avoided work that required him to write or draw, and was chronically disengaged during teacher-directed learning. He told about his work with a fill-in-the-blank story problem he created using a worksheet:

Jackson: "This one I did yesterday. It says 'I went shopping with my sister Carol and we went to z-mart. And our mother looked for boys while we looked for candy. My sister bought forty-four salad flavored gummy gum-drops. I got the candy flavored ones. In fact, I bought forty-four of them. My mother said we have to use our own money. I spended 1000 dollars in all. I think that was a pretty slimy deal.' (big grin) And this was 88."

Jackson's pleasure and focus was stemmed from his opportunity to create a problem that named himself and his best friend in class. His math thinking was correct. He was able to pick out relevant information and work with numbers that were beyond the usual scope of a first grader. He was persistent and patient with the work, and with the questioning that followed. His intended audience was his friend, who was special to him, but the connection to the problem sustained his engagement long past the time when he was working.

Even the recognition of a friend's name created engagement. During a traditional workbook assignment, students were slow to start, not sure of the learning goals, or worried that the assignment would be finished too quickly. However, there was a spike in engagement during this time. "The buzz of the room is about Joseph, whose name happens to appear in several story problems. Kids flip to the "Joseph" pages and solve those first. Joseph grins. "

A student's feeling of connection, whether learning, options, value, or ego connections emerged as an important theme in this action research project. The students' feeling of connection to the math material helped them remain engaged with their learning in whole group, small group, or individual work setting. (Table 2)

Social Context

Another recurrent theme in the data was the importance of a social context for student engagement. During periods when students were expected to sit and listen to a lesson, without interacting with one another, especially during traditional lessons, engagement was difficult to sustain. Although some instances of disengagement had a social aspect, (whispering, chatting, playing tag) there were far more instances of disengagement that looked solitary, with students turning inward to amuse themselves until the lesson was over. Students rolled pencils on clipboards, took extra bathroom breaks, traced patterns on the carpet, pulled at their own hair. When it is time to get to work, (highlighting key vocabulary and solving workbook problems) attention returned, but without deep engagement: "…26 of 28 kids are at their tables working. Thomas isn't highlighting, but is trying to solve problems. After a reminder he highlights "had" and "gave." Jackson is busy highlighting every word, Toby is working on page 25 and 26, even though he was assigned to work on page 23." Students were not exactly "off-task" but it was clear from their work that they didn't engage fully in the lesson.

In contrast were lessons that were designed to leverage social context as an integral part of the lesson. In the interdisciplinary activity called "Data Party" there was high potential for off-task behavior, but without exception, students remained engaged in the activity. Students met with partners to discuss questions of interest to them, and settled on a method of systematically collecting data. The next day, students combined with another class to ask questions and record the answers. In the third session, students organized their data according to instructions given in a mini lesson. The fourth day, each group presented their data and answered questions from the class. During each part of the activity the social context of the lesson was important and engagement with the math content was high.

In another example, students were completing traditional workbook pages that gave practice with odd and even numbers. Janie, a "gifted" second grader who also suffered from sensory processing disorder and multiple anxieties, became upset about one of the problems in the workbook. Her voice rose as she argued that the problem didn't make sense and couldn't be solved, since an odd number of balloons couldn't be divided evenly without popping a balloon. Her face was strained and her head was shaking. Her level of anxiety caused her to disengage from the lesson. Six classmates joined Janie in the discussion and brought forth possibilities for a solution, which seemed to add a supportive social context to the experience. Could two people share the odd balloon? Could they give one away? Could time with the balloon be divided? Janie's tension eased and she was able to reengage with her work. The students who took part in the discussion continued with their math work. Those who were not talking about the math problem disengaged and went off-task.

The theme of a social context was associated with engagement in students' math learning; in the 25 documents that comprised the data for this study, 11 made note of the social context for learning. Of those 11 lessons, 9 had high levels of student engagement and 2 had medium. In the four documents that reported low engagement, only one placed learning in a social context. (Table 2)

Active Learning

The third theme that emerged was the need for students to be actively engaged in their learning. In this project, active learning was characterized by handwork or creative, constructive activities like knitting, sewing, building, painting, dancing, drawing, or origami. Indicators of engagement were frequently present during lessons that required students to make something, do something or move with purpose.

Of the 11 instances of high engagement reported in Table 2, all 11 occurred in conjunction with active learning. There was one instance of active learning with low engagement. In this traditional lesson students were assigned to use "linker cubes" to measure various objects in the room and record the measurements. Others were assigned to build representations of fractions with geometric blocks. Both activities met the criteria for active learning. Field notes indicated that there was activity, but not enough focus on mathematics: students became intrigued with the materials and used them for balancing, spinning, and building tall towers rather than measuring or building fractions.

More often, however, lessons that included opportunities for active learning were linked to high engagement. After an activity that included building "spinners, zoomers and balancing toys," while testing, measuring and recording data, students were able to articulate their math learning in post-interviews. The engagement that was present during the lesson was still present when the building and playing were over and discussion was taking place. Students were highly engaged in reporting their findings and describing the math they used. Joseph, a first grade boy, told how he used math in his work with the zoomer: "…it gots to be equaled when you have the string, and it gots to have an amount of time, cause if it was like 90 seconds it would go fast and no one would see it, and that's why you need to have it straight and go very calmly, cause if you go fast it won't work."

Active learning experiences were most effective in lessons that were carefully planned to include the other elements; connections, a social context and the right amount of challenge. (Table 2)

Challenge

The fourth theme that recurred in lessons that were highly engaging was challenge. In this study, challenge is defined as an appropriate level of difficulty; not too easy and not too hard. Students who found pride in their work, and who felt competent and accomplished, had higher levels of engagement. When the task caused frustration or stress, indicators of engagement were lower. Of the 25 sets of field notes, 19 mentioned that most students felt challenged or proud of their work. In three some felt challenged, and in three others none felt challenged. If there was a low level of challenge (either too hard or too easy), there was also a low level of engagement.

In a post-choice time discussion, several students gathered to talk about their work with origami. Isaac talked about making a crane:

"Um I just want to say I think it really helps people to make a peace crane, because at my aftercare we have a little quiet time after we play outside and that's when I kind of became an expert at making cranes- at that time."

Teacher- How do you feel about being able to do that?"

Isaac-"I think it's really amazing and how cool they are and they're colorful, they're peaceful, they're big, and I think it's awesome that I could do that.

Teacher- "Was it hard or easy to learn?"

Isaac-"Actually, my teacher at aftercare, she asked me how to fold one, so I taught, and then everyone wanted to learn, and then we came up with this thing with my friends. I showed them and now they know how to fold them too. And we give our cranes and stuff to people."

In this case, there was the proper amount of challenge, which created a sense of deep pride in the student. When the challenge was not appropriate, the opposite occurred; students became frustrated and disengaged. For example, in a workbook lesson, Julian was stuck on one of the review problems having to do with money. He looked close to tears. The teacher asked why he was on page seven when other kids were on page 12 or 13. He frowned and tapped the page, unable to speak. The teacher said "skip that one! Sometimes you need to leave a problem and come back to it." Julian, relieved, was able to return to his work, and proudly work through the remaining problems.

Four themes, connection, social context, active learning and challenge, recurred during periods of high student engagement in math learning. When all four elements were present, engagement was highest. In lessons with low engagement, there were between zero and two of the four elements present. The next section will describe findings around specific interdisciplinary projects.

Interdisciplinary Math Activities

How do interdisciplinary math projects affect student engagement in mathematics learning? The four themes that characterized times of high student engagement were consistently present during interdisciplinary math project work. However, connection, social context, active learning and challenge can be present in traditional lessons as well. This section unpacks specific data that addresses the connection between interdisciplinary math projects and engagement.

The interdisciplinary units of study described in this action research project were based on Dr. Ernest Boyer's "eight human commonalities," outlined in his book, *The Basic School.*

Four commonalities are addressed each year, forming the center of our multi-age curriculum. The data collection period spanned two units of study.

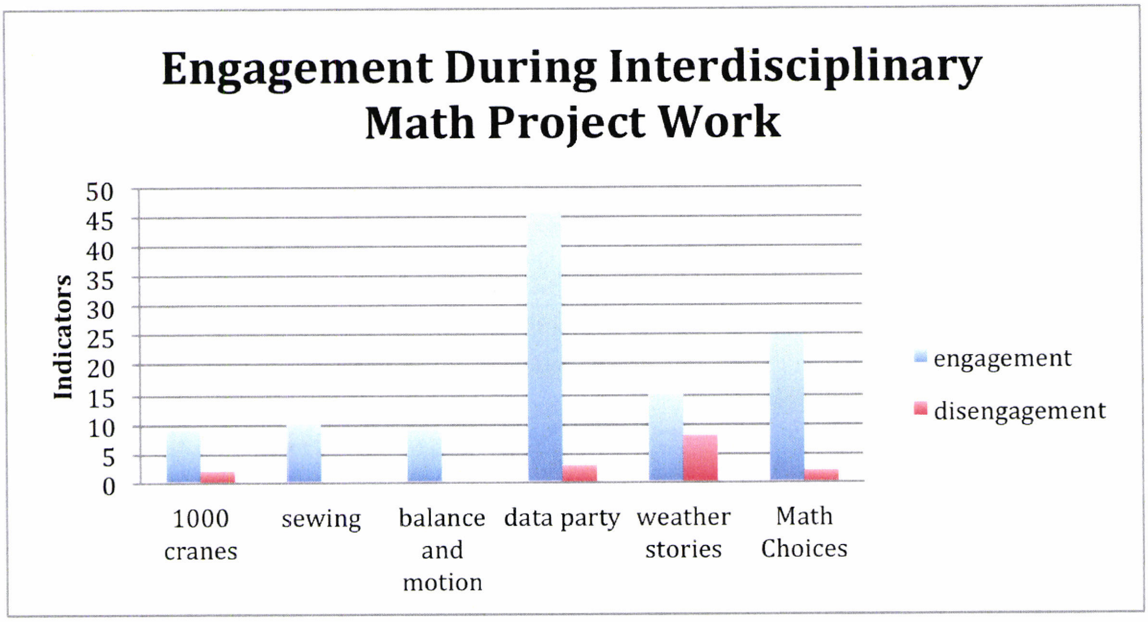
Table 2. Interdisciplinary Math Projects in Context

Interdisciplinary Units of Study- January to June					
Express Yourself			**Eyes to the Sky**		
*What is art? *How can we use art to express ourselves? *How do people around the world express themselves through art?			*What's Up? *What makes weather happen? *Why are people around the world connected to the sky?		
Sample Curricular Areas/Lessons			**Sample Curricular Areas/Lessons**		
Literacy	Soc.Studies/ Science	Math	Literacy	Soc.Studies/ Science	Math
Folktales	Map Work	1000 cranes	The Little Cloud	Rain and clouds	Data Party
Quiltmaker's Gift	Social Skills Sharing	Sewing mice and quilts	Cloudy w/a chance of Meatballs	Severe weather and causes	Weather Stories
NonFiction /Artist bio.	Balance and Motion	Measurement and Timing	Individual weather projects integrating literacy, science		Math Choices

Table 2 provides context for our interdisciplinary math project work that took place during the data collection period. Each math project had literacy, science, and social studies activities that formed part of a cohesive curriculum "story." Traditional math lessons from the *Investigations* curriculum were also interspersed with project work providing a contrast to interdisciplinary math projects.

Interdisciplinary math projects were consistently associated with high levels of engagement that was sustained over time, sometimes over a period of days. Figure 1 compares the number of indicators of engagement and disengagement noted in the field notes taken during six interdisciplinary lessons.

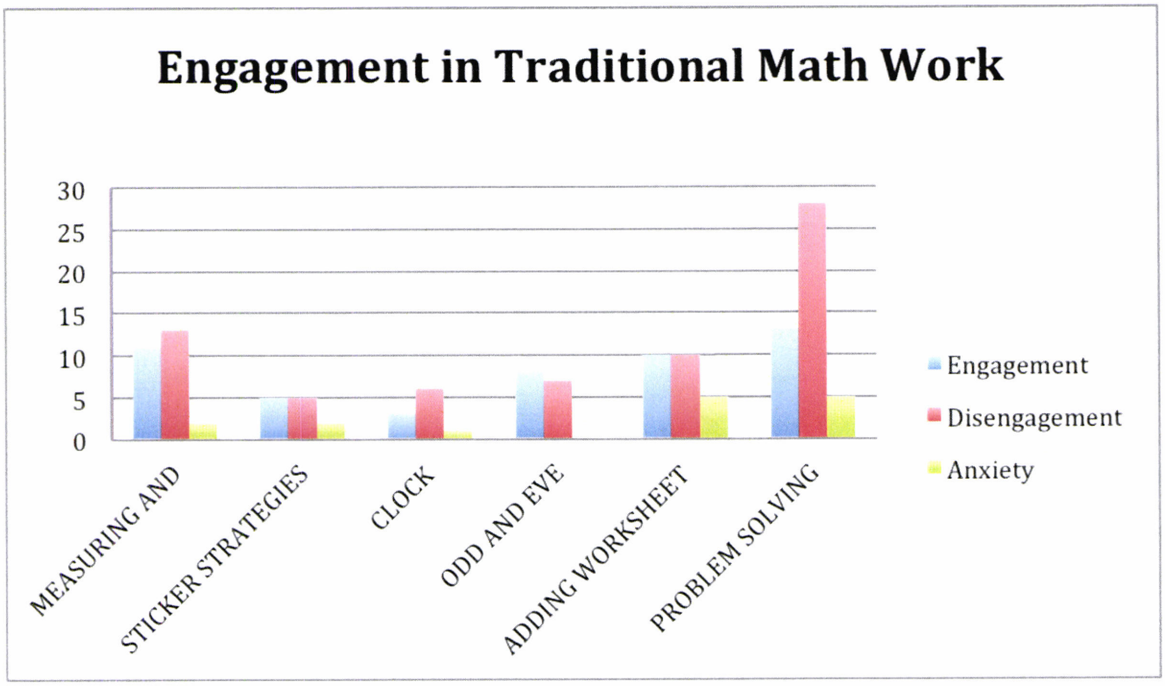
Figure 1. Comparison of Indicators of Engagement and Disengagement



Although indicators of disengagement (talking, leaving the area, rolling pencils, etc) were sometimes present during interdisciplinary project work, indicators of engagement (leaning forward, productive work, math talk, etc) were significantly more frequent. Even though the themes connection, social context, active learning and challenge, may be present in traditional lessons, (Table 2) indicators of engagement were not as high.

During traditional math work, (Figure 2) indicators of disengagement were more frequently present, along with specific indicators of anxiety. Although it is clear that some students were engaged in this kind of work, the higher level of disengagement was significant. The presence of indicators of anxiety (hair-pulling, tears, withdrawal) were troubling during traditional lessons, even though they affected a small number of students. In general, it appeared that engagement was higher during interdisciplinary lessons than traditional lessons, even when some elements of engagement (connection, social context, active learning, challenge) were present.

Figure 2. Indicators of Engagement, Disengagement and Anxiety in Traditional Math Work.



Math Learning

After looking at what is happening in the classroom during periods of deeply engaged learning, and then determining the affect of interdisciplinary project work on math engagement, the next step was to examine whether learning from interdisciplinary projects fostered generalized mathematics understanding among the students involved. To determine if students met mathematical learning goals was a complex and varied process that included embedded and standardized assessments.

Embedded Assessments

Both traditional and interdisciplinary math lessons that were part of this study included an assessment embedded in the activity itself. For example, in the "sewing" activity, if the student was able to produce a felt mouse, using measurement, geometry and pattern required, the learning goals were marked as "high." If the student needed significant help, the learning goal was "partially met." In this case, feedback was given to students as they worked, and students continued until their goals had been met. Students were also asked in an informal math conference about their feelings of competency with the new skill. In general, a high level of engagement was associated with a high level of student learning in math. (Table 3)

Math learning was categorized into five areas that were related to state standards and renamed in student-friendly terms. These are Space, Pattern, Explaining Thinking, Number and Data. Each lesson was designed to address between one and five state math standards. Table 3 shows the relationship between the two types of lessons, the range of standards addressed, and the math goals met by the lesson.

Observations of interdisciplinary project work in Table 3 all indicated high engagement and high proportion of learning goals met. The products in these cases were completed satisfactorily, and student discussion indicated understanding of the math concepts that were embedded in the project. The traditional lessons were characterized by lower engagement, fewer math goals addressed, and fewer math goals met.

Table 3. Interdisciplinary and Traditional Math Work, Engagement and Learning Goals

Lessson	Traditional or Interdisciplinary	Engagement	Math Goals Addressed S.P.E.N.D.	Math Goals Met (embedded assessments)
1000 Cranes	Interdisciplinary	High	SPEND	High
Sew a Mouse	Interdisciplinary	High	SP	High
Balance/Motion	Interdisciplinary	High	SED	High
Data Party	Interdisciplinary	High	END	High
Weather Stories	Interdisciplinary	High	EN	High
Math Choices	Interdisciplinary	High	SPEND	High
Measure/Fractions	Traditional	Low	SN	Low
Sticker Strategies	Traditional	Medium	N	Medium
Clock	Traditional	Low	S	Low
Odd/Even	Traditional	Low	N	Medium
Adding 3 Digits	Traditional	Medium	N	Medium
Problem Solving	Traditional	Low	EN	Low

Standardized Assessments

In addition to embedded assessment, students at each grade level were given 2 standardized assessments designed to evaluate learning from the traditional curriculum. The first assessments measured student progress against grade level standards for the fourth (final) quarter of the school year. These assessments measured specific skills that were covered in the district's curriculum, and were sometimes addressed through interdisciplinary work in the course of this study. Among first graders in the study, only one student (Victor) had serious difficulty in several categories (number sense, adding and counting coins). The rest of the first graders demonstrated that they had met the math goals set forth by the district for the fourth quarter, or had only a few errors in the test.

Table 4. First Grade, Fourth Quarter Assessment

Student	Number sense	=,- ten	Add story	Subtr story	Equi-valence	Coin value	Coin Adding	Time	Total
Joseph	5/5	3/4	4/4	2/2	3/3	3/3	3/3	3/3	26/27
Amy	3/5	1/4	4/4	2/2	2/3	2/3	3/3	3/3	20/27
Victor	1/5	3/4	4/4	2/2	3/3	0/3	0/3	3/3	16/27
Aaron	5/5	4/4	4/4	2/2	3/3	3/3	3/3	3/3	24/27
Heidi	5/5	4/4	4/4	2/2	2/3	3/3	2/3	3/3	23/27
Billy	5/5	2/4	4/4	2/2	3/3	2/3	3/3	1/3	22/27
Stephanie	5/5	3/4	4/4	2/2	3/3	3/3	3/3	3/3	26/27
Peter	5/5	4/4	4/4	2/2	3/3	3/3	3/3	3/3	27/27
Jackson	5/5	4/4	4/4	2/2	3/3	3/3	3/3	0/3	24/27

Table 5. Second Grade, Fourth Quarter Assessment

Student	Number and Operation	Algebra	Geometry and Measurement	Total Points
Thomas	Partially meets	Meets	Partially Meets	43/82
Kendra	Partially meets	Meets	Meets	78/82
Janie	Meets	Meets	Meets	78/82
Kellen	Partially meets	Not meeting	Partially meets	44/82
Tim	Partially meets	Meets	Meets	71/82
Toby	Meets	Meets	Meets	76/82
Margaret	Meets	Meets	Meets	76/82
Brendan	Partially meets	Partially meets	Not meeting	48/82
Michael	Meets	Meets	Meets	82/82
Rose	Meets	Meets	Partially meets	73/82
Julian	Partially meets	Partially meets	Meets	66/82
Isaac	Meets	Meets	Meets	82/82

Second grade students had similar results on their fourth quarter assessment, which included 82 items in all, in contrast to the 27 on the first grade assessment. The test questions were categorized into 3 areas: number sense, algebra, and geometry and measurement. In this assessment, points were given for each item, and a grade of "meets, partially meets, or "not meeting" was given for each category.

Two students had a score indicating that they were "not meeting" a learning goal in one area each. Five students had a combination of "meets" and "partially meets," while 5 students met all of their learning goals according to this assessment. There was no particular area that indicated that the students, as a group, showed the need for remediation.

The next assessment given to both first and second grade students was an "initial assessment" for their upcoming school year. This assessment was much less detailed and was meant to let the new teacher know whether the student was prepared for grade level work. Although this assessment was given in early spring, students in both grades met the goals for beginning second or third grade successfully, with one exception.

The second grade initial assessment, given to first graders, asked students to write a number sentences, or equation, that matched a given problem, draw the solution to a word problem, put 2 digit numbers in order, and solve single digit addition problems. Table 6 shows results from this assessment. Only one first grader, Jackson, lost significant points on the 'adding facts" section. He skipped several problems, but did well on the rest.

Second graders were also given the third grade initial assessment. This test looked at whether the current third graders were prepared for third grade work in seven categories: place value, story problems, pattern, measurement, time, money and number sense. Of the 11 students who took this test, only one student had significant trouble. "Kellen" had difficulty with the fourth quarter assessment also. Ten second graders met the math goals for beginning third grade.

Table 6. First Graders Results on Second Grade Initial Assessment

Student	Number sentence	Draw to show understanding	Order numbers	Adding Facts	Total
Joseph	2/2	2/2	16/16	36/36	56/56
Amy	2/2	2/2	16/16	36/36	56/56
Victor	2/2	1/2	16/16	36/36	52/56
Aaron	1/2	1/2	14/16	36/36	52/56
Heidi	1/2	2/2	16/16	36/36	55/56
Billy	2/2	1/2	16/16	36/36	55/56
Stephanie	2/2	0/2	16/16	36/36	55/56
Peter	2/2	2/2	16/16	36/36	56/56
Jackson	2/2	1/2	16/16	27/36	46/56

Table 7. Second Graders Results on Third Grade Initial Assessment

Student	Place Value	Number Stories	Pattern	Measure	Time	Money	Number sense	Total
Kendra	5/5	4/4	2/3	3/3	3/3	3/3	5/5	25/26
Janie	5/5	4/4	2/3	3/3	3/3	2/3	5/5	24/26
Kellen	3/5	1/4	1/3	3/3	1/3	1/3	3/5	13/26
Tim	4/5	2/4	3/3	3/3	3/3	2/3	5/5	22/26
Toby	3/5	2/4	2/3	3/3	3/3	3/3	5/5	21/26
Margaret	5/5	4/4	2/3	3/3	3/3	3/3	5/5	25/25
Brendan	5/5	4/4	2/3	2/3	3/3	2/3	5/5	24/26
Michael	5/5	3/4	3/3	3/3	3/3	3/3	5/5	25/26
Rose	4/5	4/4	3/3	3/3	3/3	3/3	5/5	25/26
Julian	5/5	2/4	1/3	3/3	3/3	2/3	5/5	21/26
Isaac	5/5	4/4	3/3	3/3	3/3	2/3	5/5	25/26

Conclusion

Data collected and analyzed over the course of this action research project told a story of engagement and disengagement during math learning. The findings were organized around three research questions:

1. When students are deeply engaged in math learning, what was happening in the lesson?
2. How do interdisciplinary math activities affect student engagement in mathematics?
3. Does learning from interdisciplinary projects foster generalized mathematics understanding among the students involved?

Findings revealed four themes (connection, social context, active learning and challenge) that create a theory of student engagement during math learning. They also indicate that interdisciplinary activities do contribute to engagement, and that students' math goals are well met with interdisciplinary work. In the next chapter, findings are discussed, along with implications and recommendations.

CHAPTER V

Discussion

The purpose of this study was to look deeply at math instruction in my first and second grade classroom and develop a theory of engagement; specifically whether interdisciplinary math projects have an affect on engagement during math learning. At its core, the project was about finding ways to help student find math interesting, relevant, fun, and engaging. During language arts, science, and social studies lessons, capturing students' hearts and minds is not a problem, but all signs, including high-stakes test scores, indicate that students are not so engaged in math learning. A review of the literature bears this out as well. Researcher David Sousa points out "Children often say, "I can't do math!" But you never hear them say, "I can't do language!" Why the difference?" (Sousa, 2008, p.1)

When young children struggle, become frustrated, or feel bad, there is no denying what is happening. They wear their hearts on their sleeves. During math learning in a primary classroom, this might look like polite inattention, but more often is quite the opposite. Students who are disengaged often hoot and holler, pinch and poke, fidget and fight, vandalize and vanish. Researcher Phil Schlechty refers to this phenomenon as a response to school tasks; he notes that In the place of authentic engagement, students may show ritual engagement, passive compliance, retreatism, or rebellion when faced with assigned tasks. (Schlechty, 2002, p.3) His thesis is that reform efforts that focus on teachers and students will miss the mark. It's the work we ask them to do that needs attention. "The task of the teacher, therefore, is to design work that is responsive to student needs and motives, which results in students' learning those things it is intended that they should learn." (Schlechty 2002, p. 38) This chapter will discuss the findings from my research into the affects of interdisciplinary project work on student engagement in math learning, and suggest implications for consideration by classroom teachers.

Overview of the Study

In order to develop a theory of student engagement during mathematics learning, I addressed three research questions:

1.When students are deeply engaged in math instruction, what was happening in the lesson?

2. How do interdisciplinary math activities affect student engagement in mathematics?

3. Will learning from interdisciplinary projects foster general mathematics understanding among the students involved?

Using the methods associated with grounded theory, I observed my class at work, taking field notes and sometimes recording lessons, activities and brief interviews. I developed a list of indicators of engagement and disengagement, and used these to determine the kinds of activities that coincided with deeply engaged learning. As the "treatment," students were presented with a series of "interventions," or interdisciplinary projects that put math goals in the context of other fields of study. These interdisciplinary projects were alternated with more traditional lessons from the *Investigations* curriculum. After data collection, field notes were analyzed to determine the presence of indicators of engagement and disengagement. I developed a theory of student engagement during mathematics instruction, which included four elements, or themes, that were most often present during periods of engaged learning.

Summary of Findings

Careful analysis of the data led to findings that addressed each of the questions that guided this action research project. When students were deeply engaged in mathematics learning, what was happening in the lesson? There were four elements that most often appeared at the same time: connection, a social context, active learning, and challenge. Four kinds of connections could help students become engaged in their learning. One was a *learning* connection, in which students found themselves interested in a new aspect of some prior learning. The second was connection through *options*. When students were empowered to choose their own math learning, their engagement was dramatically enhanced. The third was *value*, in which students could see that the task was relevant, useful or helpful to them in some way. The fourth was an *ego* connection, in which students' names were written into the math task, or they were encouraged to relate their math work to something from home. These four kinds of connection were most often part of engaged learning. In addition to connection, a social context provided a way for students to support each other in their work. Active learning, defined as making something, doing something, or moving in a purposeful way, was the third element that was present during engaged learning. Finally, work that provided the right kind of challenge was an important element of student engagement during math learning. These four elements emerged as recurrent themes and provided the basis for a theory of student engagement in mathematics learning.

Next, I looked at whether interdisciplinary project work had an effect on engagement during math learning. During each interdisciplinary lesson, engagement was high. Interdisciplinary projects intrinsically included connection, social context, active learning and challenge as part of their structures. In the traditional lessons the four elements were less frequently present, and engagement was lower. Finally, I considered whether interdisciplinary project work adequately fostered students' understanding of math concepts. In all of the interdisciplinary projects, students' learning goals were met. This was only the case in some of the *Investigations* lessons. (Table 2, Table 3)

Conclusions

Because of the greater likelihood that interdisciplinary project work will integrate elements of connection, social context, active learning, and challenge, interdisciplinary project work has a positive affect on student engagement during math learning. By definition, interdisciplinary work is connected work. Although it falls under the "progressive" category, it has a long and respected history: "The notion of an integrated approach to curriculum springs back from tenets of modern psychology and philosophy, developed by John Dewey, Jean Piaget, Zoltan Dienes, Jerome Bruner, and others. These individuals have adopted a holistic view of the learning process and have been concerned with children acquiring an understanding of fundamental structures. Integrated studies, also known as thematic curricula, offer variation in the teaching and learning process that is probably not attainable under normal classroom procedures." (Humphreys, Post, & Ellis, 1981, p. 21). Integrated projects lend themselves to social context, with children's questions, thoughts, and prior knowledge at the center. They are more likely to be active in nature, with something to make, do, find out, or explore at the core of the work. The right kind of challenge is easier to find in interdisciplinary work; because of the "holistic view of the learning process" (Humphreys, Post & Ellis, 1981, p.21) students are more likely met in their "zone of proximal development" (Vygotsky,1978) and able to do work that is "just right." When these four elements are present in a lesson, student engagement, and therefore student learning, is high. (Table 2, Table 3)

The results imply that interdisciplinary math projects do have a positive affect on student engagement in math learning. However, the key elements of connection, social context, active learning and challenge also coincided with high engagement in traditional math lessons that were not part of an interdisciplinary project. Although interdisciplinary project work was most consistent in producing high engagement, it was possible for students to engage in traditional lessons if one or more of the key elements were present.

Recommendations

Interdisciplinary project work clearly has an important place in planning effective, engaging math instruction. However, in the current educational climate, teachers are often urged to present the required curriculum with "fidelity." When creating interdisciplinary units of study that will include math goals, it is important that the teacher conscientiously examine both state standards and district recommended curriculum to be sure that all necessary learning targets are addressed. It is not enough for the students to be busy and happy; the teacher must also attend to the desired math learning goal and create opportunities to assess whether the desired learning is taking place. At the same time, teachers must take care to meet the students' needs for connection, social context, active learning and challenge if engagement is to be high enough for math learning to take place.

If the decision is made to anchor math instruction in a published curriculum, without linking to the connection and context provided by an interdisciplinary unit of study, teachers can make adjustments to help students engage more deeply in their work. They can help students connect personally to the material by rewriting math problems to include names of the students in the class, provide learning choices when possible, and during discussion, help students to see the value (importance or relevance) of the work. Structured, cooperative grouping can provide social context, and learning can be made more active by using games that reinforce math skills. Finding ways to make "one size fits all" work "just right" for every student is a difficulty with traditional math work from any published curriculum, and will create some behaviors associated with disengagement. These elements taken together will help students engage more deeply in math work, but lack the relevance, richness, authenticity and coherence that a well-planned interdisciplinary unit of study has to offer.

The results of this action research project will be used as justification for the creation of a continuing series of interdisciplinary math projects in my classroom. There will be more mathematics work that is authentically connected with the rest of the curriculum, and less work that is segregated by a disciplinary designation. It is possible that other teachers may use this work as a stepping-stone in their own pathways to helping their students become more deeply engaged in math learning through interdisciplinary project work.

Finally, as schools succumb to pressure to adhere to "common core standards," it is important to collect and document examples of students engaged in all kinds of learning, especially in areas where high-stakes test scores are tumbling and students report frustration and feelings of inadequacy.

Limitations of the Study

The findings of this action research project were limited by the size and nature of the participants in the study. Although 21 of 28 students agreed to participate, the sample was not reflective of the racial or socioeconomic diversity of my class. Although all students in the class successfully participated in the lessons and activities that were part of the treatment, only three study participants were students of color, and none were English Language Learners. Data collected did not include observations, notes, or interviews from students who would have added to the richness of the data.

It is also the nature of action research that successful practices are repeated and unsuccessful practices are discarded. As an active participant/observer, I made educational decisions for the benefit of my students that changed our work as we went along. In this kind of study, it is impossible to draw a conclusion of cause and effect; I must be satisfied with noticing which interventions went along with the best results. The freedom to make changes along the way is also an important benefit of action research.

Future work is needed in the area of engagement, identity and equity. How do students' perceptions of themselves as learners change based on their ethnic heritage or status as an English language learner? Would interdisciplinary project work play a role in leveling the playing field and allowing all students better access to high level, engaged learning through connection and context? It would also be interesting to take a deeper look at the relationship between "handwork," and math learning, in light of recent neuro-scientific evidence that the same part of the brain controls both fingers and counting. (Sousa, 2008.) Linda Crawford, in her book *Lively Learning*, suggests that "The arts can give children a familiar structure that helps them learn and remember what numbers are and what they can do." (Crawford, 2004, p.145) This could have important impact on curriculum development, as we learn more about the connections between engagement, achievement, and mathematics.

CHAPTER VI

Personal Reflection

My action research project was an opportunity for me to look deeply into my own practice, find out what was working and what wasn't, and make some changes that would make life better for me and for my students.

The process caused me to think back into my life as an elementary school math learner. I learned to count, add and subtract along with the rest of the crowd. Multiplying and dividing added some pressure, because I was expected to memorize the facts backward and forward, but I just didn't do it. All that work interfered with my repeated reading of *Nancy Drew* mysteries and the *Little House* series. Why was it that I could practice "The Spinning Song" on the piano hundreds of times, read *Betsy-Tacy* over and over, and embroider thousands of perfect stitches, but couldn't be bothered to memorize the multiplication tables? Eventually I learned the steps needed for long division, but never did have immediate recall of the facts. I got through math in junior high and high school by cheating, evading, and cramming. College meant remedial algebra…twice. Finally, as an undergrad at Augsburg, I had a wonderful class called "Math for the Liberal Arts," where I learned that math was elegant, beautiful, and full of amazing stories of discovery. As I learned how to teach math to children, I reconstructed my own understanding of how numbers go together in different ways, learned to give mathematics a context, and set out to share the joy, like Bertrand Russell when he said, "Mathematics, rightly viewed, possesses not only truth, but supreme beauty."

The process of creating an action research project that would allow me to look carefully at conditions that created engagement in my students during math instruction was painfully enlightening. In my school as in others, progressive values had given way to demands for "fidelity to the curriculum." I had gathered my own data on the curriculum and its effectiveness with my first and second grade students. It was too easy for some, too hard for others, and just right for a few. It was hard for me to get through a lesson peacefully and fruitfully. Frustration gave way to unproductive behavior among many students. It seemed to me that the *Investigations* curriculum wasn't working for everyone. This action research project gave me a way to find out what was happening in my classroom during math learning time.

It was empowering to carefully design math projects that had the same math goals as those found in the *Investigations* curriculum and teach them to my students in an engaging context. I had the permission of my district and my principal, although even as a true-blue progressive educator, he was a proponent of the *Investigations* curriculum, and for good reason. *Investigations* was based on solid constructivist theory, and has at its core students' own discoveries of theories of mathematics. My experience with the curriculum, however, led me to speculate that it's isolation from the rest of our interdisciplinary study was causing many students to believe that math time was a good time to "check out." The action research project gave me a chance to see if I could do better and still meet the same goals.

I also had to recognize my own biases against the idea of a standardized curriculum in general, and the *Investigations* curriculum in particular. I examined the curriculum carefully both when presenting its lessons, and when using the *Investigations* goals to create my own interdisciplinary limits. I wanted the comparison between the two styles of teaching to be fair and not colored by my feelings about the efficacy of either. This exercise helped me realize the value of a well-written curriculum as a guide. Since my data collection process, the school district has backed away from it's position that *Investigations*, taught as written, will lead to student meeting of all the grade level math standards. Two units have been moved from third grade to second, and the motto is now, "the standards are our curriculum." In addition, our new principal is interested in developing interdisciplinary project work as the center of the curriculum school-wide.

During the data collection process I was able to watch carefully. I put my biases about different learners aside and saw what was really happening. Building this habit has made a real difference in my teaching. I developed a routine of regular "conferencing" with students during their work time, no matter what we are working on. Knowing that I am nearby, about to check in, preparing to ask about work, and expecting an exchange about thinking and learning, has made its own difference in student engagement over the past two years. I find I can zero in on a few learners each day, while the others are fruitfully engaged in independent or small-group work.

My belief in the value of interdisciplinary project work was strengthened by the experience. I was introduced to the idea as an undergraduate at Augsburg, and was student teacher with two fine, progressive interdisciplinary practitioners. Over the years, even though there is a strong research base, and most teachers say that they believe it is best to present curriculum in an integrated manner, our school district has moved away from this kind of thinking. We are urged toward "focused instruction" and "alignment" that some interpret to mean that teachers should be on the same page at the same time, district–wide. My review of the literature affirmed my long-held belief in the value of interdisciplinary instruction, based on the "classics" like Dewey, Piaget, Jacobs and Boyer, and also on newer thinking based on brain research and massive studies of efficacy in the classroom.

Finally, I am grateful to have had the chance to focus on my students, think deeply about their learning, read widely about engagement and interdisciplinary learning, and clarify my own thinking by writing about all of it. I now have a better understanding of what I need to learn and do in order to effectively share the beauty and complexity of mathematics with my students.

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Appendix A

Student Engagement in Mathematics Through Interdisciplinary Activities

Consent Form

Your child is invited to be part of a research study of student engagement in mathematics through interdisciplinary activities. All of the students in my (Kristin Sonquist's) class at xxxxxxxxxxxx School are invited to be part of the study. I am conducting this study as part of my master's project in Education at Augsburg College. My advisor is Associate Professor Elizabeth Ankeny, Ph.D., Augsburg Education Department.

Background Information:

I am interested in collecting students' stories about their learning in math. I want to find out whether they are more interested and engaged in math learning when they apply math concepts to real-life projects like knitting, cooking, origami, creating a weather station, and others. I am hoping to find ways to help all students become more engaged in their math learning, and to find how math helps them learn in all areas of their lives.

Procedures:

If you agree to have your child participate in this study, there will be no special requirements for parents. I will be conferencing with your child during math time as usual, asking about their work, and paying special attention to times when he or she is especially engaged in math learning. I will make notes about your child's math learning, and may make video-recordings of your child at work. All conferencing, field notes and video-recording will take place during math lessons during the school day. I will ask questions that will help me learn more about your child's mathematical thinking, and be able to adjust my lessons and activities based on my findings.

If you do not agree to have your child participate in this study, your child will participate in all math projects, but data from student conferences and observations will not be included in the study.

Risks and Benefits of Being in the Study:

There are some risks to participating in this study. I will be asking probing questions during our math time. Although every precaution will be taken to preserve anonymity of the students, the small size of the sample creates a small possibility that student may be identifiable.

Interviews, video-recording, one-on-one conferencing are all activities that might happen in the course of any school day. I am not offering any prizes or inducements as part of this study. Indirect benefits include possible improvements in math instruction for your child and furthering knowledge in general.

Confidentiality:

The records of this study will be kept confidential. The final project will be presented at a symposium at Augsburg College and the published thesis will be kept on file at Lindell Library. There may be other published reports that use the data collected during this research. xxxxxxxxxxxx School will also receive a copy of the published report. I will also report on the results of the study at xxxxxxxxxxx School if requested. In the thesis, or in any other published report, I will not include any information that will identify you or your child. All data will be kept in a locked file. Only my advisor, Associate Professor Elizabeth Ankeny, principal Steve DeLapp, and I will have access to the data or video-recordings. If the research is terminated for any reason, all data and recordings will be destroyed. While I will make every effort to ensure confidentiality, anonymity cannot be guaranteed due to the small number being studied. Raw data, including video-recordings, will be destroyed by June 2014.

Voluntary Nature of the Study:

Whether or not you allow your child to participate will not affect your current or future relations with Augsburg College, xxxxxxxxxxxxxxxx, or Kristin Sonquist. If you decide to let your child participate, you are free to withdraw your consent at any time. Your child is also free to skip any questions during the interview process.

Contacts and Questions:

The researcher conducting this study is Kristin Sonquist. My advisor is Associate Professor Elizabeth Ankeny, Ph.D, Augsburg College Education Department. You may ask any questions you have by email, phone call, note, or arrange a conference with me. My cell phone number is xxxxxxxxxxxxx. My advisor's phone number is 612-330-1548.

You will be given a copy of this form to keep for your records.

Statement of Consent

I have read the above information or have had it read to me. I have received answers to questions asked. I consent to have my child participate in this study.

Signature of parent or guardian ______________________________ Date________

Signature of minor subject's assent __________________________ Date________

Signature of investigator _________________________________ Date________

I consent to allow my child to be audiotaped (or videotaped)

Signature ____Date ______________

I consent to allow of my minor child's quotations in the published document (parents/guardians)

Signature ____ Date______________

Thank you for your help,
Kristin Sonquist

Appendix B

Dr. Ernest Boyer's Human Commonalities

(Excepted from *The Basic School: A Community for Learning* by Dr. Ernest Boyer)

The Life Cycle

The Goal: All Basic School student understand that human life has a beginning, a time of growth, and an ending. They acquire a basic knowledge of the body's needs and its functions, and adopt personal habits that promote wellness. They develop an appreciation for the sacredness of life, and understand how life experiences differ from one culture to another.

The Use of Symbols

The Goal: All Basic School students understand that people communicate with each other through symbol systems. They explore the history of language, consider the purposes of communication, learn about new technology, and discover how mass communication can enhance or diminish human understanding. And they discover that integrity is the key to authentic human interaction.

Membership in Groups

The Goal: All Basic School students understand that everyone holds membership in a variety of groups, beginning with the family. They consider how organizations shape our lives, how we, in turn, can shape institutions, and they develop, in the end, a sense of civic and social responsibility.

A Sense of Time and Space

The Goal: All Basic School students learn that people everywhere have the miraculous capacity to place themselves in time and space. Students explore our shared sense of time through history and through intergenerational connections. They learn about our nation's history and study the traditions of other cultures. And they gain perspective, as well, about where they are located, spatially, on the planet and in the universe.

Response to the Aesthetic

The Goal: All Basic School Students understand that people respond to beauty and can be expressive in the arts. They explore the rich variety of artistic expression. Learning about the various works of art, recognizing the benefits of making art, and knowing some of the ways in which visual and performing arts have evolved in different cultures.

Connections to Nature

The Goal: All Basic School students recognize that everyone is connected to the natural world. They learn about the scientific method and, in the process, increase their understanding of the world around them. Above all, students discover the beauty and wonder of nature and develop a profound respect for it.

Producing and Consuming

The Goal: All students learn that people, as a part of being human, engage in making and using things. They recognize the value and dignity of work, distinguish wants from needs, and understand the importance of becoming creative producers, informed consumers, and responsible conservers.

Living with Purpose

The Goal: All Basic School students learn that all people seek meaning and purpose for their lives. They understand the importance of values and ethics, learn how religious experience has consequentially shaped the human experience, and begin to see the significance of service.

(Boyer, 1995, p 94-107)

Appendix C

Typical Math Schedule

11:50-12:20 Quiet Math Choice Time

A menu of choices with standards-based, curriculum connected, differentiated learning targets. Students choose the activity with teacher's approval. Choices may include weaving, knitting, origami, extreme dot-to-dots, number scrolls, tangrams, chess, card games, mancala, workbook pages, *Investigations* math games.

12:20-12:35 Mini-Math-Meeting

Whole group practice of Investigations Math Routines, (Quick Images, What Time is It, Number Squeeze. Odd or Even, etc. Often takes the form of a whole group game.)

12:35-12:45 Main Lesson (Interdisciplinary or Investigations)

New concepts presented or previous learning revisited in whole group setting. Directions given.

12:45-1:30 Worktime

Students may work individually with teacher support, or in small groups based on a given criteria, or in grade-alike groups, depending on need. Teacher gives feedback and support.

1:30-1:40 Workshare

Students come together to share accomplishments, connections, ask questions, set new goals, record learning.

Appendix D

"Math Conference" Protocol

Kristin Sonquist   Student Math Conferences

Date_______________ Time________________

Student's Name ______________________________ grade ___________

Investigations lesson __________________

Interdisciplinary Activity ____

Questions will be open-ended. Conferencing will take place during curriculum-based Investigations activities and interdisciplinary activities. Follow ups will vary according to response and the activity.

1. Interview will begin with a statement of purpose- "I want to find our how your work is coming along I am going to make some notes to help me remember what we talked about. I'm looking for math activities that will help your learning stay with you for a long time.

2. Initial Questions:

Tell me about your math work today.__________________ How are you using math to help you with __________________________. (During interdisciplinary activities)

Or

Tell me about your math work today._____________________ Did your work with (name the interdisciplinary activity) help you solve your math problems

3. Possible follow-up questions/ prompts (highlight those used. Write in any that are not included in this list, including follow up questions, or prompts for more elaboration.)

How are you using math to do your ____.

Show me how you (counted, measured, arranged, made your pattern, etc, depending on the math skill employed.)

How do you feel about your work?

Think out loud for me while you ___________________________________.

Did you find any connections with our Math Book?

How did you know what to do?

Draw your thinking for me.

Do you have any worries about your work?

What kind of work do you like best? What do you like about your work?

What patterns are you finding? (Show me, draw one)

Have you had problems (struggles) with your work?

How is your Investigations work coming along?

Can you show me how you ___________________________ in your Investigations book?

What will you try next?

Final Question:

Is there anything else you would like to tell me about your work?

Interviews may be recorded or may be written up from observer notes.