

Spring 2007

Constructivism in a Primary Math Setting

Sarah Connors

The College at Brockport, scaiazza@spencerportschools.org

Follow this and additional works at: http://digitalcommons.brockport.edu/ehd_theses

 Part of the [Elementary and Middle and Secondary Education Administration Commons](#)

To learn more about our programs visit: <http://www.brockport.edu/ehd/>

Repository Citation

Connors, Sarah, "Constructivism in a Primary Math Setting" (2007). *Education and Human Development Master's Theses*. 297.
http://digitalcommons.brockport.edu/ehd_theses/297

This Thesis is brought to you for free and open access by the Education and Human Development at Digital Commons @Brockport. It has been accepted for inclusion in Education and Human Development Master's Theses by an authorized administrator of Digital Commons @Brockport. For more information, please contact kmyers@brockport.edu.

Constructivism in a Primary Math Setting

by

Sarah Connors

Spring, 2007

A thesis submitted to the

Department of Education and Human Development of the

State University of New York College at Brockport

In partial fulfillment of the requirements of the degree of

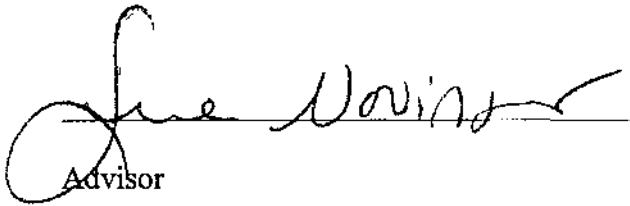
Masters of Science in Education

Constructivism in a Primary Math Setting

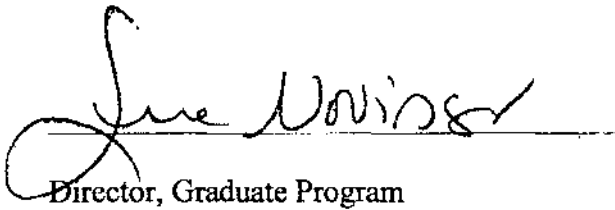
by

Sarah Connors

APPROVED BY:


Advisor

7-30-07
Date


Director, Graduate Program

7-30-07
Date

Table of Contents

Chapter One: Introduction.....	3
Chapter Two: Review of the Literature.....	10
Chapter Three: Methods and Procedures.....	34
Chapter Four: Results.....	48
Chapter Five: Conclusions and Recommendations.....	99
References.....	108
Appendix.....	111
Appendix A.....	Letter of Consent
Appendix B.....	Survey for Parents
Appendix C.....	Student Interview #1
Appendix D.....	Students Interview #2
Appendix E.....	Today's Magic Number
Appendix F.....	Oranges and Cherries
Appendix G.....	Oranges, Cherries, and Grapes
Appendix H.....	Dinosaurs and Tigers
Appendix I.....	How Many Hands at Home?
Appendix J.....	Cats and Paws
Appendix K.....	At the Beach
Appendix L.....	Feet, Fingers, and Legs
Appendix M.....	Practice Page I (Hundreds Chart)
Appendix N.....	Picture of the Classroom During Centers
Appendix O.....	Collect 15 Together
Appendix P.....	Double Compare
Appendix Q.....	Ten Turns Game Sheet
Appendix R.....	Ten Turns
Appendix S.....	Counters in a Cup

Appendix T.....Total of 10
Appendix U.....On and Off

Chapter I: Introduction

Background

For four years I studied the theory of constructivism as an undergraduate at Niagara University. I participated in a week-long conference at St. Lawrence University, and wrote an honors thesis about math and constructivism. I preached the theory and even had expectations of someday earning my doctorate and writing a book about constructivism. I acquired understanding for the topic in a constructivist manner. The more I explored constructivism, the more I discovered. When I got my job in the summer of 2005, right out of college, I had *delusions of grandeur*. I thought with the convenience of my own classroom, I could move from theory, discussions and presentations and make the theory of constructivism real and begin my journey of writing a book. However, instead of exploration and discovery, I found myself making copies of worksheets five minutes before the students got off the bus. Constructivism is a theory that makes sense to me and it broke my heart that it was hardly present in my classroom. I did not feel that I was doing my students justice by having them do worksheets.

Purpose

Constructivism is a theory about learning and knowledge that finds its roots with theorists such as Jean Piaget and Lev Vygotsky. Constructivist learning environments are student-centered where students take charge of their learning, utilizing the teacher as a guide. Students construct their own meaning of concepts by building from their existing knowledge. Constructivism requires students to be

actively involved in their learning by using higher-ordered thinking skills at all times. This theory moves away from the notion that children learn through rote memorization where teachers provide all the necessary knowledge to students. Children can demonstrate their own knowledge and meaning through exploring and demonstrating their new knowledge by a variety of authentic assessment means. Assessment in a constructivist learning environment is done throughout the entire learning process. Reflection on the learning process completes the learning cycle and is therefore seen as a key element to the constructivist theory (Connors, 2006).

Problem Statement

Throughout my years as an undergraduate student and into my first two years as a teacher, I have been exposed to the heated debate over constructivism in the classroom. Over the years I have learned that some schools are not sure how to implement constructivist theory into their classroom and some schools have had great success. “Groups of parents have condemned constructivist math for playing down computational tools as borrowing, carrying, place value, algorithms, multiplication tables and long division, while often introducing calculators into the classroom as early as first or second grade” (Freedman, 2005, p. 1). An article was published in the BBC from an associate professor at Royal Holloway University, London. Dr. Sylvia Steel comments that children should learn their tables by rote memorization. She continues by saying studies show that those students who learned their tables by rote did their sums more effectively (Call for more times table chants, 2004). Additionally, Dr. Steel criticized practices seen in constructivist learning

environment. “Children who used blocks or fingers to work out the problems were slower and less accurate” (Call for more times tables chants, 2004). As I read articles similar to this one published by the BBC, I become frustrated because the theory of constructivism does not down play the importance of memorizing facts. I think that many people have misinterpreted the principles of the theory and are making assumptions. Ralph A. Raimi, professor at the University of Rochester states that “Arithmetic is not trivial mathematics, and it certainly will not be “discovered” by school children. It must be taught and practiced” (Raimi, 2005, p. 1). Raimi makes another assumption about constructivism against the curriculum in Penfield, “A good mathematics program takes advantage of the mathematical discoveries of thousands of years of civilized effort, while Penfield has them counting with sticks, starting history all over again” (Raimi, 2005, p. 1).

With the new mathematics standards leaning toward more problem solving approaches to mathematical understanding and expecting students to think more critically, in addition to what we know about childhood development, constructivist theory makes sense. I wanted to experience first-hand what happens when constructivist principles form the basis for mathematics instruction in a primary classroom.

Research Questions

The following are the questions I tackled for my thesis project: What happens when constructivist principles form the basis for mathematics instruction in a primary classroom? The following is a list of sub-questions in place to guide the study: How

do first grade math journals guide students to deeper understandings of math concepts? What teaching strategies are useful in scaffolding students' meaning making as they use math journals? In what ways can I change my teaching practices and adapt the curriculum provided by the school in order to teach from a constructivist perspective? What does student engagement look like when you ground instruction and curriculum in constructivist principles? In what ways are student attitudes affected by math instruction that is grounded in constructivist principles?

Significance of the Problem

As I head into my second year of teaching, I am better able to apply what I have learned from my prior experience in order to incorporate even more constructivist principles into my instruction, and on a more consistent basis. My primary research question is what happens when constructivist principles form the basis for mathematics instruction in a primary classroom? I realize that "elementary mathematics is usually not sophisticated, but it is deep" (Aharoni, 2005, p. 2). "In reality, no one can *teach* mathematics. Effective teachers are those who can stimulate students to *learn* mathematics" (Battista & Clements, 1990, p. 1). When student minds are stimulated, they can more readily build knowledge and develop as critical thinkers. I want to lead my students down a path of exploration and discovery, not misunderstanding, in hopes they become life-long learners. This study will hopefully clear the doubts I still hold about constructivist methods at the primary level.

Rationale

I wanted to lead a non-comparison study of constructivist practices in primary classrooms. In my first year of teaching, I was hesitant to utilize much of my knowledge with constructivism because I was more concerned with becoming familiar with the curriculum. As I reflected on my math instruction, I was able to extract components that were in fact principles of constructivism. With constructivism as a framework, teachers encourage students to make mathematical meaning. Furthermore, constructivist theory requires that the learning environment stimulates student interest in order to enable the learners to develop or construct their *own* meaning. These meanings are fostered in situations that are consistent with societal norms and expectations. Students are best able to construct their own meanings by assuming responsibility and using teachers as guides who only intervene occasionally (Brooks & Brooks, 1993). I found myself being able to pinpoint situations where I did in fact foster student meaning-making by acting as a guide to their understanding of math. I recall asking more students for their reasons for solving a problem a particular way and to explain their answers.

Definition of Terms

Bloom's Taxonomy: a hierarchy of six categories of skills arranged within the cognitive learning domain: knowledge, comprehension, application, analysis, synthesis, and evaluation (Clark, 1999).

Cognitive learning domain: one of the academic learning domains that addresses knowledge where learners comprehend information, organize ideas, and evaluate information and actions (Simpson, 1972).

Constructivism: a theory of knowledge and learning; not a method of teaching. Students build new knowledge on pre-existing knowledge, exploring and discovering through authentic means (Brooks & Brooks, 1993).

Learning domain: includes three types of learning: psychomotor, affective, and cognitive, according to Benjamin Bloom (Simpson, 1972)

Metacognition: thinking about thinking (Gordon, 1996).

Radical constructivism: cognition is considered adaptive in the sense that it is based on and constantly modified by the learner's experience (Boudourides, 1998).

Schema: a mental structure that represents some aspect of the world used to organize current knowledge and provide a framework for future understanding (Wikipedia).

Study Approach

My thesis was a qualitative research project because of the focus I have on individual students. For my project I guided my students to mathematical understanding through discussions and math centers. I worked with students in small groups as well as one-on-one as needed. I took daily observations notes and reflected on the lessons daily by the use of a teaching journal and memos. I kept copies of students' journals and paper center work from a focus group of three students.

Through consistent reflection on my students' learning and my own teaching, I better understood what my students needed in order to be successful in mathematics.

Summary

As we become more enlightened regarding the complexity of childhood development we see that the theory of constructivism appears to meet the needs of children according to their stages of development. We know children learn by exploring and discovering. We know children need support from their peers and more knowledgeable adults in order to construct new knowledge from their schema. Despite all we know about childhood development, why the controversy? Within a constructivist learning environment, children appear to be engaged and deepening their understanding of increasingly more complex mathematical concepts.

Chapter II: Review of the Literature

Introduction

Constructivism is a theory about knowledge and learning. It is not a “new idea”. Constructivism finds its root with psychologists such as Jean Piaget and Lev Vygotsky. One of Piaget’s focuses is on the developmental stages. One cannot learn until developmentally ready. The Zone of Proximal Development is one of Vygotsky’s well known concepts. Teachers scaffold instruction resulting in learners becoming more independent with the new learning. Constructivist learning environments foster critical thinking skills, exploration and discovery. These concepts are associated with Jerome Bruner. Constructivism requires collaboration. Students collaborate with one another to construct new knowledge. Students collaborate with the teacher who functions as a guide to learning, not the main contributor. Reflecting on learning is a key component to constructivism that allows for a deeper understanding of a concept.

A Definition

Constructivism is not a method of teaching, nor is it a strategy; lecture and group work constitute as strategies (Brooks & Brooks, 1993). Furthermore, constructivist theory requires that the learning environment stimulates student interest in order to enable the learners to develop or construct their *own* meaning. Students are able to construct their own meanings by taking charge of their learning and using teachers as facilitators to their learning process (Brooks & Brooks, 1993). The move from a traditional view of learning with the notion that knowledge is transferred and absorbed to the idea that knowledge is actively constructed in the learner’s mind, is

transforming curricula and the learning environments at all levels. In constructivist learning environments, students actively process information by the use of prior knowledge, skills and strategies. As a result, learning is now considered a process that is constructive, cumulative, self-regulated, goal-orientated, situated, and collaborative (De Jager, Jansen, & Reezigt, 2004).

Historical Perspective

Jean Piaget

Renowned developmental psychologist, Jean Piaget, holds a *mild or trivial* view of constructivism. This mild or trivial view stems from his views of the psychological development of children (Building an Understanding of Constructivism, 1995). According to Piaget, knowledge is not passively transmitted by an educator, but actively constructed by the learner (Runesson, 2005). Piaget presents the sociocognitive theory that depends on the social interaction of students which creates cognitive conflict. Cognitive conflict is when students with various thoughts engage in a conversation where they may not agree. Cognitive conflict also occurs when a student is engaged in a problem-solving activity where there is a contradiction between the learner's existing understanding and what the learner experiences. This then results in the learner questioning his or her beliefs and therefore the learner can try out new ideas. The result is Piaget's notion of disequilibrium. "Disequilibrium forces the subject to go beyond his current state and strike out new directions" (Palincsar, 1998, p. 350). As a result, they need to elaborate reasoning and the rationale for their thoughts. In particular, conversation

tasks tend to show more cognitive growth in children than those working alone. Crucial to this theory is the active engagement of students during problem-solving activities (Palincsar, 1998). The fundamental basis of learning according to Jean Piaget is discovery. “To understand is to discover, to reconstruct by rediscovery, and such conditions must be complied with if in the future individuals are to be formed who are capable of production and creativity and not simple repetition” (Building an Understanding of Constructivism, 1995, p. 1). Furthermore, understanding is developed step-by-step through active engagement (Building an Understanding of Constructivism).

No learning can take place unless a learner is developmentally ready for it. Piaget’s approach is based on the notion that knowledge can never be a “‘representation’ of the real world...instead it is the collection of conceptual structures that turn out to be adopted” (Boudourides, 1998, p. 1). Human intellect proceeds through two stages of development: adaptation and organization. Adaptation breaks down into two parts: assimilation and accommodation (Boudourides, 1998). “External events are assimilated into thoughts and...new and unusual mental structures are accommodated into the mental environment” (Boudourides, 1998, p. 2). The organization process is the structuring of the adapted mental material. This process is accomplished through a series of “increasingly complex and integrated tasks” (Boudourides, 1998, p. 2). In other words, the learner is challenged with tasks that become increasingly more complex only when the learner is developmentally prepared for the more challenging tasks. Again, unless

human intellect has not proceeded through the necessary stages of development, no learning can take place.

As an individual constructs new knowledge through the association of new ideas, interactions with objects, and with the transmissions of information from the environment, the information may not be consistent with life experiences. This unbalanced situation is characterized as the constructive error according to Jean Piaget. The constructive error “generates a new intellectual action to reach a new equilibrium...this dynamic process of knowledge construction based on the error is a necessary step towards cognitive development” (Machado, Maia, & Pacheco, 2005, p. 3).

Lev Vygotsky

Like Jean Piaget, Lev Vygotsky was a developmental psychologist. Vygotsky’s relevance to constructivism comes from his theories about language, thought, and mediation by society. Vygotsky takes a *social* version of constructivism where learning cannot be based on direct association. Furthermore, the process of knowing involves others mediated by community culture (Boudourides, 1998). “He sees collaborative action to be shaped in childhood when the convergence of speech and practical activity occurs and entails the instrumental use of social speech” (Boudourides, 1998, p. 2). In addition, Vygotsky believes that thought develops *from* society *to* the individual. Individuals collectively, or individually, can negotiate conceptual change through dialogue because according to Vygotsky, development is determined by language (Boudourides, 1998). Moreover, Vygotsky says that students

learn through “interacting with peers, teachers, manipulative tools, and their contextual setting” (Jaramillo, 1996, p. 3). The interaction with peers may expose students to a variety of prior experiences and spark cognitive conflict that would lead to the construction of knowledge. Interactions with teachers also foster the construction of knowledge when they act as a guide to learning within the Zone of Proximal Development. Manipulative tools enable students to explore and discover concepts that can lead to understanding and construction of knowledge (Jaramillo, 1996).

Vygotsky is recognized mostly for his construct of the Zone of Proximal Development (ZPD). ZPD is determined by the distance between individual capability of solving a problem and the potential development under the guidance of a more knowledgeable adult or peer (Palincsar, 1998). With the ZPD construct, students need to be pushed beyond what they can handle independently under guidance. Vygotsky believes students need to be *guided* by adults or a more knowledgeable peer as well as discover things on their own (Jaramillo, 1996). Generally speaking, where Piaget believes that one cannot learn until they are developmentally ready, Vygotsky believes that learning pushes or leads to development. The Zone of Proximal Development is regarded as a better indicator of cognitive development than what children can accomplish alone. “Productive interactions are those that orient instruction toward the ZPD” Palincsar, 1998, p. 352).

Cognitive development, from the Vygotskian perspective, is studied by examining the processes that individuals participate in when engaged in shared

experiences. Moreover, cognitive development is studied by examining how this engagement influences the engagement in other activities. “Development occurs as children learn general concepts and principles that can be applied to new tasks and problems, whereas from a Piagetian perspective, learning is constrained by development” (Palincsar, 1998, p. 353).

Within the Zone of Proximal Development, others mediate the learning. They act as facilitators to the construction of new knowledge. In the ZPD, teachers scaffold instruction by first activating prior knowledge. As students learn to work within the ZPD, the teacher gradually releases the responsibility of learning onto the student. According to Vygotsky, in the beginning students may need a great deal of support, but eventually teachers lead them to independence. After the concept has been learned, the teacher establishes a new ZPD for the student and once again scaffolds their instruction so that the learner becomes independent (Useful instructional strategies for literature-based instruction, 1997).

Jerome Bruner

Jerome Bruner, Ph.D. is a psychology professor at Harvard University. Bruner has had recent influences on constructivist theory. Bruner’s key ideas are that learning is an active, social process in which students construct new ideas or concepts based on their current knowledge (Mercer, 1995). The level of a learner’s prior knowledge in comparison to the knowledge to be learned cannot be too great. If there is a large gap, students may become overwhelmed and lose interest. Furthermore, students need prior knowledge in order to sustain interest to therefore learn new

material (Wakefield, 1997). He suggests that teachers should encourage students to discover principles by themselves (Mercer, 1995). “The...discovery learning mode requires that the student participates in making many of the decisions about what, how, and when something is to be learned and even plays a major role in making such decision” (Mercer, p. 1). Bruner holds that students should not be told the content by the teacher. Instead, students are expected to explore examples and from them, discover the principles or concepts which are to be learned. According to Bruner, the curriculum should be organized in a way so that students continually build upon what they already know, similar to a spiral (Mercer).

Benjamin Bloom

Educational psychologist Benjamin Bloom is the person responsible for *Bloom's Taxonomy*. Bloom sees three types of academic learning, known as the *learning domains*: psychomotor, affective, and cognitive. The psychomotor domain refers to basic motor skills, coordination, and physical movement. The affective domain deals with a learner's emotions, interest, attention, awareness, and values toward various learning experiences. The cognitive domain addresses knowledge. Within this domain, learners comprehend information, organize ideas, and evaluate information and actions (Simpson, 1972). Constructivism is primarily concerned with the cognitive learning domain.

Bloom's Taxonomy is broken-down into six categories of skills within the cognitive learning domain: knowledge, comprehension, application, analysis, synthesis, and evaluation. These six skills are arranged into a hierarchy on a scale of

difficulty. Learners who demonstrate a more complex level of cognitive thinking are able to perform at the higher end of the taxonomy. Knowledge is the most basic skill whereas evaluation is the highest level on the taxonomy (Clark, 1999). Knowledge deals with defining, naming and memorizing information. Comprehension is the step above knowledge on the taxonomy where information is identified, translated, reviewed, and located. The application level is where information is demonstrated, practiced, and illustrated. The next category on the taxonomy is the analysis level where information is compared and contrasted, criticized, and questioned. Synthesis is where information is arranged, assembled, collected, and formulated. The final category, highest on the hierarchy is evaluation where information is judged, appraised, and supported (Clark).

Knowledge Construction

The theory of constructivism not only encourages meaning making for new learning, but it also enables students to think and work at higher levels all of the time. Higher-order thinking enables students to develop a conceptualized understanding of mathematics (Brooks & Brooks, 1993). When students are challenged to think at a higher level in a constructivist learning environment, they are thereby encouraged to go beyond simple recall (Clark, 1999). In constructivism, teachers would want to plunge more deeply into a topic so that students are better able to use these higher-ordered thinking skills to become critical thinkers and problem-solvers. Even at the elementary level, critical thinking and problem-solving skills can flourish. A person with a constructivist point of view would say, "In reality, no one can *teach*

mathematics. Effective teachers are those who can stimulate students to *learn* mathematics” (Battista & Clements, 1990, p. 1). When student minds are stimulated, they can more readily build knowledge and develop as critical thinkers.

Metacognition

Metacognition is essentially thinking about thinking. “Learners need to be made aware of how they learn, by monitoring and gaining control of their cognitive processes” (Gordon, 1996, p. 1). De Jager, Jansen, and Reezigt (2004) led a comparative study that measures learners’ metacognitive growth in varying learning environments. Metacognition includes two elements: skills and knowledge. It refers to the knowledge that learners hold about their own cognitive performance. Teachers are essential for the development of metacognition because it is not developed automatically. De Jager et al focused on two research questions: Can we measure metacognition adequately by means of a questionnaire? Which effects do learning environments that differ in degree of teacher structuring have on metacognition, and do these learning environment produce differential effects for students of different intelligence levels? (De Jager et al., 2005, p. 182).

The pedagogical strategies for the study included direct instruction and cognitive apprenticeship. The teachers for this group received lessons specifically designed to increase the implementation of direct instruction or cognitive apprenticeship in addition to a 15-hour training and coaching sessions. A control group of teachers was included in this study. These teachers did not indicate that they practiced a specific instructional model and they did not receive any training.

Metacognition was measured for the students by questionnaires, interviews, thinking aloud protocols or simulated tutoring. The pedagogical strategies were measured by means of observations of reading comprehension lessons. The focus of the observations was on the characteristics of direct instruction and cognitive apprenticeship. Some of the characteristics of the direct instruction groups included: retrospect of prior learning, teacher provided instruction in interaction with students, teacher regulating guided practice, independent work, feedback is given during a lesson, and the teacher concluded each lesson with a summary of the content. Characteristics of the cognitive apprenticeship learning environment included: teaching and facilitating the students to activate their prior knowledge, having the teacher propose problems and coaching problem-solving processes, having the teacher fade-out their guidance during cooperative learning experiences, requiring the teacher to model and reflect on the learning experience, and having the teacher discuss the applicability of the content (De Jager et al, 2005, pp. 184 – 185).

Metacognition was measured by means of questionnaires, interviews, thinking aloud protocols, or simulated tutoring. Over the course of a year, the mean scores of metacognitive skills for the direct instruction and cognitive apprenticeship groups experiences a significant gain. The control group scores were lower than the experimental groups. Two important concluding points to this study are direct instruction and cognitive apprenticeship foster metacognition and explicit teacher training and specific attention of teachers for metacognition is needed in order to augment student metacognition (De Jager et al, 2005).. With the development of

metacognition, learners can more readily reflect on their learning and take their thinking to higher level in order to construct new knowledge (Gordon, 1996). Direct instruction and cognitive apprenticeship may support children's development of metacognition because they are exposed to the backgrounds and experiences of their teachers and peers. Learners can then take those experiences and apply those to their own experiences and learning.

Reflective Practitioner

Just as reflection on learning and metacognition are key components for students in a constructivist learning environment, reflection is also vital for practitioners. Reflective practice is a way for teachers to actively seek out opportunities to grow professionally. Reflective practice allows teachers to learn from experience (Clegg, 2003). The ability to reflect *in* action (while doing something) and *on* something (after) has become an important feature of professional development (Atherton, 2003). More experience does not necessarily guarantee more learning (Clegg,). Reflection is a key to active learning as well as sense-making for all learners (Branscombe, Castle, Dorsey, Surbek, & Taylor, 2003). "One cannot be a constructivist teacher without being reflective" (Branscombe et al, 2003, p. 204). Teachers examine their own teaching practices as they pose questions for themselves and answer them through reflection (Branscombe et al).

Reflective practice begins with the examination of a teacher's own actions and beliefs. Once identified, the teacher should describe it in writing and then think deeply about the writing (Shahid, 1997). Reflective practice makes the teacher

engaged in a cycle of thought and action (Branscombe et al, 2003). This process results in a change in behavior and as a result, a teacher can grow professionally (Shahid, 1997). “If we are to become more effective teachers, we need to become more reflective teachers” (Clegg, 2003, p. 1). As cited in Branscombe et al (2003), J. Smyth poses four reflection questions for teachers: As a teacher, what do I do; What does this mean; How did I come to be this way; How might I do things differently (Branscombe et al).

Summary of Historical Perspective and Knowledge Construction

Piaget’s views that learners cannot construct new knowledge until they are developmentally ready for it differs significantly from Vygotsky’s idea that teachers scaffold instruction and development only happens when the individual learner is ready. Students are pushed to explore and discover concepts. They first activate their prior knowledge and build from the intelligences of others, and under the guidance of a teacher. As students plunge deeper in to understanding concepts, they are required to think more critically. Furthermore, students are able to think at higher levels on Bloom’s Taxonomy because they are constantly reflecting on their learning which causes them to achieve more critical thinking skills.

Implications for Mathematics Curriculum, Instruction and Assessment

In a constructivist classroom setting, the curriculum is presented in a whole to part manner with an emphasis on the larger concept. Curricular activities rely heavily on primary sources or data and manipulative materials. Students are viewed as thinkers with emerging theories of the world. They are encouraged to reflect on their

thinking (metacognition) and learning. As a result, pursuing student questions and discussions are highly valued. Assessment of student learning is interwoven with instruction. It is done through teacher observation during discussions, activities, portfolios, and exhibitions (Brooks & Brooks, 1993).

There are some noticeable shifts in the performance indicators concerning emphasis of students' engagement in their learning and therefore, their understanding with the new New York State Regents mathematical standards. Key words that denote a shift in emphasis include: *support*, *evaluate*, *apply*, *represent*, *develop*, *apply*, and *draw conclusions*. The new wordings for particular performance indicators call for more critical thinking skills (Alignment modifications, pp. 1-3). The former standards for mathematics were more broad across concepts and grade levels. The new standards are broken down into specific categories and grade levels.

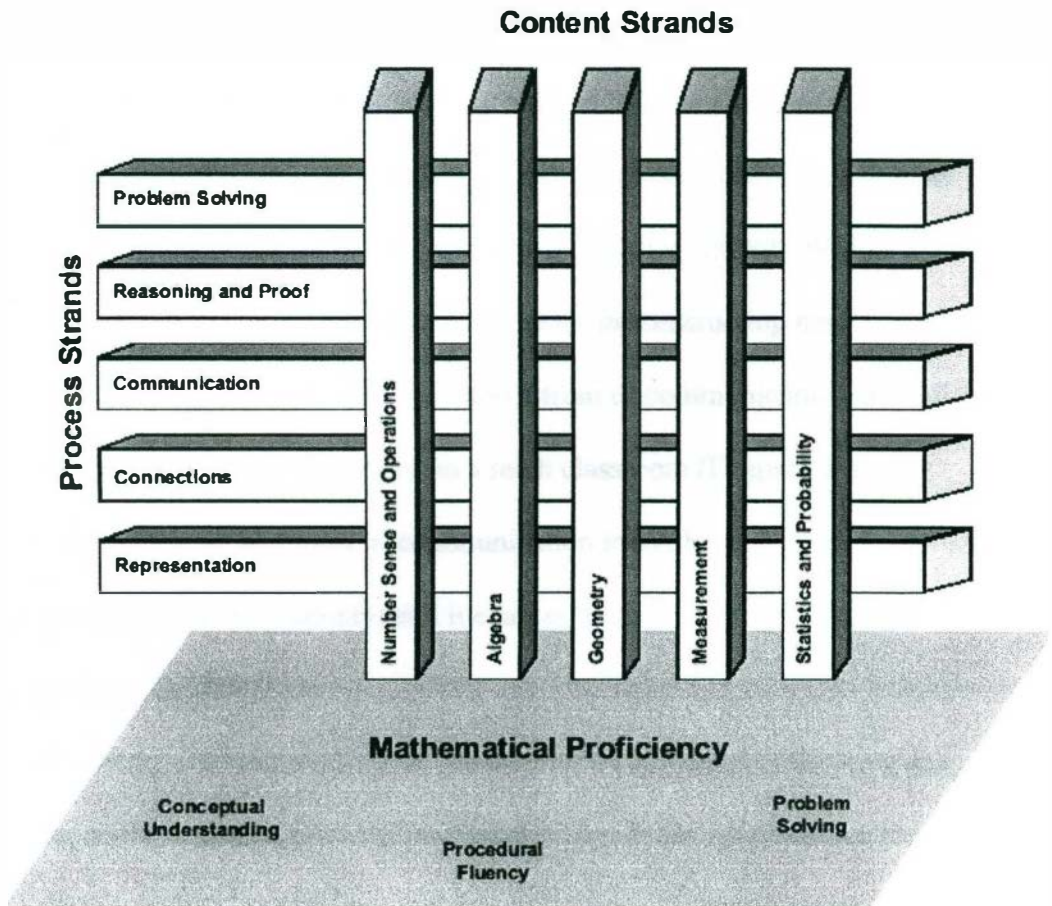
As a result of the revamped emphasis on critical thinking skills for mathematical concepts, pedagogical changes need to take place. The transition from learning mathematics through isolated facts and skills to students achieving conceptual understanding, procedural fluency, and problem-solving abilities is evident by the emphasis on critical thinking skills and the development of students' understanding of mathematical procedures. "The study of mathematics is a study of ideas and concepts. Yes, students need to know the procedures, but knowledge of those procedures without understanding is surface knowledge that is virtually meaningless" (Kadamus, 2005, p. 2). Process performance indicators and content performance indicators were developed to show the integration of process and content

(Kadamus). (*Approximate percentage*, p.1). Teachers need to now gear their instruction to developing these critical thinking and problem-solving skills. They need to focus more on the process of solving a mathematical problem rather than the answer in order to foster the development of mathematical understanding that the new learning standards require.

New York State Standards for Mathematics

The following diagram shows the vertical and horizontal relationship of the process and content strands for the New York State Standards for Mathematics (*Introduction*, p. 3). Within each of the horizontal process strands, there is a content strand found within. Number Sense and Operations is one of the largest mathematical content focuses for first grade. The state curriculum for first grade only takes this content strand to Representation, Connections, and eventually Communication. Number Sense and Operations are explored more in depth for the first grade curriculum as opposed to a breadth of math topics being studied. As students move up in grade levels, they are more focused on the higher end of the process strands. The content strands are all still taught, but the focus is more on critical thinking and problem-solving. In other words, the higher up the process strand, there more critical thinking skills are required within each content level. In first grade, a little bit of geometry is taught. There is a focus on the process strands of representation and connections. In fourth grade, geometry is still taught, but the focus is geared toward the process strand of communication. Geometry is taught is eighth grade. The focus is now on the process strands Reasoning and Proof and Problem-Solving.

New York State Mathematics Standard 3



Adapted from *Mathematics Framework for the 1996, 2000, and 2003 National Assessment of Educational Progress*.

The new Regents mathematical standards focus on the process. They are designed to foster a deep understanding for mathematical ideas and concepts where students are encouraged to problem-solve and think critically. The new New York State Mathematics Standards do not call for the memorization of facts and procedures (Connors, 2006, *Standards*).

Writing as Communication

Incorporating literacy instruction can improve students' ability to learn and understand mathematical concepts. Two benefits from literacy instruction in a mathematics classroom are that students communicate to learn mathematics and they learn to communicate mathematically (Draper, 2002). Moreover, communication in mathematics can bolster confidence in young children (Checkly, 2006). Within the theory of constructivism, communication is a key factor in constructing new knowledge. Since writing is a part of literacy and a form of communication, it would follow that constructivism supports writing in a math classroom (Draper). Students writing about their thinking as a form of communication in mathematics helps students to make connections (Checkly) and it enables them to use higher-ordered thinking skills (Russell, 2004).

Journal writing can help students to enhance their mathematical thinking and communication skills. Journaling through math can also provide opportunities for students to self-assess their learning and can therefore be a valuable assessment tool (Russell, 2004). Writing in math not only acts as an alternative assessment tool but it also prepares students for high-stakes tests (Checkly, 2006). Students have to be able to think about what he or she did in order to communicate it through writing. Students can gain valuable insight and feedback about math and the problem solving process. Journaling can help clarify thinking when one has to write about problem solving strategies (Russell). When students are expected to explain their answers and discuss their strategies, they are solidifying their understanding for math concepts (Checkly).

Baxter, Olson, Woodward (2005) led a one year study with four seventh grade students in a low-track mathematics class. The purpose of the study was to see what writing reveals about low-achieving mathematical proficiency. Three questions that guided the study were: What does writing reveal about the students' conceptual understanding? What does writing reveal about the students' strategic competence? What does writing reveal about the students adaptive reasoning? (Baxter et al., 2005, p. 120). As cited in Baxter et al. (2005), students need to communicate their mathematical thinking in order to be engaged in a process of active construction of knowledge (Ball, 1993; Cobb, Wood, Yackel, & McNeal, 1992; Lampert & Blunk, 1998; National Council of Teachers of Mathematics, 2000; O'Connor & Michaels, 1996). The five strands needed for proficiency in mathematics include conceptual understanding, procedural fluency, strategic competence, the ability to formulate and represent problems, adaptive reasoning (the capacity for logical thought, explanation, and justification), and finally productive disposition (the notion that mathematics is useful and makes sense) (Baxter et al).

Students wrote in their journals on a weekly basis in order to communicate their ideas other than orally. The teacher developed activities that would relate to the mathematical concepts in class, improve awareness of thought processes in her students, and facilitate "personal ownership" of knowledge (Baxter et al., 2005, p. 212). At the beginning of the study, the writing prompts dealt with feeling and opinions. As the year progressed, the prompts moved to ones that would elicit responses about their mathematical thinking. This shift was made in hopes that

students would feel more confident in writing about more complex mathematical topics. Mid-way through the study, the teacher asked her students to justify their explanations through writing. This higher-level thinking continued for the duration of the study. Journals were also a place for daily assessment on the concept of the day.

One particular noteworthy implication for practice brought out by this study was that the teacher was amazed by the students' ability to communicate mathematically (Baxter et al., 2005). Many of the low-achieving students were reluctant to raise their hand during discussions. If called on, students responded with one- or two-word responses. However, in their journals, students were able to communicate through drawings, symbols and words to explain their mathematical thinking. These low-achieving students shifted from passive learners to taking a more active role. Through writing, the teacher was able to see that these low-achieving students had gaps of understanding, yet these students were by "no means a homogeneous group" (Baxter et al., p. 126). A student who never participated in discussions attempted to explain his reasoning using mathematical concepts. He would use words, symbols, and drawings to represent adaptive reasoning and strategic competence. Another student who also lacked confidence was able to express her approach to problem solving in journals. In her journal, this student was able to consistently demonstrate her conceptual understanding. This particular student occasionally expressed her hesitation and would attempt to describe her thinking privately would otherwise would make her feel embarrassed in front of her peers. This student often demonstrated concrete understanding of mathematics as

opposed to abstract. Yet, writing allowed this student who demonstrated a large discrepancy for mathematical understanding tools that supported her mathematical thinking (Baxter et al., 2005).

The Baxter et al. (2005) study concluded that the low-achieving students benefited from the use of these journals mainly because it got them engaged and they eventually were able to demonstrate the five strands of mathematical proficiency. Journals showed the teacher more than just right and wrong answers. As time progressed, the teacher was able to get a more complete picture of what students did and did not understand. On the other hand, a draw back to journal writing that was brought about from this study was the workload for the teacher. It took the teacher a lot of time to read and respond in students' journals. Yet again, "The additional time needed to read the journals was offset by important benefits" (Baxter et al., p. 132). Finally, the journals not only showed students' thinking and understanding which therefore drove the teacher's planning and instruction, but it was also a way for students to communicate privately. With the use of manipulative tools, students can explore and discover the mathematical concepts and then carry that construction of knowledge into their journal writing. These tools enable hands-on learners to experience the mathematical concept before they have to verbalize it or put it into writing.

Math Games as Opportunities for Learning

Math games are an excellent source of motivation and active engagement for students learning in a constructivist learning environment. They can also act as a

form of assessment of students' mathematical understanding. Games can help children to learn math concepts as well as develop social competence. Not all methods for using math games are equally good at promoting social and intellectual development. Not all math games deal with numbers. Some math games take on a more drill and practice connotation. Games where there is competition or where students need to solve a problem before proceeding are examples of drill and practice type games. These games do have a place within the curriculum for mathematics, however, they have a limited value from a constructivist perspective (DeVries, Edmiaston, Hildebrandt, Sales, Zan, 2002).

Math games can be adjusted to meet the needs of the children. Teachers can observe their students' developmental differences through math games. Teachers can assess the strategies students use to solve a problem (Wakefeld, 1997), they can see how the strands of mathematical processes are being demonstrated, and they can use these observations to facilitate their planning and instruction (Baxter et al., 2005). Students may have some say in the rules of the games and can even adjust the games to meet their interests. Students tend to crave challenges and have the capabilities to pose meaningful problems to themselves if given the opportunity to do so (DeVries et al., 2002).

A connection can be made between math games and research on the importance of play in young children. Play at the center of a developmentally sensitive curriculum enables children to utilize their imagination and problem-solving skills in order to make connections between prior and new learning (Isenberg &

Jalongo, 1997). Piaget saw play as a vital component in childhood development. Play has a large role in the formation of symbolic thought and socioemotional development in children. Much of what is labeled “play” in early education is actually “work”. Examples of activities of “our recent efforts to specify the logico-mathematical relationships constructed by children in activities involving shadows, cooking, making musical instruments, draining and movement of water in tubes, and pattern blocks” (De Vries, Zan, Hildebrandt, Edmiaston, & Sales, 2002). Desirable work in a constructivist learning environment occurs when children are pursuing their own purposes in figuring out how to do something (De Vries et al, 2002).

Games in Collaborative Groups

Students can explore math concepts independently through games, in large group settings, as well as cooperative groups. Cooperative learning situations are where students interact in collaboration with others to foster learning. Children can learn and teach one another through discussions and debates in order to construct new learning (Morrow & Strickland, 2000). “Social interaction and collaboration within small groups of children promotes achievement and productivity. According to researchers, cooperative learning succeeds because it allows children to explain material to each other, listen to each other’s explanations, and arrive at a joint understanding of what has been shared” (Morrow & Strickland, p. 93). Just as nursery rhymes and listening and looking picture books help children to read, children acquire a sense of number when they have early opportunities to think about “number in action” (Wakefeld, 1997). Memorizing math facts can prevent children

from actively thinking about number solutions for themselves resulting in little mental growth. Dice, card and board games are a good solution to still have children practice mathematical concepts repeatedly, but students will not grow bored. With this active thinking, students tend to remember the concepts resulting in constructing mathematical understanding (Wakefeld). Coupled with collaborative learning groups, students take their prior experiences and challenge one another's thinking. This idea of students challenging one another through games is an example of Piaget's cognitive dissonance (De Vries et al, 2002). As mentioned above, according to Piaget, disequilibrium forces the learner to go beyond his or her current state and "strike out new directions" (Palincsar, 1998, p. 350).

In cooperative learning situations, students with various intelligences, diverse backgrounds, and different special needs are more likely to be accepted as opposed to traditional classroom settings (Morrow & Strickland, 2000). Students build new knowledge on their prior experiences with the guidance of a teacher, but also the prior knowledge and experiences of their peers. Additionally, students can construct new knowledge with their peers easily when the theory of multiple intelligences is applied.

"Today's effective teacher will be aware of the fact that there is more than one area in which a child can excel" (Isenberg & Jalongo, 1997, p. 50). Howard Gardner, professor at Harvard University, is the man responsible for the theory of multiple intelligences. The theory was developed not to act as an educational policy, but as an explanation of how the mind works. The nine multiple intelligences include linguistic, logical-mathematical, musical, spatial, bodily-kinesthetic, naturalistic,

interpersonal, intrapersonal, and existential. The theory provides a profile of a learner's intelligence that consists of a combination of strengths and weaknesses (Gardner, Kornhaber & Moran, 2006). "One 'IQ' measure is insufficient to evaluate, label, and plan educational programs for all students. Adopting a multiple intelligences approach can bring about a quiet revolution in the ways students see themselves and others" (Gardner, Kornhaber & Moran, p. 23). Utilizing the Gardner's theory, teachers can provide students with rich experiences that enable them to observe student performances to find misunderstandings and to guide students to achieve superior understandings. Many times these experiences are in collaborative situations where students can learn more by building off of one another's intelligences and therefore participate more actively in their own learning, achieving greater understanding (Gardner, Kornhaber & Moran). In collaborative situations where students play games, children learn and improve their mathematical understanding because each student comes to the group with different intelligences and experiences. "Children learn and improve their understanding of number as they encounter new and varied number experiences that challenge their previous understanding... The debate and exchange of view that occur naturally during dice, card, and board games encourage children to examine their own thinking" (Wakefeld, 1997). This notion of examining one's own thinking goes back to metacognition where knowledge can be constructed as students reflect on their learning (De Jager, 2004).

Summary

The theory of constructivism has its roots in developmental psychology with Jean Piaget. It calls for higher-order thinking skills so that students can think more deeply and more critically about mathematics. Constructivism calls for reflections by both teacher and student to continue the cycle of learning. New York State has made a move toward more sophisticated math standards that expect students to think at higher levels. As a result, students really need to have deep mathematical understanding.

Chapter III: Methods and Procedures

Introduction

In this chapter, I outline the methods and procedures for conducting my action research project. This study focused on a first grade class of 24 general education students during the 2006-2007 school year. The school is a K-5 building of approximately 550 students within a suburban school district in Western New York. My class has 10 boys and 14 girls. There were no students with known learning disabilities. In my analysis I focused primarily on three students: one above grade level boy, one on grade level boy and one girl working below grade level. All students were participants for data analysis when I used my teaching journal as a data collection tool. Class discussions as well as general observation notes were reflected on in my teaching journal.

Assumptions and Participants

I made anecdotal notes on all of my students and reflected on the discussions we had both in large and small group settings, although my primary focus was on three students. I chose three students of various academic ability levels. All three students have attended full-day kindergarten. Each of these students participated in whole group discussions, independent work time, and centers. When describing each student, he/she was given a pseudonym.

The first case study student, Skyler, attended the school in kindergarten. He demonstrated at grade level and above grade level progress in kindergarten in terms of counting, one-to-one correspondence, and recognition of patterns and names of

shapes. Skyler has also met and exceeded all standards in first grade. He performed well in whole group discussions, small group work sessions, and he worked well independently. Skyler tended to finish his work early and rarely needed the support of an adult. He was always willing to take on more challenging work. Skyler typically worked in a systematic way that he could easily explain to others. Although he first relied on pictures to solve a problem, he was easily prompted to use a variety of other strategies.

Jasmine is the second case study. She is a student who tended to work below grade level. She came from a city school district. Her academic performance at the other school for kindergarten as well as first grade was below grade level. She was not consistent for using a particular strategy to solve a problem. Sometimes she immediately wrote a number sentence and sometimes she would draw pictures. Jasmine struggled with reading problems and she typically needed a strong adult presence in order to understand what a problem was asking. Jasmine performed well on worksheets. She rarely needed support for completing addition and subtraction worksheets.

Matthew, the third case study student, tended to work on grade level. He demonstrated progress that met the standards for first grade. He has even met some above grade level expectations first grade. Even in kindergarten, Mathew met grade level standards. At times, Matthew's behavior inhibited his ability to perform. Strong adult presence allowed for Matthew to control his behavior enabling him to demonstrate his full potential. In large group meeting, Matthew was often distracted

which resulted in his own confusion. However, when Matthew was on task, he participated in discussions. If Matthew was not distracted by his peers, he would work well independently. His ability to perform well in a group was not consistent. However, strong adult presence kept Matthew's behavior under control during small group work sessions.

The materials needed to guide students through a meaningful whole group discussion were very accessible. They included a white board, chart paper, number lines, a pointer, and various manipulative tools (i.e. blocks, tangrams, base 10 blocks, pattern blocks, counters, linking cubes, etc.). The materials for centers were organized into five buckets. Each bucket contained the activity students must complete as well as cards to play various *Investigations* (2004) card games to reinforce previous concepts (Appendix P). There were many lessons where students were expected to complete a journal page or a worksheet independently either before or after the center activities. Students worked at tables that seated no more than five per table. The tables are spread out like a horseshoe with the carpet area in the middle. The fluorescent lights are turned off and four lamps spread out around the room are turned on to signal to the students that they need to work in a quiet whispering voice.

The math block is approximately 45 minutes. Students have 15 minutes to work at two centers per day. The remaining time is left for whole group discussions and occasional independent work time. There was a classroom aide for 30 minutes during the centers block, Monday through Thursday. A parent volunteer has been in

the classroom for the duration of the math time on Wednesdays. Occasionally, undergraduate students have come in to observe and work with students.

During the mathematics block, I typically pull a student from each center group to work on skills at his or her instructional level. I often observe students working in their center groups and I take anecdotal records. The notes I take range from how well particular students work in a group to how students work with the mathematical concepts. I typically begin and end each math block with a meeting. Sometimes these meetings are to review as well as use the time to motivate my students. Additionally, I use the meetings to teach a mini-lesson.

Research Questions

My primary research question for this study is what happens when constructivist principles form the basis for mathematics instruction in a primary classroom? The following is a list of sub-questions that guided the study: How do first grade math journals guide students to deeper understandings of math concepts? What teaching strategies are useful in scaffolding students' meaning making as they use math journals? In what ways can I change my teaching practices and adapt the curriculum provided by the school in order to teach from a constructivist perspective? What does student engagement look like when you ground instruction and curriculum in constructivist principles? In what ways are student attitudes affected by math instruction that is grounded in constructivist principles?

Instruments

In order to tackle my research questions, I equipped myself with various forms of data-collecting tools. These data-collecting tools included child interviews, a teaching journal, anecdotal records, student math journals, photographs, student artifacts, and lesson plans. In order to determine relevant data, I took into account the setting for data collection, events that occur, the people involved, and physical evidence. Most of the data collected was within the math time where students were working in a small guided math groups with me, working independently at their seats, or in small groups around the room. As mentioned above, a parent volunteer worked with students once a week and there was also an occasional aide in the classroom. All students with parental informed consent were included in the study.

The data collected from the student interviews (Appendices C and D) acted as personal accounts of student attitudes that were used throughout the duration of the study. I administered the first interview questions (Appendix C) at the start of the project. I administered the second set of interview questions (Appendix D) a week prior to the conclusions of the study. Both interviews were administered individually. I verbally asked the questions, the students responded verbally as I wrote their answers on my interview sheet. Both interviews included questions regarding student attitudes toward mathematics as well as attitudes toward working in small groups and centers. This information has aided me in answering the sub-question: In what ways are student attitudes affected by math instruction that is grounded in constructivist principles?

I wrote anecdotal records to collect data on a daily basis. These data were collected in small, guided math group settings as well as during observation periods while students worked in cooperative groups as well as independently. I looked for students making meaning of the math concepts, connections to real-world settings, as well as various strategies students generate to problem solve. As my students worked in groups, I was curious to see how children worked with their peers to show more cognitive growth than children working alone (Palinscar, 1998). I was able to write a few notes during class. Immediately after school I looked at the notes taken during class and wrote further reflections.

Daily, I gave students Blackline Masters from the *Investigations* (2004) math program to use as their math journals (Appendices F – M). I first explained the directions to the class as a whole group and modeled similar problems. I instructed students that they could answer the journal questions with numbers, pictures, or words. I would also instruct students to choose a different strategy for solving the problem if they finished early. Data from the math journals is the physical evidence of students growing in mathematical understanding. I made photocopies of these journals immediately after the mathematics block. I wrote notes directly on the copies of the journals, highlighting key conversation points I had with the students. The journals have been a place where students created solution strategies and made connections to other math concepts and to the real-world. The students' responsibility has been more than just completing an assigned task. Their responsibility was making sense and communicating about mathematics (Battista &

Clements, 1990). “When students can explain how they solved a particular problem, when they can discuss their strategies they solidify their understanding, say educators” (Checkly, 2006, p. 6). This solidity in mathematical understanding makes critical thinking and problem-solving skills prosper.

I used anecdotal records as I facilitated class discussions about new mathematics concepts. I spoke with my students about their journals in order to act as a guide to their mathematical understanding. “Interactions such as those achieved through classroom discussion are thought to provide mechanisms for enhancing higher-ordered thinking” (Palinscar, 1998, p. 350). I also used the anecdotal notes to record student discussions as they worked in their center groups. These notes were taken during the mathematics block. I wrote notes on copies of the Blackline Master journal pages. This data helped me answer two specific sub-questions: How do first grade math journals guide students to deeper understandings of math concepts? What teaching strategies are useful in scaffolding students’ meaning making as they use math journals?

I collected data on students at work through photographs and artifacts of student work. The artifacts I decided to use were any materials we worked on for the duration of the study. I used all of the math journal pages (Appendices F – M) and all papers from centers (Appendices E, P – U). I took photographs three different times during the study. The photographs were all of students working in their center groups. In the photographs, the center buckets with all materials are visible (Appendix N). Students worked at five tables with no more than five students per

group. These artifacts helped me to answer the sub-questions: What does student engagement look like when you ground instruction and curriculum in constructivist principles? How do first grade math journals guide students to deeper understandings of math concepts?

Photographs and student artifacts coupled with my teaching journal, enabled me to better determine in what ways I could change my teaching practices and adapt the curriculum provided by the school in order to teach from a constructivist perspective. I set aside ten minutes each day to write general observations, specific instances where I saw student understanding, and I also wrote about the management of the mathematics block. I reflected on both the positive aspects of the mathematics block as well as the down-falls. The teaching journal helped me answer several sub-questions: What does student engagement look like when you ground instruction and curriculum in constructivist principles? In what ways can I change my teaching practices and adapt the curriculum provided by the school in order to teach from a constructivist perspective? How do first grade math journals guide students to deeper understandings of math concepts? What teaching strategies are useful in scaffolding students' meaning making as they use math journals?

Procedures

Every day we met as a whole group for a mini-lesson. I guided students into a discussion where we explored new mathematical concepts together. My students raised questions and made connections to prior learning, just as I expected. After the whole group mini-lesson, students split into their center groups. Students were

grouped heterogeneously in groups of five so that I could pull one student from each center in order to differentiate their learning experiences. I also had the flexibility with this set-up to work with a center group and guide them in the cooperative learning experience where they could construct new knowledge as they discovered the math concept together. I tried to utilize students' multiple intelligences as I worked with them in a small group setting.

The center activities were differentiated so that within each of the heterogeneous groups, each student was working at her or his level, yet still developing mathematical understanding. The activities were generated from the *Scott Foresman* (2002) and *Investigations* (2004) math programs. Students kept their weekly work in a team folder. From here, I easily copied, dated and filed the data. I organized the data for my three focus group students by each individual student. When it was time for the data analysis stage, I was able to easily rearrange the artifacts and group by activities in order to look at the data in a different way.

Data were collected every day from February 26 – April 4, 2007. I took anecdotal records on a daily basis. I also wrote in a teaching journal on a daily basis to reflect on the lesson as well as highlighting key points of the discussion of the day. Occasional memos helped me to further reflect on how students are becoming engaged in their learning and achieving mathematical understanding. I needed to not only plan for whole group mini-lessons where I needed to be prepared to *guide* the discussion, not lead it, but I also needed to have five centers prepared. Students kept their paper work for centers in a team folder so I could easily manage and collect the

needed data. The data I collected was copied with pseudonyms, dated, and filed into a locked filing cabinet. Included in the filing cabinet was the parent informed consent.

Limitations

Grounding instruction in constructivist theory takes a lot of time on the teacher's end to plan lessons and prepare materials. Not only did I need to plan mini-lessons, but had to plan five differentiated activities for centers. However, once the center activities were planned they were left out for two weeks. In addition to the previous limitations, I also needed to prepare materials and activities for working in small, guided math groups. Setting aside time every day to reflect was a challenge, but being consistently organized made the task possible.

Data Analysis

I began with one kind of data source. I dated and made copies of the data and put them in folders. The folders were organized according to each case study student. When analyzing data, I sorted the information into categories according to larger concepts. These concepts were derived from the sub-questions. The information I sorted included topics such as students' problem-solving skills, strategies for solving problems, patterns in mathematics, misconceptions, and connections to other mathematical concepts. The data were repeated if it fell into more than one category. For example, a student may have used both pictures and number patterns to solve the Cats and Paws journal (Appendix J). First a student may have drawn the picture of four cats then wrote the number 4 under each cat and counted by fours to get to

sixteen. Another example is if a student used patterns to solve a problem that might not have worked. I placed the data in both the misconception category as well as strategies for solving a problem. This made cross-referencing the data accessible and easy to manage as well as organize. The three main concepts I focused on were thinking in constructivism, mathematical meaning-making, and communication and assessment.

In order to analyze the collected data appropriately, I set aside ten minutes every day to reflect in my teaching journal. This enabled me to remain consistent in my data collection techniques. Also, ongoing analysis helps with consistency in data collection. With consistency, I can recognize patterns, misconceptions, and understanding of the mathematical concepts. Here I reviewed math journals, photographs, and anecdotal records in response to the question: What happens when constructivist principles form the basis for mathematics instruction in a primary classroom? Basically I wrote about the students making connections to other math concepts and to the real world. The timeline for this project was six weeks. Math instruction was five times a week for about 45 minutes per session.

The variety of data collection techniques and the frequency with which data were collected allowed for an increase in the validity and reliability of the research. “Triangulation involves the use of multiple and different sources, methods, and perspectives to corroborate, elaborate, or illuminate the research problem and its outcomes” (Stringer, 2004, p. 58). The data sources for my thesis were myself and the students. The data sources included even more variety: student interviews,

student work, discussion notes, anecdotal records, and my reflections in a journal. To further provide evidence for validity and reliability, all student work was based on lesson ideas from the *Scott Forseman* (2002) math program and the *Investigations* (2004) program. Finally, the activities and discussion for these math lessons were in conjunction to the concepts found in literature, previous studies, and renowned theorists.

The data analysis stage is where I reflected on what I saw during data collection. According to Stringer (2004), in the *Look-Think-Act* cycle, the *Think* stage is the data analysis. “The Think component indicates the need for participants to *reflect* on the information they have gathered, and transform the sometimes large and unwieldy body of information into relatively compact system of ideas and concepts that can be applied to solutions to the problem at hand” (Stringer, 2004, p. 97). As I broke down the data into categories, I first laid out all of the research questions. I wrote memos to myself regarding the data for each student. These memos consisted on notes that highlighted strategies for solving a problem, misconceptions, patterns in mathematics, thinking in constructivism, mathematical meaning-making, and communication in mathematics. I then used these notes to categorize the data at the analysis stage for each student. Next, I grouped the sub-questions according to where they fit best according to the categories of thinking in constructivism, mathematical meaning-making, and communication and assessment. I constantly moved data between the categories in order to compare the three case

study students as well as to compare different data samples for each individual student.

I mainly looked at one case study student at a time to answer the sub-questions within the categories in order to gain insight to each student's mathematical understanding. I also analyzed in a comparative way with similar data samples across the students. For example, I looked at the Dinosaurs and Tigers journal (Appendix H) and would analyze how each case study student answered the question. This enabled me to answer the only sub-question that was not grouped in one of the three categories: In what ways can I change my teaching practices and adapt the curriculum provided by the school in order to teach from a constructivist point of view. As I looked at similar data samples across the three students, I was able to see how their differences in learning style, strengths, and short-comings influenced my instructional decisions.

Time Schedule

The math block was approximately 45 minutes every day. I began collecting data on February 27, 2007 and stopped collecting data on April 4, 2007. That gave me about six weeks of solid data collection from various resources. Two similar student surveys were administered, one at the start of the study and one at its conclusion. The concept for the first week of the study was representing a number by writing or drawing number sentences. The first week of the study also included a review of combinations of a number where students found a pattern (Appendices F-H).

For the duration of the study, one of the center activities that each student attended once or twice a week was Today's Magic Number (Appendix E). This is a self-differentiated center where students chose a number and came up with different ways of representing that number (Appendix E). In the following weeks we continued to work with the concept of patterns, but extended to incorporate other problem solving strategies such as using picture, words, or numbers. These activities also worked on solving word problems.

Summary

Staying organized and maintaining a schedule of reflection time enabled me to answer the sub-questions with multiple sources to validate my findings. I used student interviews, journals, worksheets, and anecdotal notes as my main sources of data. I also relied on my teaching journal, memos, and observations to further analyze my students thinking in constructivism and problem solving strategies. I focused on three students for particular data, yet still reflected on the class as a whole to help me answer my main research question: what happens when constructivist principles form the basis for mathematics instruction in a primary classroom?

Chapter IV: Results

The purpose of this study was for me to see what happens when constructivist principles lay the groundwork for mathematics instruction in a primary math setting. I wanted to see how math journals and math centers foster mathematical meaning-making and deepen students' understanding of concepts. This project was intended for me to reflect and modify my teaching strategies so that I may better scaffold students' meaning-making skills. Furthermore, through personal reflection on my teaching and my students' engagement and learning through this process, I wanted to know in what ways I could change my teaching practices and adapt the curriculum provided by the school in order to teach from a constructivist perspective. Finally, I was curious about the role that attitudes of teachers and students play in a constructivist learning environment.

The following are case studies for each of the three students in my focus group. The first student, Skyler, works above grade level, is eager to participate in any learning situation and consistently completes his work on time. The second student, Jasmine, is inconsistent in terms of working on or below grade level. She requires a strong prescription for her glasses and she has some delay in her oral language skills. This student occasionally completes her work on time, however, she always tries her best. The third student, Mathew, is currently meeting grade level expectations. However, he requires small group or one-on-one support to re-teach concepts.

When analyzing data across the three case studies, I looked at problem-solving skills and strategies for solving a problem. I looked at the strategies students relied on more readily as well as the strategies they needed support carrying-out. I also looked at the patterns generated in the teaching journals and if the concept was carried over to a new problem-solving activity. I analyzed misconceptions the students had and varied my level of support in order to move the students through their ZPDs. I looked at the extent of prior knowledge and the ability to make real-world connections for each student. Finally, I analyzed in comparison how math journals deepen students' understandings of math concepts and the degree of students' engagement when instruction and curriculum was grounded in constructivist principles.

Case Study #1 – Skyler

As mentioned above, Skyler constantly works above grade level expectations. He completes his work before other students. He always takes the challenges presented to him, especially during centers. In the first student interview conducted in February (Appendix C), Skyler said that he only “kind of” likes math. He further stated that he does not like doing worksheets and prefers doing math centers. Skyler’s reasoning for preferring centers is because he gets to do different games and be with his friends.

Thinking in Constructivism

How do first grade math journals guide students to deeper understandings of math concepts?

At the start of this project, the students' math journals were bound journals for students to work in. It did not take long to realize that the journals did not provide sufficient space for the students to work, especially when students were asked to complete a pattern (Appendices E – H). The *Investigations* (2004) math program is grounded in constructivist principles. The *Math Investigations* (2004) program provides Blackline Masters for students to journal responses. The Blackline Masters pose problems for students to solve which are grounded in constructivist principles. These Masters allow for flexibility when solving the problem. The directions in all of these forms of journals encourage students to keep track of their work by using pictures, numbers, or words. For the problems included in both Appendices G and H, Skyler used pictures to solve the pattern. Figure 4.1 shows how Skyler solved the combinations of ten patterns in a systematic manner on February 27. The question posed in Appendix H for the Math Investigations Blackline Master says: I have 10 dinosaurs and tigers. How many of each could I have? Keep track of your work. You may use pictures, numbers, or words (*Investigations*, 2004, p. 170).

```

OOOOOOOOOO
□OOOOOOOOO
□□OOOOOOOO
□□□OOOOOOO
□□□□OOOOOO
□□□□□OOOOO
□□□□□□OOOO
□□□□□□□OOO
□□□□□□□□OO
□□□□□□□□□O
□□□□□□□□□□

```

Figure 4.1. 10 Dinosaurs and Tigers Problem – Skyler

From this particular sample of Skyler's math journal, I can clearly see how he understands the math concepts. I guided Skyler to a deeper understanding of this math concept of using patterns to solve a problem when I asked him to explain why he solved the problem this way. Skyler responded, "There are many different ways to have dinosaurs and tigers. I can start with ten dinosaurs; I could also have ten tigers. I needed to be organized so I started with ten circles with are dinosaurs then the next line I have one tiger [square] and only nine dinosaurs [circles] and one plus nine equals ten." Skyler's work showed me that he used his prior knowledge of patterns to solve this problem. He knew that patterns are predictable. As he solved this problem, he used a predictable pattern of first using all dinosaurs, then one tiger, followed by two tigers and so forth.

When I looked back at Skyler's journal of the Dinosaurs and Tigers problem (Appendix H) the next day, I noticed that there were small ticks at the end of each line. The marks appeared to be purposeful which indicates to me that he was checking his work to see how many combinations he could have. For the Oranges, Cherries, and Grapes problem (Appendix G) which was given on February 28, Skyler numbered each line to keep track. When I asked Skyler why he used the tick marks on the Dinosaurs and Tigers problem and why he numbered the lines of the Oranges, Cherries, and Grapes problem, he said that it helps him to stay organized and neat. "I won't lose track of what I am doing."

As the month went on, I noticed that Skyler's first choice strategy to solve a problem was to use pictures. I also encouraged him to use words and numbers so he

could be challenged, as well as develop a variety of problem solving strategies that could be carried over to other mathematical concepts. Since Skyler was always the first student to complete his work, this also gave him something else to work on as the other students were finishing their work. At the end of the data collection period of the project, Skyler was using pictures, numbers, and sentences to solve and explain the problems presented to him. Sometimes Skyler would use pictures and number at the same time to solve a problem then add the writing piece to explain his drawings. Occasionally Skyler would use pictures and words to solve a problem then write a simple number sentence that would have also answered the question. For example, in Feet, Fingers, and Legs (Appendix L) the problem two asks for the number of feet that are at a bus stop where nine children are waiting. Figure 4.2 shows how Skyler answered this problem using pictures and numbers on April 4:

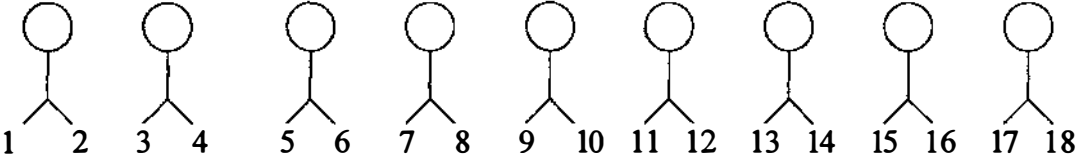


Figure 4.2. Feet, Fingers, and Legs Problem – Skyler

When I asked Skyler how he got to 18, he said, “I drew nine children and each person has two feet so I wrote numbers on each person’s foot.” He then wrote the sentence, “It is 18. I also counted.” This sentence showed me that he is attempting to explain how he solved the problem. With some guidance and minimal prompting, Skyler could have been expected to perhaps add “I counted the number of feet of nine

children”. He knew what he meant in his head because he was able to explain it to me. This strategy also showed me that Skyler understands sequence. As he drew the picture to solve the problem, he first read that there were nine children. Before he started drawing people with feet, he said to himself “nine people” and got that down on paper immediately. He then went back to count the number of feet. I can also see mastery of one-to-one correspondence since he was able to match one number per foot. Finally, this journal entry showed me that Skyler understands number sequence up to 18.

Skyler’s mathematical thinking demonstrated some key components of constructivist theory. He has a solid base of prior knowledge and experience from which he can easily draw on and apply to new mathematical concepts. He used a variety of strategies to solve a problem. Skyler can usually explain his process for solving a problem. He worked steadily through the zone of proximal development toward independence. Finally, Skyler applied previously learned concepts to new concepts.

Mathematical Meaning-Making

What teaching strategies are useful in scaffolding students’ meaning making as they use math journals?

Skyler needed some teacher prompting in order to solve the Cats and Paws problem (Appendix J) given on March 20. The problem asks for students to figure out how many paws are in a yard if there are four cats. Again, the journal page directs students to show how they solved the problem by using pictures, words, or

numbers. Skyler began solving this problem using the same system for solving the Dinosaurs and Tigers problem. He drew what appeared to be 16 cats for each line. Skyler drew a total of five lines. For the second, third, fourth and fifth lines, Skyler changed the first picture to a square, two squares for the third line, and three then four squares for the last two lines. Figure 4.3 shows Skyler’s first attempt to solve the Cats and Paws problem:



Figure 4.3. Cats and Paws Problem – Skyler’s First Attempt

As he was working independently, I stopped him and asked him to explain why he chose to solve the problem this way. Skyler did not have a response. I prompted him to visualize four cats in his back yard. I then asked him to draw what he saw to help him solve the problem. He drew the four cats then put the number four under each cat (Figure 4.4) and quickly answered 16. I asked Skyler to tell me how he arrived at his answer he replied, “You have four, then another four that is eight. Then you have four more...nine, ten, eleven and twelve...then four more...thirteen, fourteen, fifteen, and sixteen.” As Skyler counted above ten, he pointed to each leg.

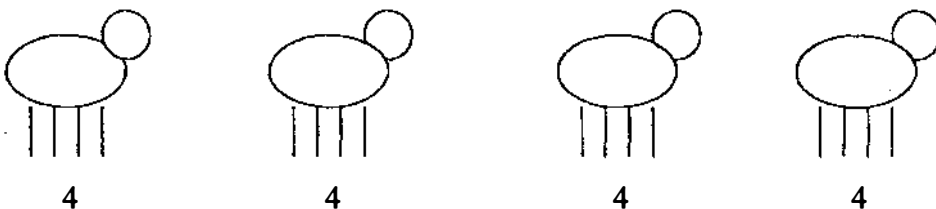


Figure 4.4 Cats and Paws Problem – Skyler’s Second Attempt

This is an example of Vygotsky's Zone of Proximal Development. ZPD is determined by the distance between individual capability of solving a problem and the potential development under the guidance of a more knowledgeable adult or peer (Palinscar, 1998). Students need to be pushed beyond what they can handle independently under the guidance of an adult or a more knowledgeable peer. My scaffold pushed Skyler's thinking because I did not provide him with the answer. I asked questions about the concept and the process and I asked him to explain his thinking. I prompted Skyler to visualize the four cats in his yard because his original strategy for solving the problem did not generate the answer. I knew that he could arrive at the answer if he could use the mental tool of visualization. In addition to mathematics, we have used the term visualize in other disciplines. Since Skyler has been exposed to the term, I knew that he could use it as a strategy to solve the cats' problem. My guidance for Skyler was an example of cognitive conflict within social constructivism. Skyler was engaged in a problem-solving activity where there was a contradiction between his existing understanding and his experiences (Palinscar, 1998). He needed the interaction with me to push him through the ZPD in order to internalize the concept. Skyler took up my scaffold and used it in his own activity. This shows how Skyler internalized mental tools through social interaction.

One of the most beneficial teaching strategies I used for the duration of this project was to highlight specific students' moments of enlightenment. It empowered the students and motivated others to continue to stay engaged so I may highlight their work. I typically did this during our large group meetings. I would refer back to key

points of discussions for many weeks, and I would also point out the things students were doing during centers. Depending on student work for math journals, there were times when I needed to group particular students together. For example, Skyler always seemed to finish his work on time, whereas another student had difficulty focusing and as a result rarely completed his work on time. I placed them together when we explored the On and Off Grid Game (Appendix U). The concept explored with the On and Off grid game is combinations of numbers. The first combinations to work on are combinations of ten. One student begins by dropping ten counting chips onto a small square card. Students count and record the number of chips on the card then have to use their knowledge of combinations of ten to know the number of chips off of the card. Students check work by counting the chips off of the card. I guided students so that they could be equally participating through modeling and starting the game as another player. I weaned myself out of the game and the two students worked very well together. At first, students relied on guessing and counting the chips on and off of the card. After a few rounds, the students were able to quickly count the number of chips on the card and quickly say the number that made the combination of ten. One of the students discovered that three plus seven equaled ten and seven plus three also equaled ten. "It flips! That makes it easy to remember!" We referred back to this concept frequently. When working with larger numbers, Skyler would say, "I know another number sentence we could make from eight plus four equals twelve...four plus eight equals twelve too because you flip the numbers around. The order does not matter for addition because it is all being put together!"

I encouraged students to relate the math concepts we were learning to real-world situations. During whole group discussions, I would ask the students “Why do you think we are learning this?” or “When could we use this outside of school?” I would also prompt the students to be thinking of other math concepts we learned about that connect to the current concept. Typically my higher-end students, like Skyler, would be able to quickly make connections as well as apply the concepts to the real-world. The following is a dialogue during a whole group meeting about the concept of pattern of numbers. The dialogue happened on February 28.

Connors: Class, let’s review skip counting by 2’s

Class: 2...4...6...8...10...12...14...16...18...20...22...
24...26...28...30...

Connors: Excellent! Now, when do you think skip counting would come in handy?

Skyler: Maybe you could count by twos when you are setting the table. It would go faster.

Connors: Can you explain that more?

Skyler: If you are counting spoons you could just say
2...4...6...8...10...instead of
1...2...3...4...5...6...7...8...9...10....See, it goes
faster.

Connors: Excellent! That was very smart of you to say! Can someone give me an example of using skip counting outside of school?

Student 2: Maybe a baseball coach will count the number of balls or bats or helmets by skip counting because it is faster.

Connors: Great! Another example of how skip counting makes counting easier!

At first I thought this was not a good sign that my other students did not come up with many, if any, ideas. Upon further personal reflection, I came to the conclusion that these discussions did in fact benefit my other students because their peers were helping them construct new learning as well as build background knowledge. Additionally, my high-end students, such as Skyler, were being role models, connecting new learning to prior and relating it to real life. As students came to the group discussions with different prior knowledge, children were scaffolding each other's thinking within a ZPD. These discussions facilitated their meaning making. Skyler and others made connections with the prior knowledge exhibited by other students and through discussion, students internalized the concepts

Communication and Assessment

What does student engagement look like when we ground instruction and curriculum in constructivist principles?

Communication and assessment in primary mathematics setting takes several different forms. There are written communications and assessment, informal

observations, and discussions. With Skyler, it was very easy to assess his mathematical meaning-making and understanding in a large group setting because he was often the one offering the moments of discovery. As I was scribing student responses to the Dinosaurs and Tigers problem, Skyler was the first to notice the pattern in Figure 5 that was discussed following the Dinosaurs and Tigers activity:

Dinosaurs	Tigers
0	10
1	9
2	8
3	7
4	6
5	5
6	4
7	3
8	2
9	1
10	0

Figure 4.5. Dinosaurs and Tigers Pattern

By the third row, Skyler raised his hand and said, “It is a pattern! The dinosaurs’ side counts up 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 and the other side counts down from 10.”

After that, another student asked to show the class what he noticed. The boy pointed to the first line and said, “Zero plus ten is 10. Two plus eight is ten. Five plus five is ten. This will help us remember our facts!” Another student then came to the front to show the class how the first and the last line are flipped. The second line and the second to last line are also flipped. This observation led to the discussion of the commutative property of addition. Skyler then added that “This will *really* help us

learn our facts! If you know the first ones [referring to lines 1-6] then you will know the other ones because they are the opposite.” I then taught an *Investigations* (2004) card game to keep the students practicing this concept on February 28. I first modeled the Total of 10 game (Appendix T) to the entire class. Then I had students play the game as a center. This game is one of the options to play when a center is complete in order to keep the students engaged.

One of the best times to take anecdotal notes was during math centers. Anecdotal notes were a way for me to keep a written record of my thoughts as I was informally assessing students. They also helped me keep track of key points of a discussion to have after centers when we gather back together for group. In other words, these notes led me to communicate with my students as I assessed them working independently and in cooperative groups. I took specific notes like I did when Skyler needed guidance on the Cats and Paws problem. I also made general comments on the strategies students were using, how well they were cooperating in their cooperative center group, and I noted areas to work on. These assessments not only determined what I was going to teach, but also helped me to determine how to teach. For example, when I saw Skyler pull away from the group to essentially play a center game by himself, I knew that I needed to teach him how to cooperate and get involved by becoming a member of the group. As I assessed students during the Oranges, Cherries, and Grapes problem, I noticed that many students did not work in straight lines and eventually ran out of room. I needed to then guide my students to stay organized as they worked and to not work too fast.

As Skyler was engaged in the Today's Magic Number center on February 27, I was able to assess his understanding of the instructions. As a large group, we discussed and I modeled a variety of ways to show a number. This was a skill that began in September. When students go to the Today's magic number center, they are to pick a number from a plastic container (Appendix N), glue it to the paper and show the number in two different ways. The options to show the number included number sentences, pictures, dice, tallies, and sticks. On February 27, Skyler had the time to work on two numbers. He was to show the number sixteen on one side of the paper and the number thirty on the other. He used number sentences as a strategy for showing each number. Figure 4.6 shows both sides of the paper of Skyler's work.

Today's Magic Number

16

I can show this number in two different ways

$$15 + 1 = 16$$

$$16 + 0 = 16$$

$$1 + 15 = 16$$

$$0 + 16 + 16$$

Today's Magic Number

30

I can show this number in two different ways

$$1 + 29 = 30$$

$$29 + 1 = 30$$

$$19 + 10 = 30$$

$$10 + 19 = 30$$

Figure 4.6. Today's Magic Number – Skyler

From this center paper I was able to see that Skyler understood the concept of the commutative property of addition. Even though the number sentences in the last box are incorrect, I can see that he understands the concept. When the directions call for him to show a number in two different ways, he interpreted that as two ways in the first box and two other ways in the second box. From this assessment, I saw that Skyler needed my support or the support of his peers to show the numbers in an alternative way.

On February 28, Skyler showed the number 15 using four number sentences.

The following figure is an example of Skyler's work

Today's Magic Number

15

I can show this number in two different ways

$$16 - 1 = 15$$

$$14 + 1 = 15$$

$$15 + 0 = 15$$

$$15 - 0 = 15$$

Figure 4.7. Today's Magic Number – Skyler

From this work I saw that Skyler understood the concept of zero. He pushed himself to go beyond addition number sentences to represent a number. Furthermore, he went beyond the concept of the commutative property of addition to show four number sentences. The number sentences in Figure 4.7 are linked. The first two are linked by the concept of one more and one less. The third and fourth number sentences are linked by the concept of zero.

From this data, I was able to see Skyler tap into his prior knowledge and experience to generate a variety of ways to show the number. In his schema, he had the concept of the commutative property of addition. He was able to use that knowledge and apply it to a new situation. Application is one of the steps on Bloom's Taxonomy. Application is a skill where knowledge is demonstrated, practiced, and illustrated.

In the final interview with Skyler, he changed his answer from "kind of" when asked if he liked math in the first interview to "yes" in the April interview. He

continued by saying that he likes math because he is good at it. Skyler likes math when he gets to work in centers because that is when he learns best. “I learn best playing games.” He said that he likes it when it is quiet. When asked when math is not fun, Skyler responded, “When we do worksheets.”

Overall, Skyler was an above average student in mathematics. He has been considered above average since kindergarten. He tended to get to work immediately and had the ability to stay focused for a long period of time. He accepted challenges, especially when asked to solve a problem in a different way. He typically worked in a systematic and organized manner. He typically carried previous concepts over to new concepts. It was very easy to scaffold his learning. Skyler always contributed to whole group discussions which enabled other students to connect to the learning and build their exposure to new concepts.

Case Study #2 – Jasmine

Jasmine came to my class early in the school year from a neighboring school district. From what I have gathered from her kindergarten report card, it appeared that her previous performance in school was similar to what I see in her academic abilities in first grade. Jasmine needs directions repeated to her as well as presented to her in a variety of ways. She works best in a silent working environment with one-on-one support. Jasmine is eager to participate in class discussions when the information is a review or deals with manipulative tools as the focus of instruction. Although she puts forth a lot of effort in her daily work, it is seldom completed in the given math block. When possible, I have the classroom aide, a parent volunteer, or

student observers work with Jasmine. As mentioned above, Jasmine struggles with her vision as well as her oral language.

For the first student interview, Jasmine said that she likes math “because it is special and because when I learn math I feel I know what to do”. She continues to say that math is fun all of the time. Jasmine states that she likes working in small groups. When asked why she likes working in small groups she responded with, “you could follow everyone”.

Thinking in constructivism

How do first grade math journals guide students to deeper understandings of math concepts?

Although very good at drawing, Jasmine typically uses numbers to solve a problem in her math journal pages. There has been more than one instance where Jasmine would not be working, someone would call out “Ten plus ten is twenty!” then she would hand her paper with $10+10 = 20$ written down. Perhaps she truly figured it out herself, perhaps not. Jasmine typically worked well on traditional *Scott Foresmen* (2002) worksheets. She usually used her fingers or counters to solve problems. Jasmine would be hesitant when working on higher-level thinking questions posed for the *Investigations* (2004) journal pages. For the Dinosaurs and Tigers journal pages, Jasmine needed one-on-one support from the parent volunteer. The parent reported to me that Jasmine just did not know where to start and needed close guidance for most of the problem solving stages. After about twenty minutes of working in the hall with no other distractions, Jasmine understood the procedure for

making the combinations of ten. To get her to that point, the parent volunteer had to repeatedly explain the concepts. As I reflected in my journal on this situation, I thought that perhaps having little animal counters would have been beneficial for my lower-end achieving students like Jasmine. They could have changed out the number of animals, making sure to leave only ten on the paper. This activity would have most likely benefited Jasmine because of her language limitations as well as her visual impairments. A physical manipulative is a more concrete representation than pictures or numerals. Vygotsky's notion of changing the mediational means made available to Jasmine could have adjusted her ZPD, and made it more likely that she would be successful with this activity. Mediational means help to carry out mental functioning (Forman, Stone, Minick, 1993). Figure 4.8 is Jasmine's work on the Dinosaurs and Tigers journal that she completed with a parent volunteer during the entire 45 minutes mathematics block on February 27.

Dinosaurs and Tigers

I have 10 dinosaurs and tigers.
How many of each could I have?
Keep track of your work.
You can use pictures, numbers, or words.

$$5 \text{ Tigers} + 5 \text{ Dinosaurs} = 10$$

$$6 \text{ T} + 4 \text{ D} = 10$$

$$\text{TTTT} + \text{DDDDDD} = 10$$

$$\text{T} + \text{DDDDDDDDDD} = 10$$

$$0 + \text{DDDDDDDDDD} = 10$$

$$\text{TTTTTTT} + \text{DDD} = 10$$

$$\text{TTT} + \text{DDDDDD} = 10$$

$$\text{TTTTTTT} + \text{DD} = 10$$

Figure 4.8. Dinosaurs and Tigers – Jasmine

The parent volunteer began with the easiest combination of ten, five plus five. This concept tends to come easy to students because they can see five fingers on each hand and they know that they have ten fingers all together. Their strategy of first labeling 5 Tigers and 5 Dinosaurs may have helped Jasmine understand the distinction between a group of tigers and a group of dinosaurs. Using Ts and Ds to generate the combinations may have helped her strengthen the mental tool of visualization. When she saw three Ts, perhaps she saw three tigers in her mind. When she saw seven Ds, perhaps she visualized seven dinosaurs. Manipulating the counters enabled Jasmine to explore the concept of combinations of ten. This manipulation could have supported and strengthened the mental tool of visualization because of the exposure

Jasmine received, resulting in a building of background experience and movement through her ZPD. Furthermore, Jasmine responded very well to scaffolding.

Math journals have helped me assess my students achieving a deeper understanding of concepts. They helped to assess any understanding of a concept. Many times I needed students to explain their journal entries in their own words because explaining the process of solving a problem requires more critical thinking skills (higher-level Bloom). For example, Jasmine appeared to understand the word problem for At the Beach (Appendix K) which was given on March 30. The following Figure 4.9 shows the *Investigations* (2004) word problem and Jasmine's response:

<p>At the Beach</p> <p>There were 9 children at the beach. Then 8 children came to the beach. How many children are at the beach?</p> <p>Show how you solved the problem. Use words, pictures, or numbers.</p> <p style="text-align: center;">$9 + 8 = 17$</p> <p style="text-align: center;">$8 + 9 = 17$</p>

Figure 4.9. At the Beach - Jasmine

At first I thought Jasmine was able to read the problem, understand that it was asking for addition, and was able to solve it independently. I was amazed that she did not

need counters or a picture to help her understand and solve the problem. I was even further amazed that she did the turn-around number sentence and demonstrated a deeper understanding of addition: its commutative property. However, when I asked Jasmine to explain what she did, she could not. Her response was simple “Because nine plus eight is seventeen.” I thought that maybe she did not really understand what I was asking or maybe she just could not put into words what was going on in her head. She did not tell me why she put the turn-around number sentence on her paper.

I proceeded to observe the student next to Jasmine on her progress. I noticed that the girl had the same answer as Jasmine. When I asked that student how she arrived at her answer, she was able to give me a detailed explanation: “First there were nine children so I wrote nine on my paper then I read that more children came so I new it had to be addition because the number was going to get larger. Then I wrote down eight and counted nine plus eight is seventeen. I put the other number sentence down because I remember that in addition, you can flip the numbers and get the same answer. The same number of kids are on the beach.” I asked Jasmine one more time how she new the answer. Jasmine finally then said, “She helped me”. Since she looked to another student for the answer, I do not believe that Jasmine was working at the edge of her understanding. I believe that she was simply relying on the other student to give her a solution strategy.

Jasmine demonstrated mathematical understanding for the Oranges, Cherries, and Grapes (Appendix G) journal prompt on February 28. Although she did not generate all of the possible combinations, she did show evidence of a pattern and a

systematic strategy for solving a pattern problem. The following Figure 4.10 is an example of Jasmine’s journal. The **O** represents the orange, the **o**’ represents the cherry, and the **0** represents the grape.

Oranges, Cherries, and Grapes
I have 9 oranges, cherries, and grapes.
How many of each could I have?
Keep track of your work.
You can use pictures, number, or words.

Oo’o’000000
OOo’o’00000
OOOo’o’o’000
OOOOo’o’o’o’0
Oo’o’o’o’0000
Oo’0000000

Figure 4.10. Oranges, Cherries, and Grapes – Jasmine

Jasmine shows a pattern when she changed the number of oranges for the first four lines. At the same time, for the first three lines, the number of grapes also changes in a pattern, starting at five going down to three grapes in a line. This artifact showed me that Jasmine had some understanding of patterns. It showed me that she knew solving this problem with pictures was the easiest for her. As she worked, I commended her for being neat and organized and knowing to using a pattern to solve the problem. I asked her why she chose to draw the pictures they way she did, she responded, “I can see what fruit I am using and I am organized”. I noted in my teaching journal that day Jasmine’s behavior during this activity. Jasmine stayed focused and did not need my guidance to get to work.

Jasmine was able to successfully work through the Oranges, Cherries, and Grapes journal problem because she had prior experience that she was able to build on from her schema. She had experienced whole group discussions of patterns with combinations. She repeatedly heard students who had successfully solved a combinations problem say they stayed organized and neat. She saw my model the strategy of using pictures that represent the words in the problem. For example, the problem was about oranges, cherries, and grapes, so I would draw pictures that resembled oranges, cherries, and grapes. When we reviewed the At the Beach journal problem, I drew a scene of a beach and people in order to solve the problem. I then used number-sentences to solve it again. As Jasmine explored the At the Beach problem and participated in a whole class discussion, she was able to learn from her mistakes and apply them to the next problem. This showed me that Jasmine was making progress through the ZPD with the help of her peers. As Jasmine applied the concept of patterns with combinations of numbers and when she was able to verbalize her reasoning, she was demonstrating thinking at the higher-level of Bloom's Taxonomy.

Mathematical meaning-making

What teaching strategies are useful in scaffolding students' meaning making as they use math journals?

As mentioned above, Jasmine requires frequent small group or individual instruction in order to build her mathematical understanding. The combination of her visual impairments and language limitations and her tendency to become easily distracted with movement and noise, make center time a struggle for Jasmine to work

productively. Each center was differentiated into at least two groups. Some centers were differentiated into three groups. Activities were printed on to color-coded card stock, set in color-coded folders, or labeled “Start Here” or Go For It!” on baggies. I instructed each student so they knew what color to look for. Jasmine knew which baggies, folders, and activities to use at each center. Each activity was aligned to the curriculum. The activities has the same objective but differed on the range of number used, amount of working for word problems and directions, and the number of problems to solve. I also differentiated instruction to meet each students’ needs by pulling one student from a heterogeneous center group to work in a small, homogeneous, guided math group. Jasmine and the other students who needed more support to move through their ZPD benefited from this structure because they were still learning from one another and they were still engaged in their learning. Since I worked with every student at some point in the week, they did not feel singled out.

On March 14, Jasmine was working at a center where she had to pick a card, and solve the missing number. The following Figure 4.11 is an example of a card I observed Jasmine working on during this center block:

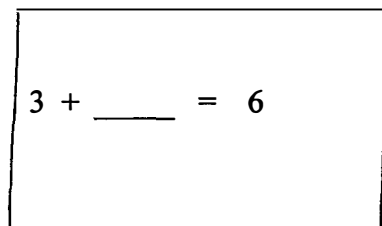

$$3 + \underline{\hspace{1cm}} = 6$$

Figure 4.11 Find the Missing Number – Jasmine

This was a differentiated center. Two students worked with number above ten and two students worked with the orange cards that had numbers less than ten. All the students used dry erase markers and a number line to solve the problem if they could not easily do it mentally. All of the other students were able to solve the answers with almost 100% accuracy. Jasmine answered almost every card incorrectly. She utilized the markers and the number line just as the other members of the group, but her answers were just a little off. I quickly noticed that it was a matter of her not understanding the concepts of addition and missing numbers. It was a matter of her misconceptions of how to use a number line. Jasmine would start on the first number, for example, three and then would count to six by first putting her finger on three and saying “one, two, three, four...I hopped four times to get six, the missing number is four.”

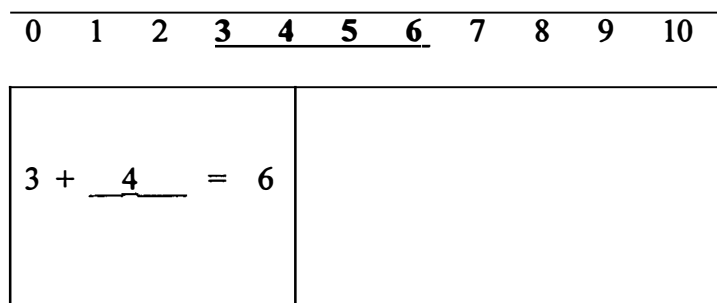


Figure 4.12. Jasmine’s counting on a number line

She understood that she needed to stop at six and to count the hops; however, she did not know that she needed to jump to the four and count that movement as the first hop. I tried working with her one-on-one to show her how to use the number line. As I later reflected in my teaching journal, I wrote how I need to further work with her

on how to use a number line, but during that center activity, I should have provided her with counters. This experience reminded me of Piaget's notion of constructive error. "Knowledge construction based on the error is a necessary step towards cognitive development" (Machado, Maia, & Pacheco, 2005, p. 3). She does well counting with one-to-one correspondence. Having counting chips would have probably enabled her to complete the center activity. I also wrote in my journal that it was her strong understanding of one-to-one correspondence that made her count each number in between three and six and that it why she got four, she saw four dots. Using a number line is a strategy to solve a problem. I should have waited to work with her on reinforcing that skill.

From the center activity to solve the missing number, I saw that Jasmine was looking to her peers for guidance on how to solve the card. She saw the other members in her group using a number line so she chose to use one as well. Jasmine, however, was stuck and could not progress through the ZPD because there was a gap in her understanding. I provided guidance which enabled her to be successful. The differentiated activities proved to be successful because the numbers were small and therefore not over-whelming to her. As she continued to work at this center successfully, I used scaffolding to push her to apply this new skill of using a number line to solving number sentences with larger numbers.

Jasmine's first attempt at the Feet, Fingers, and Legs (Appendix L) on April 2, question two did not show me that Jasmine truly made meaning with the problem. I saw a simple number sentence. When I asked Jasmine to explain how she solved the

problem, she simply said, “I donno”. After scaffolding, the following Figure is Jasmine’s answer to the problem:

Feet, Fingers, and Legs
Show how you solved each problem.
Use words, pictures, or numbers.

2. There are 9 children at the bus stop.
How many feet are there?

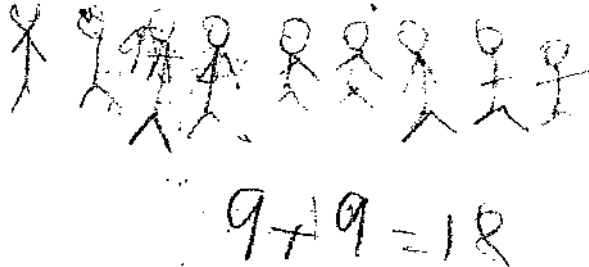


Figure 4.13. Feet, Fingers, and Legs – Jasmine

The scaffolding I provided for Jasmine was not elaborate. I made a real-world connection for her to relate to in order to visualize what the problem was asking. I asked her to think of nine children waiting for the bus together. She quickly said, “Oh! I can draw nine kids and count their feet!” When I asked her to write a number sentence she said she could write nine plus nine because “You can count one foot for each kid then the other foot.”

I was not surprised that Jasmine would be able to quickly relate to seeing nine children waiting for a bus because waiting for the bus with other students is something she did every day. I was surprised at her reasoning for choosing nine plus nine. This showed me that Jasmine relied on the information she can easily see on the paper. She easily saw 9 and used that for her number sentence. From this

experience, I realized that I need to provide her with more authentic experiences with mathematical concept so that she can work at the edge of her understanding.

Communication and assessment

What does student engagement look like when we ground instruction and curriculum in constructivist principles?

Knowing my students enabled me to plan differentiated instruction that would engage all of my students in their learning. Through constant communication with my students and consistent assessment and reflection on their progress, I was able to match their ability levels to the activities they needed in order to make mathematical meaning and to deepen my students' understanding. I also differentiated based on their prior knowledge and experiences and learning style. For example, I know that Jasmine needs manipulative tool in order to solve any problem. In order to meet her needs I always provided her with manipulative tools. I provided my high-end learners who were successful with visual and auditory learning styles with activities that required more reading. I provided my kinesthetic learners with hands-on activities in addition to their center work when I pulled them for small, guided math groups. For whole group meetings, I varied my teaching strategies to meet the different learning styles. For example, I would call student to the front, draw on the front board, do call-and-response drills, and would facilitate discussions. I found with Jasmine I needed to communicate concepts to her through a variety of means. I needed to carefully plan what I was going to say to her, as well as be prepared to say it in a different way and to repeat myself. I also knew that I needed to present concepts to her with visuals and hands-on manipulative tools. If I was not prepared,

she would not have been engaged in the learning activity. At whole group, I needed to have even more prominent visuals for her. For example, when we began our unit on base ten, I called students up to the front of the room to be my assistants holding the counting rods. That large visual was something she needed in order to stay interested and not become distracted. It was also large enough for her to see.

When engaged in the journaling activity, Feet, Fingers, and Legs (Appendix L), Jasmine needed a real-life connection in order to achieve understanding. As I took my anecdotal notes of students working through these particular problems, I was assessing my students on their problem solving strategies and skills. I noticed that most students were engaged for this journal page for the duration of the activity. Few students needed some guidance from me to complete the sheet. My higher-end learners stayed engaged when asked to solve each problem using a different strategy. When Jasmine saw problem four, I do not believe she actually read the problem. I think that she just saw two number twos and added them together with the four. Figure 4.14 shows Jasmine's first attempt at the Feet, Fingers, and Legs journal on April 3:

Feet, Fingers, and Legs

Show how you solved each problem.

Use words, pictures, or numbers.

There are 2 horses and 2 people in the barn.

Horses have 4 legs. How many legs are there?

$$4 + 4 = 10$$

Figure 4.14. Feet, Fingers, and Legs – Jasmine's First Attempt

I read through the problem with her and asked her how many horses there were. She said two. I asked how many legs do horses have. She responded four. I asked the same questions about people. I asked her what can we do to see how many legs are all together in the barn. She was not able to give a suggestion. I guided her to imagine two horses in a barn then to draw a picture of them. After she drew a picture I said that the first horse belongs to her and the second horse is mine and now she can draw us with our horses. From that point on she was able to draw the rest of the picture and solve the problem as well as explain it to me. I had her tell me what we did. She responded “There are two horses and horses have four legs and four plus four is eight because there were two horses so you have to say four two times. And there are two people, me and you, and we have four legs altogether.” She counted the number of legs of the people and the horses and said that answer was twelve.

This data showed me that Jasmine was struggling to visualize the problem. She could not solve the problem because she did not understand what it was asking. Jasmine was not engaged in the learning because of this lack of understanding. I was able to assess her lack of understanding when I saw that she had only added the two numbers together. I needed to clearly communicate to Jasmine what the problem was asking. I first had to read each sentence carefully. I then discussed with Jasmine the best strategy to use. Since she typically does well with drawing pictures, we discussed what it would look like to have two people and two horses. This scaffolding enabled Jasmine to get through the ZPD. I was not telling her to draw two people and two horses; I just prompted her to think. Jasmine was able to apply

this strategy to the rest of the problems. She read each question carefully, and drew a picture to solve the problem. She then went back and wrote the number sentences.

Jasmine was typically engaged in her work, both independent work as well as centers. Problems arose when it appeared that Jasmine was engaged, however, she was working under misconceptions or lack of understanding. Looking back at the missing number center, I was able to assess Jasmine quickly to see that she was working with a misconception due to a lack of understanding of how to use a number line.

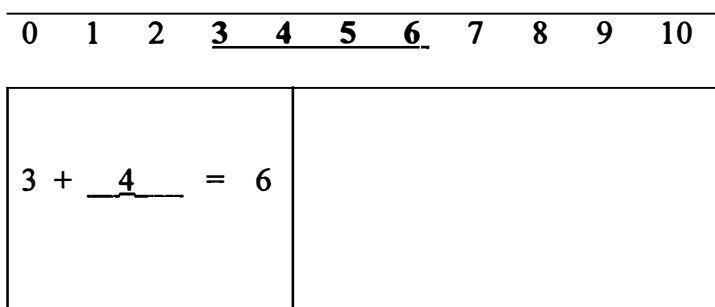


Figure 4.15. Jasmine’s counting on a number line

Jasmine was engaged. She did have some degree of background knowledge because she was able to count and hop, making one-to-one correspondence with the numbers on the line. As I tried to communicate with Jasmine that she needed to hop to the four and say “one” she looked at me like she was very confused. I tried to instruct her that she needed to count the hops until she got to the number six. Upon further reflection in my teaching journal later that day, I realized that the number line as a tool for addition was not within her ZPD. I should have brought out the counters. Counters would have been beneficial for Jasmine because she does have one-to-one

correspondence. She would have been able to see a total of six counters and take out three of them in order to see that the missing number was three.

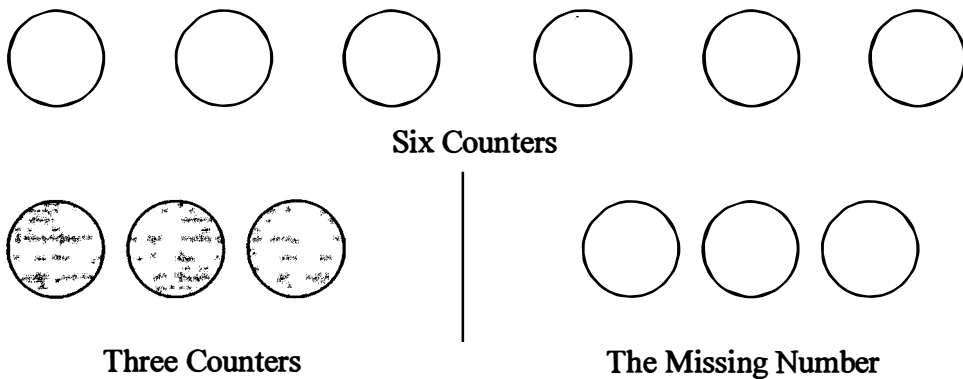


Figure 4.16. Work with Counters

In the final interview, Jasmine said that she does like math all of the time. She said that she likes it because she is good at it. She loves doing centers because she is with her friends. When asked when she learns math best, she replied, “I learn best when it is quiet”. When asked what helps you learn best, she responded, “Your help”.

Overall, Jasmine works below grade level. She periodically demonstrated understanding of a concept. Jasmine works well with the *Scott Foresman (2002)* worksheets. Although it takes her longer to move through the ZPD compared to other students, she did make progress. Jasmine can carry over previously learned concepts to new situations with strong support. She has strength in drawing and one-to-one-correspondence. She worked well with any student I placed her with as well as any aide or volunteer. One drawback to this learning environment was that Jasmine needed a lot of support that I was not always able to give her. Jasmine’s behavior

never inhibited her ability to work in mathematics. She could stay interested in a problem once she understood what she was expected to do.

Case Study #3 – Mathew

Mathew typically works at grade level standards. He often needs small group and one-on-one attention to guide his learning. When Mathew is focused on his work and is not distracted by his surroundings, he can meet grade level expectations. Throughout the duration of the study, Mathew's behavior frequently inhibited his ability to meet his full potential. Mathew tends to be easily distracted causing him to miss out on important directions and information regarding math concepts. Mathew is highly active and social; however, he is shy and hardly raises his hand in a whole group setting. He needs frequent reminders to stay focused. Behavior plans have been instilled with success through the duration of this study. Mathew typically completes his work in a timely manner, especially with the behavior plan. One commendable strength Mathew demonstrates is his expressive language. Whenever he is asked to explain his reasoning, he is able to clearly and insightfully respond.

Mathew had very positive responses to the questions on the first student interview. He stated that he likes math because "there is so much fun work and people ask questions and they help you". Mathew says that it is frustrating when people do not get their work done; that is the only time math is not fun. Mathew does like working in small groups for a few different reasons. He likes getting together with his friends and playing more games. He likes that sometimes it gets "goofy" and that makes him happy when he is sad because sometimes he gets "nervous".

Thinking in Constructivism

How do first grade math journals guide students to deeper understandings of math concepts?

As mentioned above, Mathew is a student who can easily become off task and as a result, frequently does not complete his work on time. When Mathew first worked on the math journaling page of dinosaurs and tigers on February 27, he sat with a blank page and never asked for help. When I got around to seeing him, I reread the problem to him and asked him to show me different ways to have dinosaurs and tigers. Mathew got to work immediately and stayed focused for a long period of time. After working my way around the room, at the conclusion of this activity, I checked back in with Mathew to monitor his process. I saw that Mathew had drawn one row of ten very detailed creatures. When I asked him about his drawing, he said he took his time and was being neat as he drew ten creatures.

Dinosaurs and Tigers .
I have 10 dinosaurs and tigers.
How many of each could I have?
Keep track of your work.
You can use pictures, numbers or words.

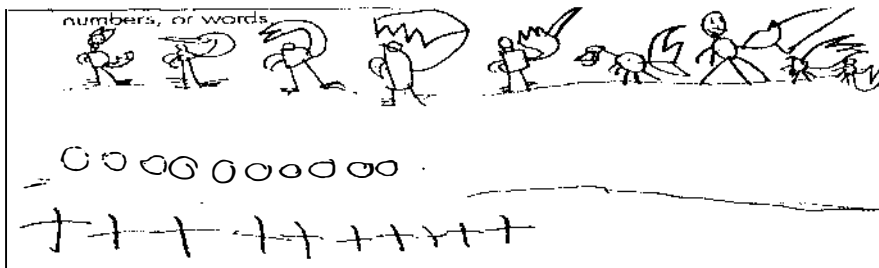


Figure 4.17. Dinosaurs and Tigers – Mathew

As I reflected that day in my teaching journal, I realized that a better way to have scaffolded his activity would have been to show him two different manipulative tools, and then have him draw simple pictures while watching him. I realized that I should have checked back with him sooner to see his progress of generating several rows. The evidence of my scaffolding is seen in the rows where he drew the circles and the lowercase Ts. Mathew told me that the circles were a fast way to draw a dinosaur and the Ts meant tigers. He did not work any further on this activity because he ran out of time. Prior to me scaffolding this activity, Mathew was using pictures as a means of solving the problem. However, since drawing is a strength for him and he usually puts a lot of effort into his art, he viewed this activity as an opportunity to be artistic. More focus was on the accuracy of the pictures as opposed to a strategy for solving a problem in a neat and organized manner.

The following is a dialogue between Mathew and me about question one on the Feet, Fingers, and Legs journaling problem on April 3:

Feet, Fingers, and Legs

Show how you solved each problem.

Use words, pictures, or numbers.

1. There are 7 people in my family.
How many feet are there?

Figure 4.18 Feet, Fingers, and Legs Word Problem

Connors: What are we going to do first?

Mathew: Draw a picture of seven people.

Connors: Good! But what are you looking for?

Mathew: I want to count their feet. (Draws seven stick figures)

Connors: Do you have an answer?

Mathew: Fourteen because 2, 4, 6, 8, 10, 12, 14!

Connors: Why skip count and not count each one?

Mathew: Because there are seven people and each person has two feet and it is easier and faster to skip count by twos.

Connors: How did you understand that so quickly?

Mathew: When I drew the picture I could see it better. I saw two feet in a group then another and another up to seven so I had to skip count seven times and I ended on fourteen.

Math journals in Mathew's case helped him see the concept from his own drawing. He was able to transfer the previous skill of skip counting into a more authentic situation. The discussion he was able to have showed me that he really did understand the concept.

Mathew was engaged in both the Feet, Fingers, and Legs and the Dinosaurs and Tigers problems. The degree of support Mathew needed to be successful varied. Mathew was able to use his favored strategy of drawing in both activities. Although he needed guidance as to the level of detail in his pictures, the strategy proved to be successful. Mathew was able to apply his prior experience with skip counting to this word problem. The word problem caused Mathew to visualize and eventually draw a picture of the seven people. The word problem made the concept of skip counting more authentic. Instead of numbers, he was visualizing a family. It was easy for Mathew to visualize this problem because it was in his schema to see seven people. It

was also in his schema to draw clear pictures. The strategy of drawing mediated his problem solving because he was comfortable with that strategy which resulted in the success of showing his understanding of the problem.

Mathematical Meaning-Making

What teaching strategies are useful in scaffolding students' meaning making as they use math journals?

For a similar activity to the Dinosaurs and Tigers journal, I made sure to check Mathew's progress at the start of work time. I made sure to come to Mathew more frequently as he worked on the Oranges, Cherries and Grapes problem (Appendix G). I also encouraged students to take a few moments to share their process of solving the problem with a neighbor. This instructional decision was to encourage the social aspect of constructivism. When I had students share their process of solving a problem, I was providing the opportunity for students to become exposed to other ways of solving a problem, thus building background knowledge.

At first, Mathew got carried away by drawing several oranges, cherries, and grapes in each row (see Figure 4.19) on February 28. He was doing a combination of the three, but there were too many in each row.

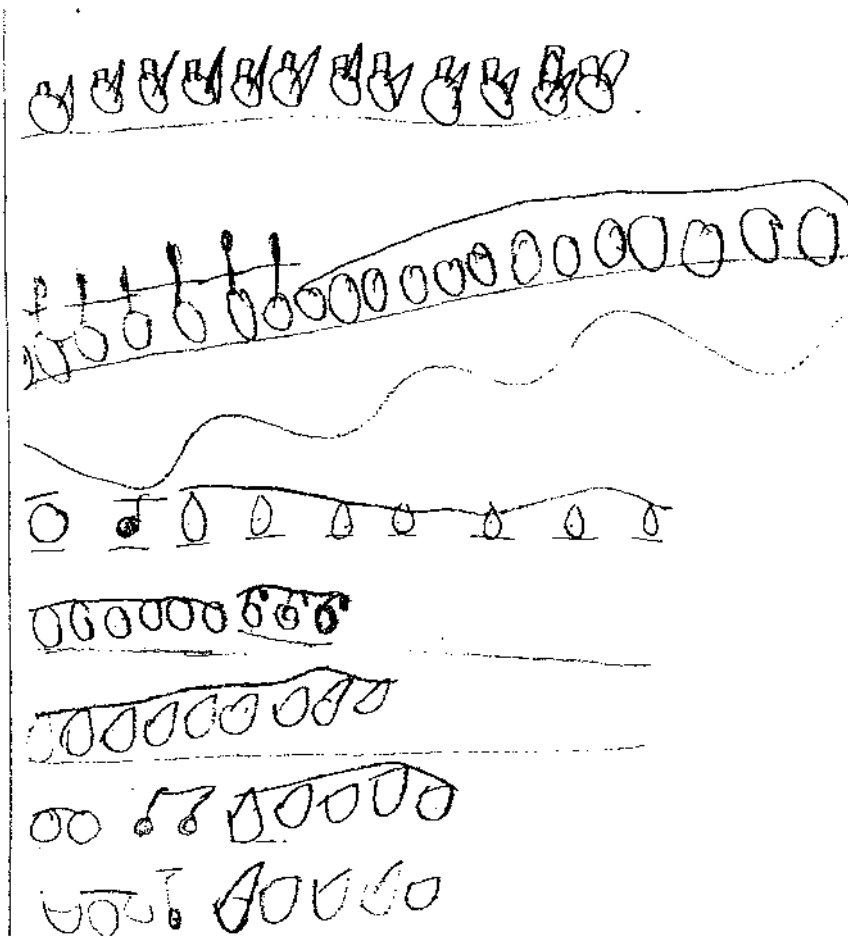


Figure 4.19. Oranges, Cherries, and Grapes – Mathew

Once Mathew saw another student counting to make sure there were only nine pictures of fruit in each row, Mathew went back and recounted. He continued the process and used different combinations of fruits to generate several possibilities. Only two out of his seven rows appeared to have a pattern. His drawing told me that he was developing his understanding of the concept as well as the strategy for using a pattern to solve combinations of numbers problem. There was some degree of organization and patterning as he solved the problem. Since he was able to generate

different combinations of fruit to reach a total of nine, I knew that he was moving toward mastery of the concept.

This was a teachable moment for me not only to Mathew but to the entire class. After a brief discussion about the strategy of having a systematic pattern of solving this type of problem, students made a connection to the pattern they discovered in the Dinosaurs and Tigers problem from earlier. They discussed that having three objects was “trickier” but it could still be done. From this point on, almost every student attempted to generate a systematic pattern for solving combinations of numbers. The following is a figure of the journal prompt and the class discussion on February 28:

Oranges, Cherries, and Grapes
I have 9 oranges, cherries, and grapes.
How many of each could I have?
Keep track of your work.
You can use pictures, numbers, or words.

Figure 4.20. Oranges, Cherries, and Grapes

- Connors:** How are we going to solve this problem? Are you going to use numbers, pictures, or words?
- Class:** Pictures!
- Connors:** Why?
- Mathew:** Because you can see it better and it is faster.
- Connors:** OK! Great! What is the problem asking us to do?
- Student 1:** It wants to know the different ways to get to nine fruit.

Mathew: That is like the other problem we did with dinosaurs and tigers!
And the oranges and cherries problem too!

Student 2: But this one is trickier because there are three different kinds of things, not two.

Connors: You are so correct! Now, what are we going to do about that?

Student 3: You really need to be organized. You can start with one orange and one cherry and the rest grapes then go to the twos.

Connors: Would you do two oranges and two cherries and the rest grapes?

Student 3: Umm...you could! Or you could keep the cherries the same until you are done getting to nine oranges.

Connors: I am hearing you tell me that there are different ways to make patterns and you can still be very organized!

Mathew needed some guidance as he worked through the Oranges, Cherries, and Grapes problem. The guidance I supplied him with helped him to stay focused on drawing nine pieces of fruit for each row and to not get carried away with drawing pictures. He continued to move through his ZPD for this concept during the class discussion. Through discussion, Mathew was becoming exposed to others' experiences with this concept causing him to build from his own background knowledge. The connections he made helped him to be successful in later problems because he applied his experience to new situations. Classroom discussions can create

opportunities for children to internalize others' strategies for solving mathematical problems. Students working together can create a ZPD.

On March 20, students worked on the Cats and Paws journal prompt (Appendix J) Mathew did get carried away drawing pictures at first. I tried to scaffold the mental tool of visualization in order to guide him to understanding of what the problem was asking. The following is the Cats and Paws problem with Mathew's first attempt:

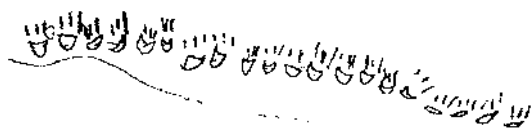


Figure 4.21. Cats and Paws – Mathew's First Attempt

Mathew informed me that he drew the paws of the cats. The marks at the top were the toes. I think he got carried away drawing the paws and lost track of how many paws altogether he needed. I tried to scaffold Mathew's meaning-making by having him visualize his own house. This real-world connection was all Mathew needed to understand what the problem was asking. He immediately drew a picture of his house with four cats then counted the number of legs for each cat. The following is Mathew's second attempts at the Cats and Paws problem.

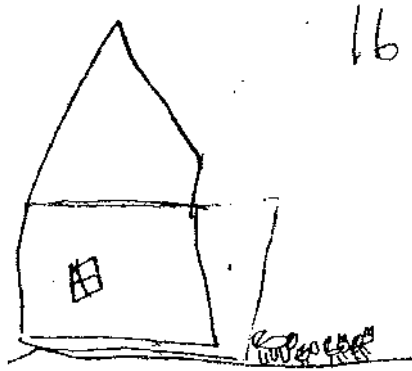


Figure 4.22. Cats and Paws – Mathew’s Second Attempt

Mathew’s response when he finished the problem was simple, “That was easy”. He told me that this time he drew his house and pretended he saw four cats and that is why he drew the bodies of the four cats unlike his first attempt.

Scaffolding students does not need to be elaborate. Mathew just needed a brief mention of a mental tool he had in his schema to be successful. To push Mathew a little further in his ZPD, I could have asked him to try solving the problem with only numbers. He would have had the experience with the visual which would have supported him with solving the problem with numbers. Had he been successful with solving the problem with number, a further push in his ZPD would have been to ask him to write a couple of sentences explaining how to solve the problem. I did ask him to explain why he chose to draw the picture the way he did. He said, “I saw a picture of my house in my head so I drew it. Then I pretended I saw four cats in my yard so I drew them. Then I counted the legs and I know cats have four legs each.”

Communication and Assessment

What does student engagement look like when we ground instruction and curriculum in constructivist principles?

From my observations and Mathew's work samples, his journaling work in particular, I know that Mathew's engagement in a mathematical activity is initially hesitant. He needs more one-on-one directions from me or a peer to lead him on the right track. Mathew, as shown previously in Figures 1, 3, and 4, can get carried away with the details in his pictures. Once Mathew makes a connection, he becomes highly engaged in an activity and rarely becomes distracted for the duration of the activity. I have seen this in his journals as well as during center time. Many of the center activities require a partner which causes Mathew to quickly get focused and involved. The center activities are things that have been modeled, played in a small guided math group, or explored at home with a parent. These experiences enable Mathew to work more productively because he has had exposure and therefore he can work without my close guidance and support. Furthermore, the social aspect plays a large role in turning exploration activities to discovery activities. With continued exposure and engagement in familiar activities, students like Mathew have been able to discover patterns, make other connections and take their learning to a deeper level.

A simple center activity like filling-in a hundreds chart with a dry erase marker and putting chunks of it together like a puzzle, enabled Mathew to notice several patterns within the chart that was never discussed before. "Look Miss Connors! When I put these two pieces together like this I saw how the five in 25 matched with 35. Then I saw all the fives matched. Then I saw how the first number in the column went up." The following is an example of the puzzle in which Mathew recognized several patterns.

1	2	3	4	<u>5</u>	6	7	8	9	10
11	12	13	14	<u>15</u>	16	17	18	19	20
21	22	23	24	<u>25</u>	26	27	28	29	30
31	32	33	34	<u>35</u>	36	37	38	39	40

Figure 4.23 Hundreds Chart - Mathew

After I showed the class Mathew’s “ah-ha” moment, another student recognized a different pattern that goes diagonally from one down to 100. Mathew recognized a similar pattern starting at the top right and going diagonally down to the bottom left. From this point, several students recognized diagonal patterns that started from different rows. With these newly discovered patterns within the hundreds chart, teaching skip counting by starting at numbers other than two, five, and ten was very easy. Students quickly understood that saying “4, 14, 24, 34, 44, 54, 64, 74, 84, 94, 104” was just as easy as saying “10, 20, 30, 40, 50, 60, 70, 80, 90, 100.”

Students were able to make discoveries and construct new knowledge about patterns because they were learning from one another. The whole group meeting met each learning style. First students were working with the concepts hands-on, meeting the needs of the kinesthetic learners. The visual learners saw the pattern on the large hundred’s chart on the front board. The auditory learners heard the pattern of

numbers. As a result, all students were engaged. All students were constructing knowledge based on their prior experiences.

As mentioned above, Mathew has excellent oral language skills.

Communicating concepts in mathematics is easy for him when he understands the problem. For example on April 3, Mathew overall worked successfully on the Feet, Fingers, and Legs word problems. Question two confused him slightly, but with minimal guidance, he was able to quickly make a connection to the word problem and solve it using the strategy of pictures successfully. The following is Mathew's first attempt:

Feet, Fingers, and Legs

Show how you solved each problem.

Use words, pictures or numbers.

2. There are 9 children at the bus stop.
How many feet are there?

////
////
////////

Figure 4.24. Feet, Fingers, and Legs – Mathew's First Attempt

Mathew said that he used sticks to solve the problem because they meant the people at the bus stop. Upon seeing this, I asked Mathew what the important information was in the word problem. He responded nine children and feet. I told him to circle that information. I then asked him to visualize the children at the bus stop. As expected, Mathew was able to quickly draw nine children and orally skip count by twos to 18. An interesting note to Mathew's strategy for solving the problem was that

he only drew the bottom halves of the children. I asked him why he did not draw the top halves of the children. He said, “Because I only needed to see their feet”.

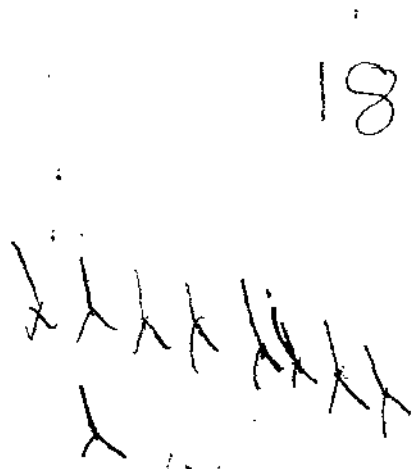


Figure 4.25. Feet, Fingers, and Legs – Mathew’s Second Attempt

As I analyzed Mathew’s response, I knew that Mathew understood the concept. He only needed the visual of the legs, not the entire person. Jasmine on the other hand for the same problem needed to see the whole person in order to be successful solving the problem. Mathew was able to easily communicate with me his thinking on how to solve the problem allowing me to assess his understanding of the concept. With minimal support, Mathew was able to make a jump within his ZPD. He quickly made a connection when he visualized the problem and he was successful. The mental tool of visualization was an example of Vygotsky’s notion of mediational means. Visualizing the problem helped Mathew to carry out the mental functioning that was going on in his head to solve the problem. I think that drawing helped

mediate his ability to visualize. Perhaps later, he might be able to skip the drawing and simply create mental representations.

The next step to guide Mathew in his ZPD would have been to ask him to solve the problem in a different way. One way would have been to ask him to solve the problem using words. This would have been within Mathew's ZPD because he does orally express himself well and he is a good writer.

In Mathew's final interview, he said that he likes math and it is fun sometimes, but he could not tell me when it was not fun. Mathew sees centers as a time playing games and that is why math is fun for him. Mathew likes working in small groups because he gets to be with his friends. His response to when do you learn best was, "When I do stuff". This was similar to his answer to the question what helps you learn best, "Doing stuff".

Overall, Mathew worked on grade level. He was able to make connections using his schema to new material. On the other hand, Mathew was easily distracted by his peers. He was typically focused when drawing pictures or working on *Scott Forseman* (2002) worksheets.

Looking Across the Case Studies

From these case studies, I found that math journals facilitate students' construction of deep understanding? Students can deepen their understanding of mathematical concepts using math journals despite a difference in academic ability. Students chose strategies for problem-solving from their schema. They applied this prior knowledge to solve a variety of problems. Within the contexts of a social

environment, students were able to construct new knowledge based on their peers' experiences. For example, students had prior experiences with pattern, in particular counting up to ten from zero and vice versa. They built on this prior knowledge when Skyler made the discovery of the pattern with combinations of ten.

Dinosaurs	Tigers
0	10
1	9
2	8
3	7
4	6
5	5
6	4
7	3
8	2
9	1
10	0

Figure 4.26. Combinations of 10 Pattern

All students at some point in the study needed to make meaning with the concept in order to be successful. Students needed to make a personal connection in order to pull from their schema a strategy for solving a problem. I found this to be the place where I needed to scaffold my students. They needed me to guide them to visualize the problem in an authentic way. After students made a connection with the problem, they were successful. I saw this with Skyler for the Cat and Paws journal. He needed me to say, "Think of four cats" in order to cause him to be successful. Jasmine needed me to help her to visualize the two of us and our two horses in order to be successful with the Feet, Fingers, and Legs journal. Mathew needed me to say, "Think of your house and four cats in your yard" to be successful with the Cats and

Paws journal. Overall, it seemed as if Jasmine needed the most scaffolding in order to make meaning whereas Skyler did not need nearly as much support.

All students, no matter their academic level were engaged in their learning, especially during centers. All students were engaged because they could work within their ZPD at each center and still feel equal with their peers. I used mediation means to scaffold students in order to move them through their ZPD. Some of the mediational means I used included the mental tool of visualization and manipulative tools such as counters and a number line. I was not the only person to work with students in their ZPDs. As students worked together and through class discussions, students took up and used mediational means as they interacted with each other. I saw student engagement also in their independent work. If students were engaged, I could assess understandings and misconceptions. Additionally, students were engaged during whole group meetings. Students communicated with one another their experiences and discoveries which resulted in a deeper understanding of mathematical concepts. For example, students used their prior knowledge of patterns to connect with the new discovery of other patterns in the hundreds chart. As students communicated in a whole group discussion, all students became engaged, made connections, and deepened their understanding of patterns in mathematics.

1	2	3	4	<u>5</u>	6	7	8	9	10
11	12	13	14	<u>15</u>	16	17	18	19	20
21	22	23	24	<u>25</u>	26	27	28	29	30
31	32	33	34	<u>35</u>	36	37	38	39	40

Figure 4.27. Hundreds Chart

Overall I found that looking at data more than once and over a period of time enabled me to gain more insight to my students' construction of knowledge. By triangulating data from the case studies, I was able to answer my main research question and the sub-questions. I answered these questions not only from student work samples, but also through my anecdotal observation notes and observations during whole group discussion time. Through reflections in my teaching journal, I was able to see my students' thinking in constructivism, mathematical meaning-making, and communication skills both verbally and in written form.

Chapter V: Conclusions and Recommendations

The research project I conducted focused on three of my students. The three students varied in academic strengths. Over the course of six weeks, students participated in whole group discussions on mathematics, small group center time activities, and independent work time. Although my focus was on the three case study students, I did observe and reflect in my teaching journal on the other students in the class. My main research question was: What happens when constructivist principles form the basis for mathematics instruction in a primary classroom? The following is a list of sub-questions that guided the study: How do first grade math journals guide students to deeper understandings of math concepts? What teaching strategies are useful in scaffolding students' meaning making as they use math journals? In what ways can I change my teaching practices and adapt the curriculum provided by the school in order to teach from a constructivist perspective? What does student engagement look like when you ground instruction and curriculum in constructivist principles? In what ways are student attitudes affected by math instruction that is grounded in constructivist principles?

To answer my research questions, I observed and took anecdotal notes on problem-solving skills, strategies for solving problems, pattern recognition, misconceptions, connections students make to prior learning, degree of prior knowledge, progress through the Zone of Proximal Development, level of support from peers, organization skills, and connections made to the real-world. I also answered the research questions by looking at student work and reflecting in my

personal teaching journal. I quickly learned the importance of reflection in a learning environment grounded in constructivism. I found that reflecting on my teaching and my students' learning helped me to achieve a deeper understanding of my students as well as mathematics. Since my teaching journal was a daily activity for me, I was reflecting and delving deeper into my students' understanding so frequently that I was therefore able to adjust my teaching accordingly.

How do first grade math journals guide students to deeper understandings of math concepts? Writing in math prepares students for high-stakes tests as well as acts as an alternative assessment (Checkly, 2006). In order to communicate math through writing, students have to be able to think about what he or she did to solve the problem. Through writing, students can gain valuable insight, feedback, and clarify their thinking about math and the problem solving process (Russell, 2004).

Writing in journals provided opportunities for students to participate in discussions. Knowledge is the most basic skill whereas evaluation is the highest level on Bloom's Taxonomy (Clark, 1999). I found that when students had to explain their answers they were working at the higher end of Bloom's Taxonomy. In the future, I will provide even more opportunities for students to teach other students and encourage more discussion where I will just guide, not lead. Having students explain their answers whether it was verbally or written in a math journal, I was able to better assess mathematical understanding.

Taking anecdotal notes and reflecting on my observations during center time provided another means to assess my students' mathematical understanding.

Knowing where each student was working enabled me to adjust my teaching and questioning according to Bloom's Taxonomy. When the concept was completely new for most students, my questioning was at the knowledge and comprehension levels of the taxonomy. As students constructed new knowledge and developed a deeper understanding of the math concepts, I was able to ask more critical thinking questions that had students synthesize, analyze and evaluate their reasoning and strategies for problem solving.

What teaching strategies are useful in scaffolding students' meaning making as they use math journals? Throughout this six week process, I was able to reflect on parts of my teaching where I could have asked different questions that would have led to more discoveries by the students as opposed to me telling them the concept or connection to prior learning. Through reflection and experience, I know the areas where I can close my mouth and guide (scaffold) students to acquiring new knowledge since I now have a deeper understanding of the teaching of primary mathematics. I know now to ask a lot of questions and to facilitate class discussions, not lead discussions. I know that I need to be aware of each student's background knowledge and be prepared to give real life examples so that students can make connections to the learning. I also know that primary students need to see, hear, and experience a concept as they work through their ZPD. Finally, I know that certain strategies work for some students and not others, resulting in a need for more scaffolding.

The teaching practice of reflection enabled me to really get to know my students and their learning styles as well as their prior knowledge and experiences. If this project was to continue, I would only become stronger at fostering a constructivist learning environment. Continuation would involve constant reflection, staying abreast of research and studies, and collaboration with my colleagues. Reflective practice allows teachers to learn from experience (Clegg, 2003). The ability to reflect *in* action (while doing something) and *on* something (after) has become an important feature of professional development (Atherton, 2003). Reflection is a key to active learning as well as sense-making for all learners (Branscombe, Castle, Dorsey, Surbek, & Taylor, 2003). “One cannot be a constructivist teacher without being reflective” (Branscombe et al, p. 204).

In what ways can I change my teaching practices and adapt the curriculum provided by the school in order to teach from a constructivist perspective? In the Vygotskian perspective, the Zone of Proximal Development is regarded as a better indicator of cognitive development than what children can accomplish alone. “Productive interactions are those that orient instruction toward the ZPD” (Palincsar, 1998, p. 352). At the start of learning a new concept, students needed a great deal of support from a more knowledgeable peer or adult, but eventually they were lead to independence. A new ZPD for the student was established and once again a more knowledgeable peer or adult scaffolded their instruction so that the learner became independent (Useful instructional strategies for literature-based instruction, 1997). For example, as I reflected the day that Mathew worked on the Dinosaurs and Tigers

activity in my teaching journal, I realized that a better way to have scaffolded the learning would have been to show him two different manipulative tools, then have him draw simple pictures with my watching him. With the manipulative tools, he could have explored making a variety of combinations quickly in order to understand the concept, instead of concentrating on drawing a few detailed pictures. Learning is doing. I realized that should have checked back with him sooner to see his progress generating several rows.

What does student engagement look like when we ground instruction and curriculum in constructivist principles? With the activities provided by the *Investigations* (2004) math program that I had known to be based on the theory of constructivism, my students were constantly engaged in their learning. Engagement looked like discussions where I acted as a facilitator. Engagement was also seen as students worked with math journals to show their understanding of concepts. Additionally, engagement was seen as students worked in center activities. All discussions and activities were highly motivational for my students. Highlighting moments of enlightenment from particular students was even more motivating and exciting for my students.

According to Jean Piaget, social interaction of students can create cognitive conflict. Cognitive conflict occurred when a student was engaged in a problem-solving activity where there was a contradiction between the learner's existing understanding and what the learner experienced. This then resulted in the learner questioning his or her beliefs and therefore the learner was able to try out new ideas.

The result was Piaget's notion of disequilibrium. "Disequilibrium forces the subject to go beyond his current state and strike out new directions" (Palincsar, 1998, p. 350). Students experienced cognitive conflict and disequilibrium as they were engaged in centers and whole group discussions.

Students generally do not construct mathematical understanding by absorbing rote mathematical procedures as a teacher models. Students develop an understanding for mathematical ideas and concepts if they are *doing something*. *Doing something* means being engaged in their learning. Students not only move their hands to be engaged but they think at the edge of their understanding. They are making connections to their prior experiences and to the real world. For example, students had to come up with a way to create all of the combinations of the Oranges, Cherries, and Grapes problem. They had to use their schema for solving combinations of numbers problem with a pattern. With the new math standards focusing more on the process of solving a problem rather than the actual answer, it is apparent that the new standards require students to become more engaged with their learning. When the performance indicators require students to apply and evaluate mathematical concepts, they have to be engaged in the mathematical instruction (Connors, 2006, *Standards*). My students were engaged in their learning from the very start of this project. It was a process that evolved over time, however, through constant reflection, I believe it was successful for my students.

In what ways are student attitudes affected by math instruction that is grounded in constructivist principles? Overall, students demonstrated a positive

attitude toward mathematics. Generally, students were excited to work during centers and eager to participate in class discussions. All three of the case study students said in both interviews that they enjoyed working in centers and playing the math games. Skyler, in his second interview, said that playing the math games in centers was where he felt he learned the best. In Jasmine's second interview she said that she liked working in centers because she got to work with her friends. I saw this aspect of center time as a motivational factor that caused positive attitudes for some students. They liked doing math because they were working with their friends. Mathew also said that he liked working in centers and that was when math was the most fun.

Students also demonstrated positive attitudes in mathematics during whole group discussions. As we celebrated moments of enlightenment, students became more willing to share their work and discoveries. I felt that students became empowered when they discovered a new concept or made connections to prior learning or connections to something in the real-world. An example of this empowerment and positive attitude was the whole group discussion of patterns in the hundreds chart. I was not the one that showed the class all of the patterns of numbers. Various students made connections to previous concepts, applied them to the chart, and built from that knowledge new discoveries.

Recommendations

I would recommend for any future work with this type of study that I would again maintain a teaching journal and commit to daily reflections. I would also

recommend looking at the data, such as student work, more than once and over a period of time. I found that I was able to discover new things about my students' understanding of mathematical concepts when I looked at a piece of work a few days after its completion. Finally, I would need to keep in mind the value of planning ahead. A primary constructivist learning environment calls for a variety of manipulative tools, several journaling pages, partner work, group work, and independent work. Materials need to be organized in order to prevent chaos.

In addition to the previous recommendations, I would again to try to get support from aides, high school or college observers, and parent volunteers. I found that it took a lot of time to plan instruction, mainly because of the preparation needed for center activities and other hand-on learning games. I also found that I needed to provide support not only for my lower-achieving students who needed one-on-one direction, but my higher-end students needed differentiated activities prepared for them. Whenever there was an extra set of hands in my classroom, I felt that I could more efficiently meet the needs of all of my students in a more timely manner. Even though Mathew is a student who is considered meeting grade level expectations, he needed a lot of one-on-one guidance and redirection. In addition to the support Mathew needed, Jasmine also required one-on-one support but at a different level. She lacked much of the background knowledge needed to complete many of the activities. Meeting every student's needs in a timely manner was not easy. As a result, I needed to plan ahead on all activities and my groupings. In order to plan

ahead on groupings I needed to take into account behavior management issues as well as ability levels.

Not only did I foster a constructivist learning environment through this project, but I learned about childhood development in terms of ZPD, Bloom's Taxonomy, mediational means, and constructive error. I had some prior knowledge (schema) that I was able to build upon by means of research, colleagues, exploration and discovery, and reflection. I can now take what I learned as a primary math teacher and apply it for future classes and build upon that knowledge. As discussed in chapter two, reflective practice allows teachers to learn from experience although, more experience does not necessarily guarantee more learning (Clegg, 2003). Reflection is a key to active learning as well as sense-making for all learners (Branscombe, Castle, Dorsey, Surbek, & Taylor, 2003).

I look forward to continuing my work with constructivism. I am eager to stay current with the research so that I may incorporate new findings into my teaching. Planning ahead and using what I have learned will allow me to differentiate my centers and teaching so that all students can explore and discover mathematics at their ability level. I am driven to work with my colleagues in order to become masterful at differentiating my lessons so that every student's needs are met. Finally, I look forward to the success of future years of teaching primary mathematics given my experience and success with this project.

References

- Aharoni, R. (2005). What I learned in elementary school. *American Educator*. Fall 2005.
- Atherton, J. S. (2004). Learning and teaching. *Reflective Practice*. Retrieved November 11, 2004, from <http://www.dmu.ac.uk/~jamesa/learning/reflecti.htm>
- Battista, M. T., & D. H. Clements. (1990). Constructivist learning and teaching. *National Council of Teachers of Mathematics*. Retrieved March 10, 2004, from <http://www.artemisillustration.com/assets/text/Constructivist%20Learning.htm>
- Baxter, J. A., Olson, D., & Woodward, J. (2005). Writing in mathematics: An alternative form of communication for academically low-achieving students. *Learning Disabilities Research & Practice*, 20 (2), 119-135.
- Boudourides, M.A. (1998). *Constructivism and education: A shopper's guide*. The Teaching of Mathematics: International Conference. Retrieved August 26, 2004, from <http://thalis.math.upatras.gr/~mboudour/articles/constr.html>
- Branscombe, N., Castle, K., Dorsey, A., Surbek, E., & Taylor, J. (2003). *Early childhood curriculum: A constructivist perspective*. Boston: Houghton Mifflin Company.
- Brooks, J. G., & M. G. Brooks. (1993). *The case for constructivist classrooms*. Association for Supervision and Curriculum Development.
- Building an understanding of constructivism*. (1995). Southwest Educational Developmental Laboratory. Retrieved December 10, 2006, from <http://www.sedl.org/scimath.compass/v01n03/2.htm>
- Call for more times table chants* (2004). BBC News. Retrieved July 19, 2006, from http://newsvote.bbc.co.uk/mpapps/pagetools/print/news.bbc.co.uk/2/hi/uk_news/education/3638636.stm
- Checkly, K. (2006). *The essentials of mathematics, K-6: Effective curriculum, instruction, and assessment*. Reston, VA: Association for Supervision and Curriculum Development.
- Clark, D. (1999). *Learning domains of Bloom's taxonomy*. Retrieved October 24, 2004, from <http://www.nwlink.com/~donclark/hrd/bloom.html>

- Clegg, K. (2003). *What's in it for you?* UK Centre for Legal Education. Retrieved October 24, 2004, from <http://ukcle.ac.uk/resources/reflections/you.html>
- Connors, S. (2006). *Primary constructivism: Can it be done?* Unpublished manuscript, SUNY Brockport, NY.
- De Jager, B., Jansen, M., & Reezigt, G. (2004). The development of metacognition in primary school learning environments. *School Effectiveness and School Improvement*, 16 (2), 179-196.
- DeVries, R., Edmiaston, R., Hildebrandt, C., Sales, C., Zan, B. (2002). *Developing constructivist early childhood curriculum*. New York: Teacher's College Press.
- Draper, R. (2002). School mathematics reform, constructivism, and literacy: A case for literacy instruction in the reform in the reform-oriented math classroom. *Journal of Adolescent & Adult Literacy*, 45 (6), 520-530.
- Flynn, P., Mesibov, D., Smith, M., & Vermette, P. (2004). *Constructivist strategies: Meeting standards and engaging adolescent minds*. Larchmont, NY: Eye on Education, Inc.
- Forman, D., Stone, A., & Minick, N. (1993). *Contexts for learning: sociocultural dynamics in children's development*. Oxford University Press, US.
- Freedman, S. (2005). Innovative math, but can you count? *New York Times*. Retrieved November 12, 2005, from <http://www.nytimes.com/2005/11/09/education/08education.html>
- Gardner, H., Kornhaber, M., & Moran, S. (2006). Orchestrating multiple intelligences. *Association for Supervision and Curriculum Development: Educational Leadership*, 22-27.
- Gordon, J. (1996). Tracks for learning: Metacognition and learning technologies. *Australian Journal of Educational Technology*, 12 (1), 46-55.
- Isenberg, J. & Jalongo, M. (1997). *Major trends and issues in early childhood education: Challenges, controversies, and insights*. New York: Teacher's College Press.
- Jaramillo, J. A. (1996). Vygotsky's sociocultural theory and contributions to the development of constructivism curricula. *Education*, 11 (1), 133-141.

- Kliman, M., & Russell, S. (1998). *Building number sense: The number system*. Cambridge, Massachusetts: Dale Seymore Publications.
- Mercer, N. (1995). *The guided construction of knowledge: Talk amongst teachers and learners*. Philadelphia: Multilingual Matters LTD.
- Morrow, L. & Strickland, D. (2000). *Beginning reading and writing*. Teachers College, Columbia University.
- Palincsar, A. (1998). *Social constructivist perspectives on teaching and learning*. *Annu. Rev. Psychol.* 49:345-75.
- Raimi, R. (2005). Why American kids aren't learning math. *The Greece Post*, July 8, 2005. Retrieved on February 9, 2006, from <http://www.nychold.com/art-raimi-050708.html>
- Runesson, U. (2005). Beyond discourse and interaction. Variation: a critical aspect for teaching and learning mathematics. *Cambridge Journal of Education*, 35 (1), 69-87.
- Russell, D. (2004). Math journals for all ages: Reflecting about mathematics. *About, Inc, Premedia Co*. Retrieved November 11, 2004, from <http://math.about.com/library/weekly/aa123001a.htm>
- Shahid, J. (1997). *Reflective practice*. Retrieved November 22, 2004, from <http://faculty.tamu-commerce.edu/espinoza/ETEC625/978/shaid/>
- Simpson, E. (1972). *The classification of educational objectives in the psychomotor domain*. Washington, D.C.: Gryphon House.
- Stringer, T. (2004). *Action research in education*. Upper Saddle River, NJ: Pearson Education, Inc.
- Wakefield, A. (1997). Supporting math thinking. *Phi Delta Kappan*, 79 (3), 233-236.
- Wikipedia. Retrieved July 21, 2007 from [http://en.wikipedia.org/wiki/Schema_\(psychology\)](http://en.wikipedia.org/wiki/Schema_(psychology))

Appendix A

February 20th, 2008

Dear Parents or Guardians,

I am conducting a research project in our classroom. It is being conducted to fulfill requirements for my thesis at SUNY College at Brockport. The project is taking a look at math journals and other forms of students work to observe their understanding of math. Other forms of data to be collected are through audio tapes, surveys, and interviews. Each student will be given a pseudonym. All data collected and my analysis of that data will be kept secure in a locked filing cabinet. Please know that the interviews with each child will not interfere with math instruction.

In order to participate in this study, your informed consent is required. You are being asked to make a decision whether or not to participate in the project. If you want to participate in the project, and agree with the statements below, please sign below. You may change your mind at any time and leave the study without penalty, even after the study has begun. Again, there are no negative consequences for refusing to grant consent or for withdrawing from the study at anytime.

I understand that:

1. My participation is voluntary and I have the right to refuse to answer any questions.
2. My confidentiality and my child's confidentiality are guaranteed.
3. There will be no anticipated personal risks or benefits because of my participation in this project.
4. My participation involves a survey that will take about 10 minutes to complete.
5. The results from the survey will be used for the completion of a class project in Course 703 (Seminar in Childhood Education) at SUNY Brockport.
6. My child will be given a pseudonym for all work that is to be used in this study. I understand that my child's work in class may be copied for data collection purposes with confidentiality guaranteed.
7. My child may be audio-taped during small group instruction with the teacher. I understand that the audio tapes will be destroyed one year from the completion of the research project.
8. Data will be kept in a locked filing cabinet in the classroom. Data and consent forms will be destroyed by shredding at the end of the Spring 2008 semester.

Appendix A (con't)

I am 18 years of age or older. I have read and understand the above statements. All my questions about my participation in this study have been answered to my satisfaction. I agree to participate in the study realizing I may withdraw without penalty at any time during the survey process. Completion of my interview indicates my consent to participate.

If you have any question you may contact:

Faculty Advisor	Faculty Member Name
Sue Novinger	Department of Education and Human Development , SUNY Brockport snovinge@brockport.edu 395-5935
Student Researcher:	rah Connors

Signature of Consent: _____

Date: _____

Thank you for taking the time to read this form. Please contact my through e-mail at _____ or at home, _____ for any further questions. If you would like to read the final research project, please contact me after May 30th, 2008

Sincerely,

Sarah M. Connors

Appendix B

Survey for Parents

The following is a survey for a graduate school project. The purpose of this survey is to generate an idea of parent attitudes toward math as well as generate an idea of your experience with math when you were your child's age. For more information on my project, please contact me via e-mail or at home.

Instructions: If you chose to participate in my research project, please make sure that you have signed the attached *Informed Consent* form. Be aware that this survey is anonymous. Return the survey in the daily take-home folder. As I receive the forms back, I will detach the consent form and the survey and place them in two separate envelopes.

1. In elementary school, I felt confident in my math skills.

Strongly agree

Indifferent

Strongly disagree

Comments: _____

2. In middle school, I felt confident in my math skills.

Strongly agree

Indifferent

Strongly disagree

Comments: _____

3. In high school, I felt confident in my math skills.

Strongly agree

Indifferent

Strongly disagree

Comments: _____

4. Math instruction in elementary school was primarily...

a. in small groups yes no comments: _____

b. using hands-on tools yes no comments: _____

c. teacher talking most of the time yes no comments: _____

Any additional comments on your early math experience: _____

Thank you for taking the time to complete this survey. Please remember, your name will never be disclosed.

Appendix C

Student Interview #1

Pseudonym: _____

Date of Interview: _____

Status:

On grade level

Below grade level

Above grade level

- 1. Do you like math?**
- 2. Why?**
- 3. When is math fun?**
- 4. When is math not fun?**
- 5. Do you like working in small groups?**
- 6. Why?**

Appendix D

Student Interview #2

Pseudonym: _____

Date of Interview: _____

Status:

On grade level

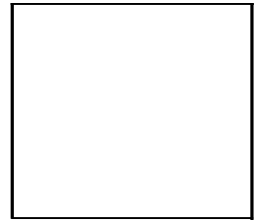
Below grade level

Above grade level

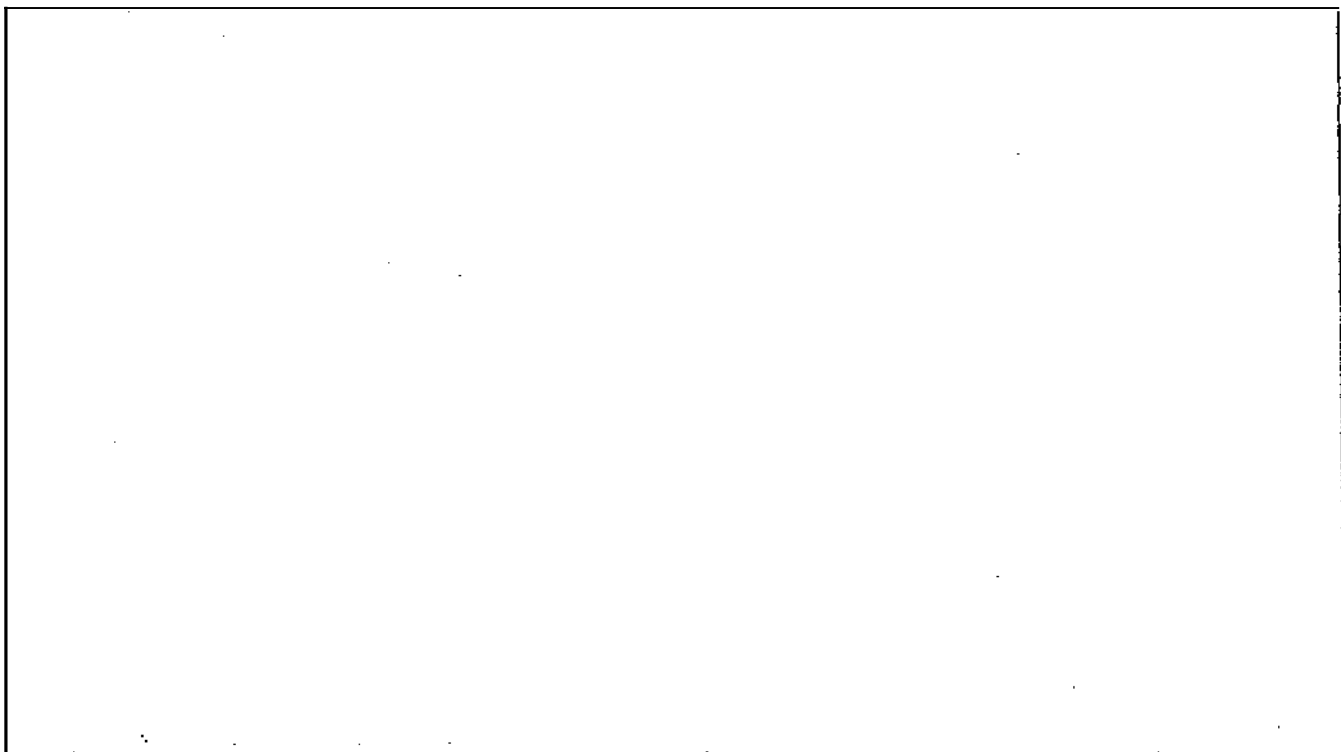
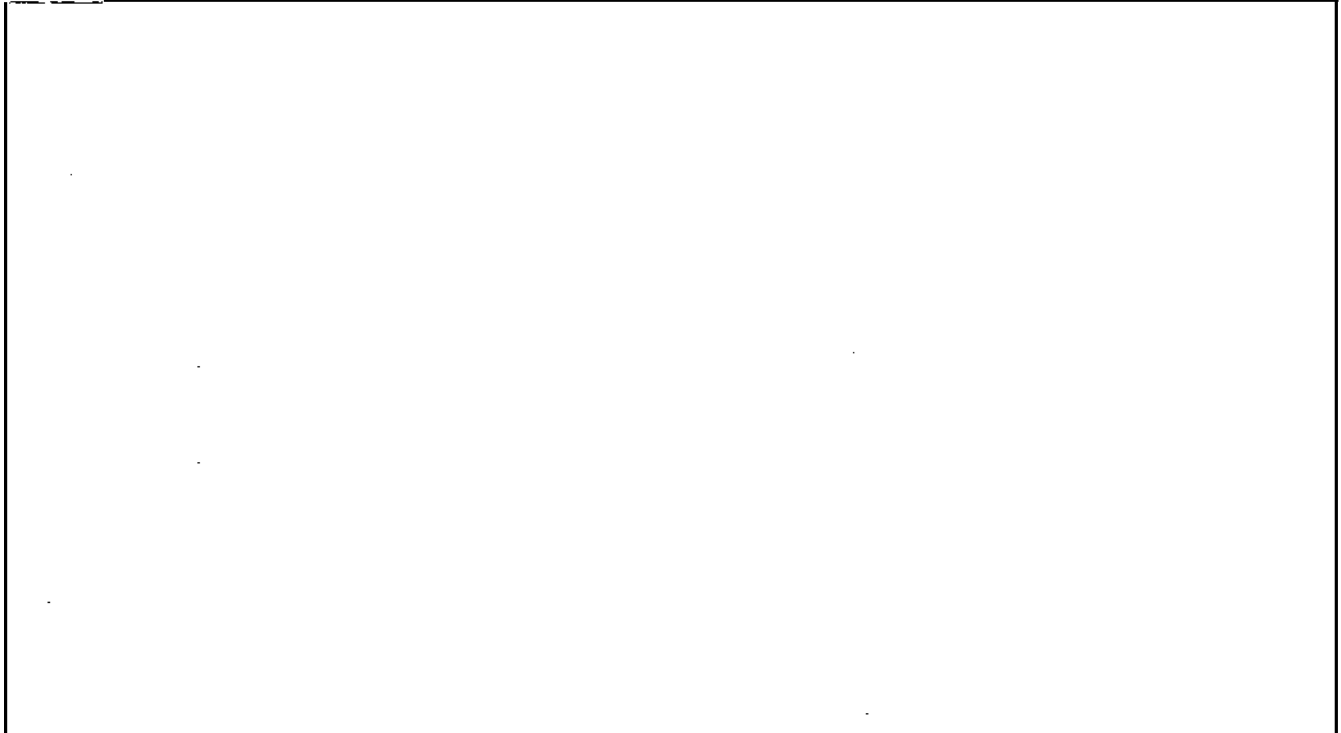
- 1. Do you like math?**
- 2. Why?**
- 3. When is math fun?**
- 4. When is math not fun?**
- 5. Do you like working in small groups?**
- 6. Why?**
- 7. When do you learn math best?**
- 8. What helps you learn best?**

Name _____

Today's Magic Number



I can show this number two different ways



Name _____

Date _____

Student Sheet 7**Oranges and Cherries**

I have 13 oranges and cherries.

How many of each could I have?

Keep track of your work. You can use pictures, numbers, or words.

Note to Families

There are many ways to solve this problem. Encourage your child to find his or her own ways to solve the problem and record the work.

Name _____

Date _____

Student Sheet 8**Oranges, Cherries, and Grapes**

I have 9 oranges, cherries, and grapes.

How many of each could I have?

Keep track of your work. You can use pictures, numbers, or words.

Note to Families

There are many ways to solve this problem. Encourage your child to find his or her own ways to solve the problem and record the work.

Name _____

Date _____

Student Sheet 6**Dinosaurs and Tigers**

I have 10 dinosaurs and tigers.

How many of each could I have?

Keep track of your work. You can use pictures, numbers, or words.

Note to Families

There are many ways to solve this problem. Encourage your child to find his or her own ways to solve the problem and record the work.

Name _____

Date _____

Student Sheet 10

How Many Hands at Home?

Draw a picture of everyone who lives at home with you. Find out how many hands there are.

Show how you solved the problem.
Use words, pictures, or numbers.

Name _____

Date _____

Student Sheet 11**Cats and Paws**

There are 4 cats in the yard.
How many paws are there?

Show how you solved the problem.
Use words, pictures, or numbers.

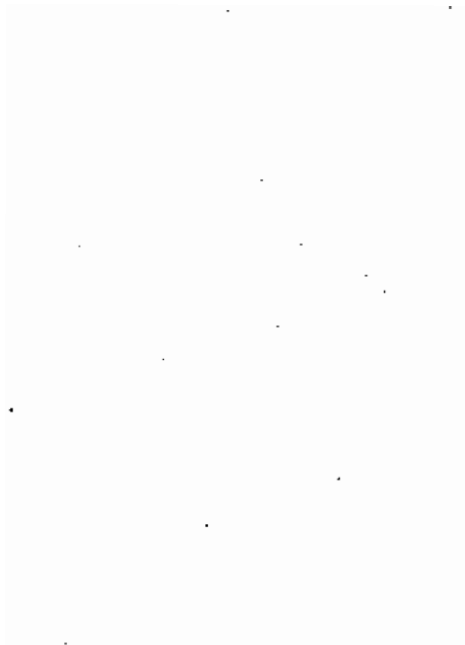
At the Beach

There were 9 children at the beach. Then
8 children came to the beach.

Now many children are at the beach?

Show how you solved the problem.

Use words, pictures, or numbers.



Name _____

Date _____

Student Sheet 13**Feet, Fingers, and Legs** (page 1 of 2)

Show how you solved each problem.

Use words, pictures, or numbers.

1. There are 7 people in my family.
How many feet are there?

2. There are 9 children at the bus stop.
How many feet are there?

Name _____

Date _____

Student Sheet 13**Feet, Fingers, and Legs** (page 2 of 2)

3. There are 2 children in the kitchen.
How many fingers are there?

4. There are 2 horses and 2 people in the barn.
Horses have 4 legs. How many legs are
there?

Name _____

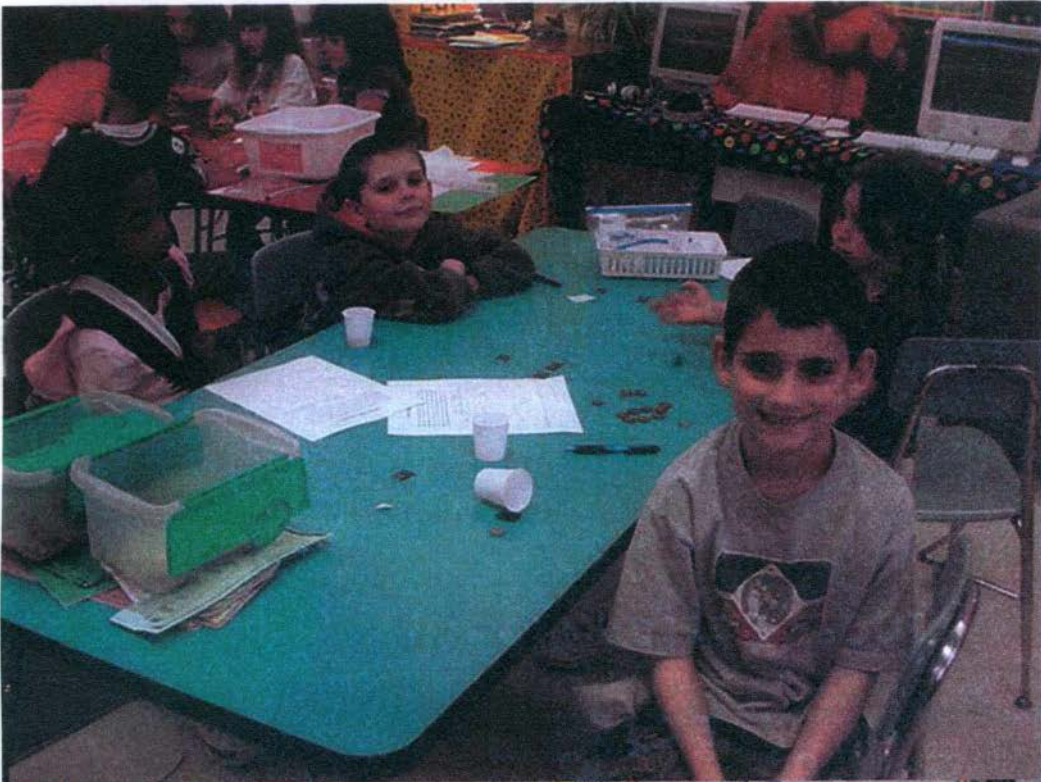
Date _____

Practice Page 1

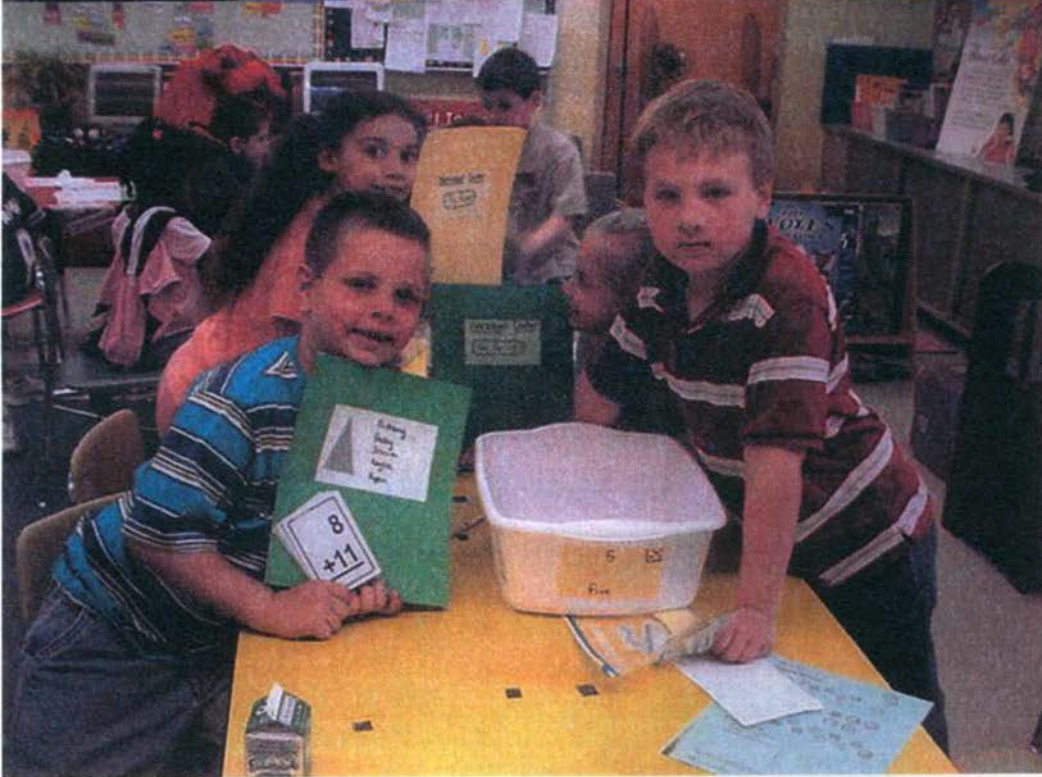
What are the missing numbers? Write them on the chart.

		23		25	26	27	28	29	
	32		34		36		38		
		43		45	46	47		49	
51			54			57	58	59	
	62	63		65		67	68		
									80
	82		84	85		87			
		93			96	97		99	

Appendix N



Appendix N (con't)



Collect 15 Together

Materials: One dot cube
25 counters

Players: 2

Object: With a partner, collect 15 counters.

How to Play

1. To start, one player rolls the dot cube. What number did you roll? Take that many counters.
2. Take turns rolling the dot cube. Take that many counters and add them to the collection.
3. After each turn, check the total number of counters in your collection. The game ends when you have 15 counters.

Variations

- a. At the end of each game, determine how many **more** than 15 counters you have.
- b. Play Collect 25 Together or Collect 40 Together.
- c. Collect **exactly** 15 counters. If the number you roll takes you over 15, skip that turn and roll again.
- d. For each turn, write the number you rolled and the total number of counters you have so far.
- e. Play with three people.
- f. Instead of a dot cube, use the Number Cards for 1 to 6. Mix them and turn up one at a time.

Note to Families

Play this game with your child. For counters, you can use buttons, pennies, paper clips, beans, or toothpicks. If you don't have a dot cube (or die), see the last variation.

Double Compare

Materials: Deck of Number Cards 0–10
(remove the wild cards)

Players: 2

Object: Decide which of two totals is greater.

How to Play

1. Mix the cards and deal them evenly to each player. Place your stack of cards facedown in front of you.
2. At the same time, both of you turn over the top two cards in your stack. Look at your two numbers and find the total. Then find the total of the other player's numbers.
If your total is more than the other player's, say "Me!"
If the two totals are the same, turn over the next two cards.
3. Keep turning over two cards. Say "Me!" each time your total is more.
4. The game is over when you have both turned over all the cards in your stack.

Variations

- a. If your total is **less**, say "Me."
- b. Play with three people. Find all three totals.
If yours is the most, say "Me."
- c. Add the four wild cards to the deck. A wild card can be made into any number.

Note to Families

In this game, your child will be finding the totals of pairs of numbers. You will need a set of Number Cards to play this game.

Name _____

Date _____

Student Sheet 14**Ten Turns Game Sheet**

Turn 1. I rolled _____ Now we have _____

Turn 2. I rolled _____ Now we have _____

Turn 3. I rolled _____ Now we have _____

Turn 4. I rolled _____ Now we have _____

Turn 5. I rolled _____ Now we have _____

Turn 6. I rolled _____ Now we have _____

Turn 7. I rolled _____ Now we have _____

Turn 8. I rolled _____ Now we have _____

Turn 9. I rolled _____ Now we have _____

Turn 10. I rolled _____ Now we have _____

Ten Turns

Materials: One number cube
Counters (50–60)
Ten Turns Game Sheet

Players: 2

Object: With a partner, collect as many counters as you can.

How to Play

1. Roll the number cube. What number did you roll? Take that many counters to start your collection. Write the number you rolled and the total number you have. (For the first turn, these numbers are the same.)
2. On each turn, roll the number cube and take that many counters. Find the total number of counters you and your partner have together.
3. After each turn, write the number you rolled and the new total.
4. Play for 10 turns.

Variations

- a. Play for fewer turns or more turns.
- b. Roll two number cubes on each turn.
- c. Instead of a number cube, use the Number Cards for 1 to 6. Mix them and turn up one at a time.

Note to Families

For counters, you can use buttons, pennies, paper clips, beans, or toothpicks. If you don't have a number cube, see Variation C. If you don't have the Ten Turns Game Sheet, keep track of the numbers rolled and each new total on a blank sheet of paper.

Name _____

Date _____

Student Sheet 9**Counters in a Cup**

Materials: Counters (5–10)
 Counters in a Cup game grid
 Paper cup

Players: 2

Object: Figure out how many of a set of counters are hidden.

How to Play

1. Decide how many counters to use each time. Write this total number on the game grid.
2. Player A hides a secret number of counters under the cup and leaves the rest out.
3. Player B figures out how many are hidden and says the number. Lift the cup to check.
4. On the game grid, write the number hidden in the cup and the number left out.
5. Players switch roles. Hide a different number of counters. (It's OK to hide the same number of counters more than once in a game.)
6. Repeat steps 2–5 until you have filled the game grid. (Hide the counters eight times.)

Optional

Your filled game grid shows different ways to break the total number into two parts. Can you find a way that is not shown?

Note to Families

For counters, you can use buttons, pennies, paper clips, beans, or toothpicks. Hide them under any container that you cannot see through. If you do not have a copy of the game grid, write the numbers in two columns on any paper.

Total of 10

Materials: Deck of Number Cards
(remove the wild cards)

Players: 1, 2, or 3

Object: Find combinations of cards that total 10.

How to Play

1. Lay out 20 cards faceup in four rows of five.
Set aside the rest of the deck.
2. Players take turns. On your turn, look for a combination of cards that totals 10.
Remove those cards and put them aside.
(Put each combination in a separate pile so they don't get mixed up.)
The 0 card may be included in any combination.
The 10 card by itself is one way to make 10.
3. The game is over when no more combinations of 10 can be made.
4. List all the combinations of 10 you made.

Variations

- a. Each time you remove cards from the layout, replace them with new cards from the deck.
- b. Play with wild cards. A wild card can be any number.
- c. Play to make a larger total, such as 12 or 20.
Replace each card you use with a new card from the deck.

On and Off

Materials: Counters (8–12)
On and Off game grid
Sheet of paper

Players: 1–3

Object: Toss counters over a sheet of paper.
Record how many land on and off
the paper.

How to Play

1. Decide how many counters you will toss each time. Write this total number on the game grid.
2. Lay the sheet of paper on a flat surface.
3. Hold the counters in one hand and toss them over the paper.
4. On the game grid, write how many landed on the paper and off the paper.
5. Repeat steps 3 and 4 until you have filled the game grid (eight tosses).

Optional

Your filled game grid shows different ways to break the total number into two parts. Can you find a way that is not shown?

Note to Families

For counters, you might use buttons, pennies, paper clips, or toothpicks. If you do not have a copy of the On and Off game grid, write the numbers in two columns on any paper.