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NEW BEGINNINGS:
BECOMING A MATH SPECIALIST

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ABSTRACT

This qualitative research study documents the lived and reported experiences of a math specialist and elementary math teachers while integrating the math program *Investigations in Number, Data, and Space* into a K-5 curriculum. The study follows the researcher as she transitions from a classroom teacher working with students to that of math specialist working with teachers. As the author facilitates the implementation of *Investigations*, she examines the influences of teacher concerns, teachers' knowledge of the program, classroom experiences, the role of professional development, and the influence of her role, as the math specialist, in the implementation process. As the research progresses, the author looks at the role of small study groups focusing on the inquiry method of teaching. The researcher found the use of the study groups to be an effective strategy, which she will continue to use while implementing *Investigations* into the curriculum.

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Most of all, I wish to thank my family who allowed me the time to read, write and do my homework. They have a tremendous understanding of my career long desire to achieve a Master's Degree. They understand my love of learning and tease that I will be a life long student!

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INTRODUCTION

There are two purposes to this action research. The first is to observe the experiences of elementary teachers using a math program developed by TERC called *Investigations in Number, Data and Space.* This implementation is a multi-step process. During the first step, teachers were asked to voluntarily use any of the methods or materials from the series. At the time of this research, we were in the second step of implementation in which teachers were required to attend nine hours of professional development and use the games and routines of the program in their math classroom. During the third step, teachers will be asked to begin using the investigations from the program.

The second purpose of this research is to examine my role as the math specialist. Not only was this a new position for me, but also the first year that the position existed in my district. This study is not meant to reflect any of the other elementary schools in the district; rather it is a snapshot of some of the experiences of my school and my position as a specialist.

RESEARCHER STANCE

A Life Changing Event

Life can be sneaky. You can be having a perfectly normal day when, out of the blue, an event occurs that transforms the rest of your life from that moment onward.

My life-changing event happened late in May of 2004. I was finishing my ninth year of teaching at a rural Pennsylvania elementary school. I had taught kindergarten for two years, first grade for six years, and I had just nearly completed a year of teaching third grade. I had asked for the transfer to third because I wanted to teach a curriculum with a more difficult content, especially in the area of math. I was interested in assuming the position of the building math curriculum leader when the position became available due to the retirement of the teacher who was the current curriculum leader. In order to be more highly qualified for the position, I wanted to have the experience of teaching math beyond the first grade level. I was glad that I had asked for the transfer; I loved third grade and planned on staying there for many years.

Before the students arrived on this particular morning, I happened to meet the principal of the school in the hallway. I expected him just to say good morning, which he did, but then he went on to tell me about the school board's decision to institute a new position of math specialist in each elementary school. He asked me to consider applying for the position for our building.

There was much to think about. As much as I loved math, I was not sure that I was willing to give up having a classroom to be the math specialist. I also had questions about how I would be received by the staff and what special talents I might bring to the position.

A Journey to Constructivism

I believe that one of the reasons that I was asked to apply for the position of math specialist was my constructivist approach to teaching math. My instruction was rarely lecture; rather, my students were involved in a variety of "hands-on" and small group activities designed to enhance understanding of concepts and skills. However, my methodology had not always been constructivist.

While I was in college, I had a dual major in Human Development and Elementary Education. The Human Development major appealed to me because I was particularly interested in why and how children learn, which naturally blended with Elementary Education. One class, prominent in my memory, was that of my Math Methods Course. My professor was a strong advocate of keeping students actively involved in learning. I vividly remember her standing in the front of the class using a cookie sheet to model how students might use magnetic manipulatives. I thought that was a wonderful idea! Her message stayed with me and I always believed in using as many student manipulatives as possible.

When I began my career in the 1970s as a teacher in a second grade classroom, the use of teaching "centers" was very popular. My understanding of centers at that time was that the students should rotate through different predetermined activities, while the teacher was involved with instructing small homogeneous groups. I followed this structure daily, but I had two major concerns. One was that the development of center activities was very time consuming for the teacher. The second was that the students were not always on task, and I was not always sure what they were learning from the center activity. As I look back, the class had the look of a centers based classroom, but there were actually many attributes of a more traditionally structured classroom. Even though I had small groups, we were all working right from the book, just on a different page. Even though I had the students moving around the room in centers, the activities I used were for practice or drill, students did not have any choice in choosing an activity, and the activities were not leveled for different abilities.

After two years of teaching second grade, I moved to a new school and taught fifth grade. Here I felt totally out of my element, and I reverted to teaching the way I had been taught in fifth grade, in a very structured, traditional manner. I did not use learning centers; rather I demonstrated math problems on the board and then assigned homework. Looking back, I cannot believe that I tried to get the students to understand long division in that manner! Yet, I will never forget the frustration I experienced when they just could not get it!

I was only in that fifth grade for one year. I had gotten married, moved, and started a family. When I returned to teaching 10 years later, I was assigned to kindergarten. Much of my college education was geared toward the very young learners so I felt very comfortable in this setting and we had a wonderful time! In my math instruction, I used song, dance, literature, and any kind of manipulative I could find. I served on the math committee and was involved with writing curriculum.

After two years of kindergarten, I moved up to first grade. One pivotal moment for me occurred during a curriculum meeting in which one teacher talked about how some teachers were using *Math Their Way*. As she was a very traditional teacher, she made it clear that she did not care for this program. I however, knew immediately that this was a topic that I needed to explore. During that next summer, I enrolled in a professional development class based on the *Math Their Way* program, and the manner in which I taught math changed from that time onward.

Math Their Way is based on teaching to the students' developmental level. The activities used are developmentally appropriate; they are often student selected, and student directed. As the students progress through the different levels, they begin to form their own understanding of the concepts of addition, subtraction, geometry, and a variety of other math topics. The role of the teacher is that of facilitator, always nudging the students and providing the activities to

lead them to the next step of development. I would later come to understand this methodology even more as I read the works of Vygotsky (1978) when he talked about the zone of proximal development. This "is the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (p. 86). As you lead students through more challenging material, the "zone of proximal development today will be the actual developmental level tomorrow" (p. 87).

After taking the *Math Their Way* course, my first grade classroom had a different look. You would be able to tell just by walking into the room that math was an important part of my curriculum. I had one whole wall dedicated to math manipulatives, and many of my teaching displays were centered on math concepts. Many of these items were common to any math classroom, but some were there just to spark the interest of the students. For example, I had a selection of Barbie shoes that the girls especially enjoyed using for adding and subtracting activities, and the Matchbox cars were one of the favorite manipulatives used by the boys.

The mornings in my first grade always started with a good dose of math during our morning meetings. We did not just learn about concepts on a page in the math book, but through real life experiences. For example, we graphed the weather and during the winter months we would set a container of water outside

the door to see if the temperature was cold enough to make it freeze. During the actual math class, we would start with literature or song, we had our lesson of the day, and then we would move to center time. These centers were quite different from those of my early days in second grade. These centers were discovery in nature, they had a wide range of applications, and the students had choice in what they would do. Best of all, these centers involved a minimal amount of teacher preparation because the materials were common to a number of activities that could be easily adapted by simply changing the focus of the activity or by changing the response sheet. As the teacher, I would move through the classroom to monitor the student involvement and to ask focused higher-level thinking questions for the students to ponder.

I thought that my teaching method was finally established, until I came across some sample material from the publisher of our core math curriculum called *Investigations into Number, Data and Space.* This program had a totally different look to it from tradition textbooks. The only books were a series of curriculum guides for the teachers. There were no student books, only black lined masters that supported the activity the teacher was doing to teach a particular skill. Again, I was curious and interested. I tried to read through the sample book, but I was a bit lost as to what the program was about and how it would be implemented. I set the sample book aside until a few years later when the Assistant Superintendent decided that we should take a closer look at the

Investigations program. She bought one entire set of curriculum guides and resources for each grade level. I was still on the math committee, so I was given the materials for first grade. I used some of the ideas and materials, but must admit that I did not jump into the program. For each lesson, there were several pages to read related to the activity, plus, there usually was a considerable amount of teacher preparation. The underlying philosophy of the program was for students to have more of an understanding of the basic concepts, not just the algorithms. The philosophy fit my own, but I found myself using only bits and pieces without any commitment to the entirety of the program.

As I began to take graduate courses, I noticed that the *Investigations* program was referenced repeatedly whenever math was being discussed. I decided that I needed to take another look into the *Investigations* curriculum. When I moved to third grade, I used the activities from *Investigations* to introduce the concepts of multiplication and fractions. I found both of the investigations to be helpful in the formation of students' understanding of these concepts. Finally, when I attended the National Convention for the National Council of Teachers of Mathematics (NCTM) in Philadelphia, almost every presentation I attended advocated using one or more activities that came from the *Investigations* program. Many of the activities were some that I had already used in my classroom. I felt empowered by this, but also noted that none of the presenters used the *Investigations* program exclusively.

My Decision

Looking back, I realize that the decision to take the offer to become a math specialist really was not that difficult. When the math committee first made the suggestion to the school board to have a math specialist in each building, I knew that I would some day like to have the job. It just came sooner than I expected. I have always enjoyed helping other teachers find information or activities. If I knew that they were looking for something, I would often spend my own planning time trying to help them with their quest for ideas.

One element of my decision was that the Assistant Superintendent was making another push for the use of *Investigations*. She was ordering more curriculum guides with the intention that every teacher would try at least some of the games or activities of the program during the next year. I reflected on my own *Investigations* journey, and realized that even though I still had much to learn about the program, I also had a lot to offer the staff. Even though I would miss the classroom, I decided to accept the position.

During this same time period, I was also involved in setting up an action research project to fulfill the requirements of obtaining my Masters in Curriculum and Instruction through Moravian College. My research question began to involve my role in helping teachers learn more about the *Investigations* program. I knew that if the teachers were to use the program, they would need to have a positive

experience; otherwise the books would be destined to just sit on the shelf. Dewey (1938) said:

> It is not enough to insist upon the necessity of experience, nor even of activity in experience. Everything depends upon the *quality* of the experience, which is had. The quality of any experience has two aspects. There is an immediate aspect of agreeableness or disagreeableness, and there is its influence upon later experiences. The first is obvious and easy to judge. The *effect* of an experience is not borne on its face. (p. 27)

Dewey goes on to say that "Hence the central problem of an education based upon experience is to select the kind of present experiences that live fruitfully and creatively in subsequent experiences" (p. 28). My research question would deal with how I, as a math specialist, could enhance the quality of the teachers' experiences using activities from *Investigations*, and to help ensure future incorporation of the philosophy and activities into their classroom curriculum.

RESEARCH DESIGN AND METHODOLOGY

Designing the Proposal

Mill (1999) defines action research as a "systematic inquiry conducted by teacher researchers, principals, school counselors, or other stakeholders in the teaching/learning environment, to gather information about the ways that their particular schools operated, how they teach, and how well their students learn" (p. 6). My research question would not only examine the experiences of the teachers as they implemented this new program, but would also look at my own development as a math specialist.

In my district, there are three elementary schools. The school in which I teach has approximately 630 students. The area is rural but there are several housing developments in progress, which have resulted in a steady increase of enrollment. Most students have a middle class background, but our population covers the full spectrum of economic income. There are 31 classroom teachers who teach math and four Special-Education teachers. The students in kindergarten through second grade stay with their classroom teacher for math instruction, with an average class size at approximately 20 to 22 students. Third grade through fifth grade are grouped homogeneously for math instruction, with the top groups having a larger class size (approximately 24) than the lower groups (17 or fewer students). The teachers have a wide range of teaching experience, from nearly new teachers to teachers near retirement.

The first step in the research process was to submit an application to Moravian College's Human Subjects Internal Review Board (HSIRB). This board reviewed the application to ensure that the study was to be conducted in an ethical manner. The research proposal was accepted before the research was enacted (see Appendix A).

In order to facilitate the incorporation of the *Investigations* program into the curriculum I planned to:

1. Assist with the professional development courses dedicated to learning the methods and games of the *Investigations* math program.
2. Provide classroom assistance to teachers while they used the *Investigations* activities. This assistance could include but was not limited to assistance with planning, gathering of needed materials, modeling, team teaching, and conducting small group instruction.
3. Meet with grade level teams to discuss and reflect upon the use of the *Investigations* activities that were being used in the classrooms.
4. Meet with individual teachers and discuss the implementation of *Investigations* activities in their classroom

As the research was being implemented, I recorded my observations, experiences, and conversations in a field log. These "field notes are direct observations of what is being said and done as well as impressions or hunches of the observer" (Arhar, Holly, & Kasten, 2001, p. 140). As I recorded experiences

into my journal, I began my analysis by using observer comments about methods, hunches, and ideas that occurred as I wrote or reread the journal and other data. These were clearly identified as my comments and not part of the data. I also analyzed the data by using analytic memos. These memos examined patterns of behavior, key ideas, events, or dilemmas. Ely, Vinz, Anzul, and Downing (1997) noted, "Analytic memos can be thought of as conversations with oneself about what has occurred in the research process, what has been learned, the insights this provides and the leads these suggest for future action" (p. 80). Specific types of analytic memos may be used, such as a memo that focuses on figurative language, on metaphors, or on quotations from the data (Arhar, Holly, & Kasten, 2001).

Data collected included an initial survey (see Appendix B), completed by the teachers, to show the teachers' knowledge and implementation of the *Investigations* program. A similar but expanded survey was given at the midpoint and conclusion of the research process (see Appendix C). Interviews were used to gain more knowledge of teachers' perceptions in regards to both the *Investigations* program and to the role of the math specialist (see Appendix D). All surveys and interviews were documented, kept confidential, and stored with the research log in a secure location.

I also planned on using narrative devices in order to analyze data. These narrative devices could be layered stories (the same story told from several perspectives); vignettes (small stories within a story), poetry; or a narrative report

written from another perspective, such as from the perspective of the students, the teachers, or administrators (Ely, Anzul, Friedman, Garner, & Steinmetz, 1991). As I examined the data, I planned on applying the writings of Dewey, Freire, Vygotsky, or other educational theorists. As I wrote my study, I used frequent participant checks, which gave the participants of my study an opportunity to verify, challenge, or clarify what I had written.

One of the main methods of analysis was the use of codes, bins, and themes. Codes are a way of categorizing key experiences in the data. As commonalities in the codes emerged, they were grouped together into what is called a bin on a graphic organizer. As I looked through the codes in each of the bins, I began to form theme statements to help me organize the findings of my study (Bogdan & Biklen, 1998).

Before beginning my study, I read about Stages of Concern (SoC) which are taken from the Concerns Based Adoption Model (CBAM) as described by Dass (2001). These stages categorize characteristics of teachers involved with implementing a new innovation to the curriculum. I planned to code my journal using these stages of concern, which are listed below with their identifiable characteristics.

Stages of Concern

SoC 0 (awareness) and SoC 1 (informational) relate to awareness of the innovation in terms of characteristics of the innovation and requirements for its

use. Teachers may have a high level of anxiety and may be more concerned about "doing it right" and meeting the requirements rather than understanding the essences of the approach.

SoC 2 (personal) relates to an individual's capability to meet the demands of an innovation, their role in relation to the reward structure, and potential conflicts with existing structures and implications of the program status. Teachers may worry about the time they put into the innovation compared to what they get out of it. They may have concerns about the time needed to organize materials and activities. Other concerns may be that they are concerned about assessments matching instruction and concerns about whether or not the program will stay or is it a "flash in the pan?"

SoC 3 (management) relates to aspects of actually implementing the innovation, such as organizing and managing the time demands. The teacher concerns may include management factors such as time, availability of resources, how to work with grade-level teams, and how to manage students.

SoC 4 (consequence) focuses on the impact of the innovation on students and includes areas such as the relevance of the innovation for students, evaluation of student outcomes, and changes needed to improve student outcomes.

SoC 5 (collaboration) considers the co-ordination and co-operation with others regarding the use of the innovation. This collaboration may be

- teacher and students

- teacher and other teachers
- teacher and administrators,
- teachers and human resources in the community

SoC 6 (refocusing) relates to the more universal benefits from the innovation, including the possibility of major refinements or even replacement with a more powerful alternative.

Teacher comments and interviews will be used to determine stages of concern.

I feel that it is extremely important to look at the teachers' attitudes. Dass (2001) concludes his article by saying, "Since it is the teachers who are ultimately responsible for bringing about educational reform, their concerns must be sought out and paid attention to if reform is to be successful" (p. 982).

Presenting My Study to the Staff

After getting permission from the building principal (see Appendix E), I introduced my research project to the staff during a faculty meeting. I began by explaining that the field of education research is moving in a new direction, teachers are now doing qualitative research in their own classrooms to improve their own practice. I explained that as a fulfillment of my Master's Degree, I was being asked to do a research project focusing on my teaching practice, which now meant that I was looking at my role as a math specialist. My research would look at how I was facilitating the incorporation of *Investigations* into the curriculum. Since it was a district mandate that all teachers begin using some elements of the

Investigations program, I made it clear that I would not be asking the teachers to do anything extra beyond what they were already being asked to do except for participating in surveys, interviews, or other types of participant checks. I told the teachers that I would be using pseudonyms to mask their identities and all information would be kept confidential. Teachers would be able to drop their participation with the research at any time without consequence and that participation or non-participation had no relevance to any teacher evaluation by the building principal. Finally, I told them that they would have an opportunity to read any part of my thesis that referred to them by a pseudonym before the thesis was submitted to the review committee. All teachers involved with teaching of math in my building signed a participant consent form (see Appendix F) to be a part of the study.

LITERATURE REVIEW

Integrating New Concepts into the Curriculum

Connelly and Clandinin (1988) suggest that teachers read curriculum materials "according to their own personal, practical knowledge" (p. 149). They realize that all teachers bring their personal experiences and abilities into their teaching of any curriculum. "Good curriculum materials have many different potentials for different people in different circumstances. As teacher, we must realize this potential" (p. 152). Connelly and Clandinin expand on this idea by citing Eisner's views on curriculum.

> Eisner (1979) makes the point that all schools teach three curricula: the explicit, the implicit (i.e., the "hidden"), and the null. The explicit curriculum is the curriculum as stated, including the intentions of developers, policy makers, and others. It also includes lists of content and so forth. The implicit, hidden curriculum names all those things that are taught even though we do not set out to do so. The null curriculum refers to those things deliberately excluded. (p. 153)

The actual curriculum taught in the classroom is a mixture of the explicit curriculum, the hidden, the null, and also some personal choices made by the classroom teacher. It is my hope that as I assist teachers to learn more about *Investigations*, that the explicit and the actual enacted curriculum become more closely aligned.

Why Use Investigations?

Morkos, Berle-Carman, Rubin, and Wright (1994) give this definition of the *Investigations* Curriculum.

> *Investigations in Number, Data, and Space* is a new K-5 curriculum presented through a series of teacher books rather than traditional textbooks. Each book explores major mathematical ideas while communicating mathematics content and pedagogy to teachers. Depth in mathematical thinking rather than a superficial exposure to a series of fragmented topics is emphasized. Students find more than one solution to many problems they work on, and they invest their own strategies and approaches rather than relying on memorized procedures. Students choose from a variety of concrete materials and appropriate technology, including calculators, as a part of their everyday mathematical work. While working as a whole class, individually, in pairs, and in small groups, students express their mathematical thinking through talking, drawing and writing. (¶ 2)

The *Investigations* Curriculum was funded by the National Science Foundation and was developed through TERC, a not-for-profit education research and development organization based in Cambridge, Massachusetts. TERC emphasizes an innovative, inquiry-based approach to learning. TERC researchers Morkos, Berl-Carman, Rubin, and Wright (1994) found that 3rd and 4th grade

students substantially deepened their understanding of mathematical concepts after being instructed using *Investigations* materials. A follow up study by Morkos, Berle-Carman, Rubin, and O'Neil (1996) compared second grade students who were taught solely with the *Investigations* model with those taught in a more traditional classroom. The students using *Investigations* were accurate with their mental math 80% of the time compared to 30% of the time for the control classroom. The *Investigations* group demonstrated greater flexibility in their thinking, and students were able to choose from a wide range of strategies when solving problems. Similar results were found in studies conducted by Goodrow (1998) and the ARC (Alternatives for Rebuilding Curricula) Center (2003).

The Investigations Teacher

The *Investigations* program is very different from the traditional approach to teaching mathematics because more emphasis is placed on the students constructing meaning of the concepts. This is accomplished through inquiry-based activities instead of solving problems from the text or a worksheet. The curriculum guides also have a component that explains more about the pedagogy and principles that underlie each investigation. Remillard and Bryans (2004) conducted a five-year study focusing on the role of the curriculum in supporting teacher learning. The study took place in a small urban school where 61% of the students were from low-income families, and the student population had a racial

mix of 60% African American, 30% White, and 10% other. The school had a history as a progressive school and had a school-wide emphasis on teacher development and, in particular, improving mathematics teaching. Seven of the eleven classroom teachers, with a range of 3 to 30 years of experience, participated in this study. Remillard and Bryans (2004) found similarities in how teachers viewed the curriculum and how they used the materials. They found three predominant categories that reflected the classroom implementation of the *Investigations* curriculum:

1. *Intermittent and narrow use*. These teachers "used the materials minimally, primarily relying of their own teaching routines and resources to guide their curriculum. When they did use *Investigations*, they tended to use the resource narrowly, selecting familiar tasks and using repertoires they had developed over years of teaching when enacting them in the classroom" (p. 374).
2. *Adopting and adapting.* These teachers "regularly adopted mathematical tasks from the curriculum guides, but drew on their own strategies and approaches to enact them in the classroom. In other words, they adapted them to fit their familiar approaches to teaching" (p. 374).
3. *Thorough piloting.* These teachers "tended to read and use all parts of the curriculum guides in their teaching. These teachers used *Investigations* as

> their primary guide in teaching mathematics from structuring the curriculum to selecting tasks to facilitating students' work on those tasks" (p. 377).

Besides looking at how the teachers were implementing the curriculum, Remillard and Bryans (2004) were also interested in how the curriculum fostered teacher learning. They believe that structured opportunities for learning such as professional development and teacher study groups are critical to teacher learning, but for the purposes of this study, they focused on teacher learning from the actual curriculum materials themselves. They again categorized teachers to illustrate their findings.

1. *Minimal engagement in learning.* These teachers had minimal interaction with the teacher study group. They used the curriculum intermittently and did not use the "reform-oriented suggestions. Thus, their use of *Investigations* provided them with few opportunities to learn about students' thinking, explore unfamiliar mathematical ideas, or consider alternative approaches to teaching" (p. 380).
2. *Expanding one's repertoire of activities.* These teachers tended to use the *Investigations* curriculum by consistently adopting tasks that they integrated into their own pedagogical practices. This limited their opportunities to expand their ideas about the teacher's role in fostering learning (p. 380).

3. *Insights into student thinking.* The teachers used the "suggestions in the teachers' guides to encourage students to explain their thinking, they were given opportunities to learn more about student thinking" (p. 381).
4. *Constructing the teacher's role in orchestrating student learning.* As teachers more actively pursued learning about student learning, they "found themselves needing to find resources to help them respond to diverse and unanticipated ideas" (p. 381). These teachers found themselves closely reading the guiding suggestions and background knowledge in the curriculum guides and constructing new teaching practices as they progressed through their lessons.
5. *Exploration of mathematics.* As the teachers worked with their students to explain the underlying meanings of the math, they realized that they needed to gain a clearer understanding of the concepts for themselves. "As they facilitated their students' work on the mathematical tasks in the curriculum, they found themselves contemplating and often struggling with the underlying concepts" (p. 382). This prompted the teachers to expand their own mathematical knowledge.

In writing the conclusion, Remillard and Bryans (2004) state that teachers using a curriculum such as *Investigations* would benefit by having opportunities to read and explore the materials and by having conversations with other teachers about how to use these materials. "In particular, teachers need opportunities to

interpret information written to them in these resources and consider ways that these insights might figure into their interpretations of students' work and decision making while teaching" (p. 386).

The Role of Professional Development

The study above stresses the importance of professional development. This is especially important when considering the implementation of a reform curriculum such as Investigations. "Reform requires most teachers to rethink their own practice, to construct new classroom roles and expectations about student outcomes, and to teach in ways they have never taught before – and probably never experienced as students" (Nelson & Hammerman, as cited in Darling-Hammond & McLaughlin, 1995, p. 597).

Klinger (2004) suggests that the majority of past professional development programs were marginally successful at best. She cites the National Joint Committee on Learning Disabilities (NJCLD, 2000) as they "described previous professional development activities as too linear or top-down in approach, characterizing them as sit and get sessions, in which relatively passive participants were made aware of the latest ideas regarding teaching and learning from experts" [italics added] (p. 248). The new model of professional development is one of a supportive community in which teachers work and learn together. Darling-Hammond and McLaughlin (1995) suggest that effective

> professional development today also means providing occasions for teachers to reflect critically on their practice and to fashion new knowledge and beliefs about content, pedagogy, and learners. This involves teachers both as learners and as teachers and allows them to struggle with the uncertainties that accompany each role" (p. 597).

Teachers need the time to acquire new knowledge, time to develop new practices, and time outside of direct contact with children to plan and reflect on how to implement these practices effectively in their classroom. Griffin and Case (1997) suggest that effective professional development has three components. First, there should be opportunities for teachers to construct mathematical knowledge and reflect on this knowledge construction by using problem-solving activities that reflect the activities developed for children. Eckmeir and Bunyan (1995) support this component, finding that when teachers experienced the same hands-on strategies as their students, that math anxiety is reduced and mathematical knowledge is increased. The second component by Griffin and Case (1997) is that there should be opportunities to examine teaching practices through guided discussions. Third, teachers need opportunities to discuss their own teaching successes and challenges with colleagues, in round-table discussions. Griffin and Case (1997) suggest the use of a mentor teacher to facilitate the professional development sessions.

Acquarelli and Mumme (1996) hold similar views of professional development, saying that teachers need to belong to learning communities that place inquiry at their center. Development must be grounded in classroom practice. Teachers must experience reforms in their own classrooms and have opportunities to grapple with the difficulties that arise. Teachers need to be able to share not only their successes but also their trials. Landrum, Cook, Tankersley, and Fitzgerald (2002) found that not only did teachers value the opinions and experiences of their peers, but they also found them to be more trustworthy and usable than information from other sources.

As a math specialist, I will need to encourage teachers to talk to one another in a guided manner. Griffin and Case (1997) noted that teachers have a strong preference for discussing their teaching practices rather than reconstructing their mathematical knowledge or analyzing their own methods of knowledge construction. A commentary of this study by Collis (1997) noted that teachers often stay with these "safe" topics. It is the "leader's task to be aware of this characteristic of the professional group and, while allowing some time for this practical and often valuable activity, ensure that the focus on (re)-construction of knowledge is not lost" (¶14). Collis goes on to say that in order to achieve the required results, teachers must also increase their understanding of the discipline of mathematics and develop their understanding of the cognitive structures underlying the new approaches.

Barriers to Implementation

Klinger (2004) suggests that there are common barriers when implementing a new practice. These can be lack of time, inadequate support from administrators, high-stakes testing and pressure to cover content, a mismatch between teacher style and the practice and insufficient in-depth understanding of the practice. In contrast, teachers reported that factors that enhanced their sustained use of innovative practices were:

1. *Support networks*. Having colleagues working on the same practice.
2. *Administrative support*. Teachers knew that the instructional practices were important to their principal and that the principal expected to see them in the classroom.
3. *Student benefits*. Teachers identified student benefits as a strong influence on their sustained use of practices.
4. *Student acceptance*. Teachers were much more likely to continue using a practice if their students liked it and were enthusiastic about it.
5. *Flexibility of the practice.* When teachers perceived that they could modify the practice to suit their instructional style or their students' needs, they developed more ownership of the practice.
6. *Readily available materials*. Teachers reported that they simply did not have time to hunt around for materials, find books, or make materials on

their own, so the availability of materials influenced the extent to which they implemented a practice.

MY STORY

The Journey Begins

When my fellow teachers heard the news that I was to be the building math specialist, they were very receptive. There was a great deal of teasing and joking going on but, as the beginning of school approached, I felt a bit of nervousness in the staff. One example occurred while I was in the school in mid-August setting up my office. I was visiting Connie when Mona (all names are pseudonyms) entered the room. Connie said to Mona, "I thought that you were going home hours ago!" Connie then teased Mona by saying, "No wonder your kids have trouble learning time!" Mona reacted by saying, "Oh sure, make me look bad in front of the math specialist!"

Later that same day, I was talking with George and Don. Conversation was light and good-natured but when the topic of my job arose, Don said, "Oh, I can see you now, coming into my room and laughing in the back." I've always believed that there is a lot of truth being said when someone jokes around. Here in one day's span, there were two incidents where teachers were beginning to see me differently, as someone who was more in authority. Klinger (2004) talks about the relationship between researcher and teacher, but I would like to expand this to include specialist and teacher. "It took time and patience to establish trust, to get to know one another, and to build relationships and an adequate comfort level. Thus the demeanor of researchers should be non-threatening and non-judgmental"

(p. 254). Even though I have known these teachers for years, this was a new situation and I realized that I had to begin anew to establish trust.

The First In-Service

A professor from a local college lead the first in-service of the school year and I was there to give support. The purpose of the day was to give the teachers an introduction to *Investigations in Number, Data and Space.* During this school year, the teachers would be required to begin using some of the games and activities from this series.

The day began with the kindergarten through second grade teachers. Even though I was there as a support person, I was extremely nervous. Some teachers were cooperating and experiencing the activities, some were talking among themselves, and some were doing things totally unrelated to the in-service. It was not until break that I found out exactly what the teachers were thinking.

Mona came to me and talked about how teachers are always asked to do more and more without having anymore time to do the things that need to be done. I tried to assure her that the *Investigation* activities would fit nicely into her regular classroom routine. The games could be done as centers, or as a "when you're done" activity, or even a recess game. She nodded her head and then began her next objection. She was distressed that the teachers were going to have to share materials. I explained to her that the kits are very expensive, and after this year, we would find the pieces of the kit that are the most beneficial to the

program, and order those for every teacher. From the research that I had read by Dass (2001), I knew that Mona's concerns were common during early stages of implementation. I could hear the frustration and almost anger in her voice.

Another teacher, Steph, came to me and requested that I come into her room to offer support. She was teaching the lowest group and was having trouble envisioning how she would organize her classroom to incorporate what we were learning about in the in-service. During the day, many teachers approached me about coming into their classroom, which made me wonder about the scheduling of my own time. Julie and Kris seemed to be excited about the activities that were being presented. They realized that some of the activities needed a certain amount of teacher preparation. They suggested that it would be nice to have a "Make and Take It" workshop. When I later talked to the Assistant Superintendent about this, she responded that making things did not fit the definition of professional development. So now I had my first challenge, how do I support Julie and Kris? As I talked to the math specialists from the other two buildings, we brainstormed ways that we could help the teachers with some of the preparation work. For example, we could send items to the duplicating center or we could put games on card stock and have them laminated.

In the afternoon there was a new group of teachers, those that taught grades three through five. These teachers seemed to be more receptive to what was being presented. I heard one teacher say, "I like this game!"

One thing that I learned during the afternoon was that it is important for teachers to fully understand the games and activities that they will be doing with the students. I had set out the materials needed for one of the games and it turned out that I had put out the wrong kind of fraction dice – I was not aware that there are different kinds of fraction dice! Luckily, the presenter had brought her own dice and we were able to continue with the activity. If this had been a classroom, I would have been in trouble!

Overall, the first day of in-services went very well, but I was exhausted. There was a lot of stress in hoping that the teachers reacted positively. I felt comfortable talking to administrators and I enjoyed the other math specialist. I was hopeful that it would be a good year.

How Big is a Million?

Rena came to me early in the year asking me to show her where the materials were located for fifth grade. Rena is a veteran teacher and she seemed interested in learning more about what *Investigations* had to offer. After going through the curriculum guides and resource box, she told me that she enjoys teaching with manipulatives and hands-on activities. I was excited at the prospect of what Rena would bring to my research, but then she told me that she did not think that she would be a participant. She was feeling overwhelmed by the beginning of the school year and worried that she would not be able to make a commitment to one more thing. I assured her that my research would not add

anything more to her workload than the district was already asking and that I would support her with any activity she was willing to try in her classroom. She was not completely convinced, but agreed to sign the consent form to be part of my study. I was determined not to let her down!

Fifth grade has the curriculum that I have the least familiarity, so I decided that I would begin my personal delving into the program at the fifth grade level. There are several different books covering a range of topics for each grade level so I focused on the activities that would be covered first in the classroom, namely place value and number sense.

I spent several hours reading through the curriculum guides, and making copies of the games and activities related to place value, including copies of any black-lined masters that the teachers would need to duplicate for the activity. I did this because my building had only two sets of curriculum guides that six math teachers and I were sharing. When I was finished, I placed the packets into the fifth grade teachers' mailboxes.

Later that day I saw Rena and Ben looking through the packet and joined the conversation. Rena showed some interest in some of the activities that helped students understand the meanings of numbers. When we came to the decimal game in the packet, Ben said that he had an activity that he liked better that used baseball data. I told him that was fine. Our goal is to use whatever works to help students understand the concepts, it does not have to be from the basal series or

from *Investigations*. This was a short, informal meeting after school that resulted in a nice exchange of ideas.

A few days later Ellen came to me early in the morning. She was excited about some of the activities from the fifth-grade packet I had given her. She told me that she was glad that I took the time to put the information together because when she saw that there are so many different books to the curriculum guides, she would not know where to start looking for the specific skills her class would be working on. She admitted that she probably would not have taken the time to search for the information on her own. She told me that she was going to begin the Array of Dots activity that morning. I was excited to hear this and asked her to check in with me later.

The Array of Dots activity (see Appendix G) uses one-inch squares that contain 100 dots (10 x 10). The purpose of the activity was to develop an understanding of 10,000 by creating arrays that represent the factor pairs of 10,000. When I saw Ellen in the hall later, she grabbed the wall and said "Oh, My!" Apparently her lesson did not go as well as she had hoped! I asked her if she was going to give up. She said, "Oh no – not after one lesson!" The class homework for the night was finding out how many hundreds are in 10,000. The next day she was going to begin having the students construct arrays of 10,000. I promised that I would be in to help.

The students were already working when I entered Ellen's room the next day. Ellen seemed a bit nervous at first and I was hoping that it was not because I was there, but as the lesson progressed she seemed more relaxed. There was a lot of cutting and pasting going on by the students and she seemed to really appreciate the extra pair of helping hands. As the students worked, we asked them questions to verify their understanding of what they were doing. The students made a variety of arrays, one group made a 5 x 20 array, one made a 10 x 10 array and one even made a 1 x 100 array. We both delighted when one student said, "I wonder how long one million dots would be?" That was the next step of the lesson. We were certain that our foundation was laid.

A few days later I went to Rena's classroom. Her students were doing the same activity that Ellen's students had been doing. It was interesting because Rena's class is ranked higher in our homogeneous groupings, yet she was having trouble getting the students to produce an array other than 10 x 10. I shared with her some of the arrays that Ellen's class had done. Rena said that she thought that this was a wonderful activity for the upper kids because it forced them to think out of the box. It was also good for the lower students because it helps them to more fully understand the concepts. She finished by saying that she loved activities like this that work for all students.

A few days passed before I went back to Ellen's classroom to see how her students were progressing with the "How Big is A Million" activity. This activity

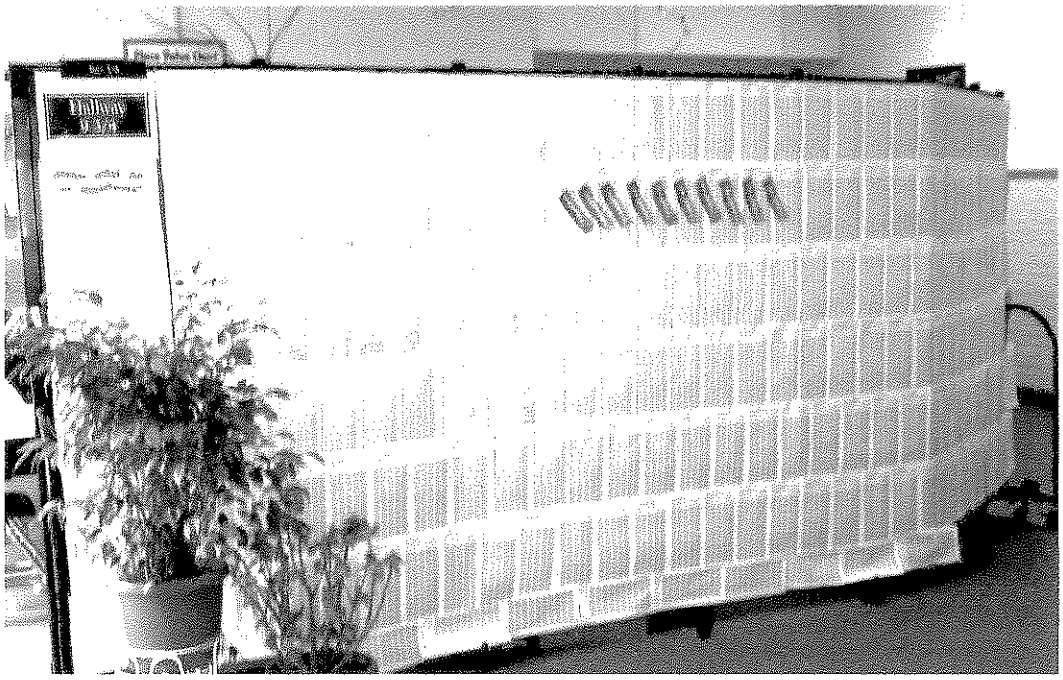
involves using sheets of papers with 5,000 dots (see Appendix H), numbering the dots, and then adding them to a classroom display. When finished, the display would have 200 pages of 5,000 dots each! Ellen has a small class and the project was becoming cumbersome. I suggested that she chunk the work and have the students complete just a couple of pages each day. Ellen thought that this was a good idea because if the project took a longer time it would reinforce to the students in another way the enormity of one million.

Two weeks later I was again in Ellen's classroom. Her students were adding more pages to their classroom display. Ellen said that she thought that the students were getting bored with the activity; later that day she stopped me in the hall and said that she was thinking about taking a break from this investigation. I had a feeling that if she stopped, that she would never get back to it. I offered to help her at the beginning of each class period so that she would have to spend only 5 or 10 minutes a day adding to the display.

Finally, after almost three weeks of working on the activity, Ellen's class made it to a million! What a celebration we had! Ellen bought *100 Grand Candy Bars* so that we could add the wrappers to the display and we took pictures of all the students holding the paper with the one-millionth dot. I was just passing out reward certificates to each of the students when the principal walked in and congratulated the class on their success. We had fun trying to imagine how much wall space we would need if we tried a One *Billion* Activity. Later that day, Ellen

admitted that there was a point when she really did not think that she wanted to finish the activity, but she was glad that she stuck with it. In the beginning, the students had trouble counting by 5,000. They did not make the connection with counting by 5's and counting by 5,000. At the end of the activity, they could do this with ease. She also thought that the students had a better understanding of place value because several minutes every day were spent talking about the meanings of the digits and their location within a larger number. Most of all, her students had a true understanding of one million.

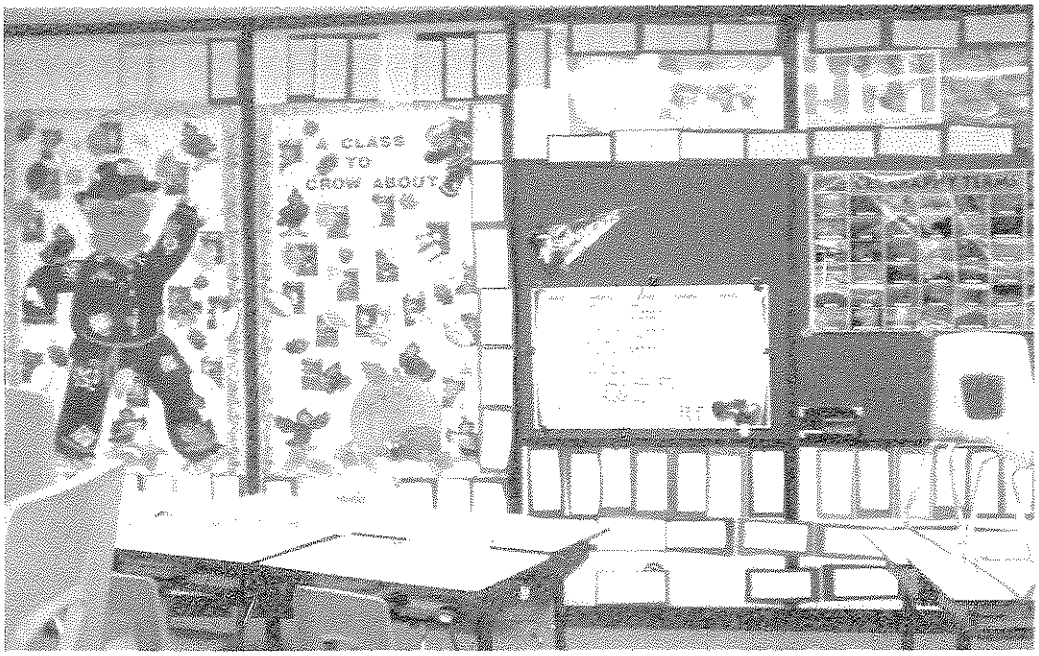
Figure 1. Ellen's One Million Dot display



Rena's class also worked on the *How Big is a Million* activity. Her class is larger and they worked on it when there was extra time at the beginning or end of class. It actually took Rena's class longer to complete the project but Rena was

still very happy with the results. She and her students were surprised at the amount of space needed for one million dots. Rena's class mounted each page of 5,000 dots on construction paper and made a border to Rena's classroom display. When they were finished, the dots framed the entire wall!

Figure 2. Rena's display of one million dots.



As I reflect back on this activity, I learned several things. One is that giving teachers packets of information is not necessarily the best way to distribute information. I did participant checks with some of the teachers and they agreed. They said that information given in that manner is often filed and never used. I was trying to be mindful of the time demands put onto teachers by not calling a meeting, but perhaps a short meeting would have been beneficial to go over the

information and to offer my support. Out of the six 5th grade math teachers, Ellen and Rena were the only two that attempted this investigation.

I also learned that building trust takes time, but it is well worth the effort. Going into other teachers' classrooms was a new experience for me. I wanted my job to center around the students, but I also did not want to force my way into a classroom. Rena and Ellen had similar thoughts. They are not used to having other teachers in their room, but by the end of the project we had a very comfortable working relationship and they appreciated my assistance.

Don

Part One – Learning the program

As the Million Dot investigation was running its course in the fifth grade, I was making teacher contacts and working with other grade levels. While I was reading the curriculum guides for the fourth grade, I began to get frustrated. My district bases instruction on the state standards while *Investigations* is more of a developmentally appropriate curriculum. The problem is that these two curriculums do not always match up. For example, *Investigations* has numerous activities for fourth grade that use the concept of 100 and 10,000; however, the standard in fourth grade is for numbers up to 100,000. Nevertheless, I began to prepare a packet of activities and games based upon the Joint-Usage Plan supplied by Scott Foresman, the publisher of our math text. Once again, I headed to the copy machine to make multiple copies of the information that was found in the

curriculum guides for the teachers who did not have their own manuals. I was standing beside the copy machine, but I just could not bring myself to start working. It is a large task correlating all this information, then making and distributing packets, and I was wondering to myself if anyone would use what I was giving to them. I looked at the clock and realized that fourth grade classes were at their specials so I decided to talk to the teachers to get some direction about how I should proceed.

As I left the copy room, I found Don standing just outside the door. Don is a fourth grade teacher with over 30 years of experience. We were near the school lobby, so I asked him if we could sit down there and talk. I explained my frustration at the mismatch of curriculum standards and *Investigation* activities. Don asked for examples, and I explained some of the activities using the 100 chart, which I thought might be too simple for his class. He thought those activities would be fine because they encouraged mental math. I then told him that there is an activity for 10,000. He immediately said, "I don't have to do the dots like Ellen is doing, do I?" I laughed, and then showed him how *Investigations* had an activity in which the students make a book showing 10,000 by using blank 100 charts. Don teaches one of the top math groups and he did not feel that his students needed this. He also felt that it was a lot of paper and a lot of work for the skill that was being taught. We then looked at an investigation that involved making 10,000 squares on the wall. Both of us had trouble picturing the activity in

our minds, plus it also involved a lot of paper and a lot of time. As Don leafed through the books he said, "It looks like we got the best of the program at the in-service. But a good program is a lot more that just games." I agreed and commented that *Investigations* is more than games, it is just that these activities did not correlate to our curriculum. We continued our discussion to try to decide what he would do to meet the district requirement of an *Investigations* activity before the next professional development workshop in October.

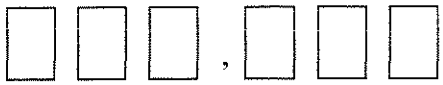
Part Two

Game Day – From My Perspective

Don and I planned two games, and the next week I went into Don's classroom to present the games to the class. I am always nervous the first time I go into a classroom. I wonder to myself how I will be perceived by the teacher and the students. I wonder if the students will respond to me, if they will listen, if I will have discipline problems, and if they will *like* me. I was even more nervous about going into Don's classroom. We have a friendly relationship from working in the same hallway the previous year, but this was different, now I was going into his room as the "math specialist."

After being introduced by Don, I explained the two games that we would be playing. One game was a place value game called "Biggest Number Wins" (see Appendix I). The game is not found in *Investigations*, but is similar to the games in the program. In this game, students pick one number card at a time and

place it on a game board that represented the digits of a number. These students were working on numbers up to 999,999 so the game board looked like this:



The second game, called "Close to 1,000" (see Appendix J), had the students draw eight cards, then they would choose six cards to make two three-digit numbers. The students would add their numbers together to try to get close to a sum of 1,000. Their score was the difference between their sum and 1,000.

Co-teaching with another teacher in their classroom means giving up, to some degree, control of my personal teaching style. I need to follow the other teacher's lead and follow their classroom procedures. My personal style is one where students often work in groups in which they have a lot of freedom to move around the room and to choose their own partners. I see Don as a more traditional teacher. The students' desks all face the front in rows, however, two or three desks are pushed together side to side. Don had the students stay at their seats and play the games with the student next to them. I had to admit this worked out very well. There was not any time wasted with deciding who to play with or where they should go. Half the class played the place value game with me monitoring the game, and half played "Close to 1,000" with Don monitoring, then the students would switch activities halfway through the period.

I was nervous the whole time. The students played the place value game quickly, so after they had played it a few times, I made adaptations, such as making the smallest number the winner, or having three students play together and having to compare all three numbers. I was even more nervous when Don came to me and said that he thought that the students were struggling with the "Close to 1,000" game. Lucky for me, I knew that this game was an extension of a game called "Close to 100" (see Appendix K). It was the same concept but with fewer cards and two-digit numbers instead of three-digits. I explained the adaptation to the students, but then I also helped some of Don's group to be certain that they understood the game. During the second rotation, I started place value group and then spent most of my time helping the students play the "Close to 100" game. I was so relieved at the end when Don said that he liked the activities. He said that he could tell that the students were really thinking. I was happy to hear this, and happy that the period was successful.

Game Day – Don's Point of View

Well, today Mrs. Wilburn is coming in. What will this be like? We have never had a math specialist before, and I'm not used to people coming into my room. I've been teaching over 30 years, is she going to try to change what I do? I hope that she does not criticize me. I work hard and the students seem to understand what they are doing in my class. The games we have planned seem

interesting. We have been working hard and I'm sure that the students will enjoy a game day. I'm very interested to see how the students react to these activities.

The students seem to like Mrs. Wilburn, and they are excited to play the games. This should be okay. I'm glad that she is including me when she talks. I'm glad that I have the students sitting next to each other; it sure made it easy for organizing partners.

As the students begin to play, I realize that they are challenged by this activity. They are having trouble looking at the cards they can use and deciding on which three digit numbers to construct. After mentioning this to Mrs. Wilburn, she changes the game to "Close to 100." The students were able to play the game easier with this adaptation and Mrs. Wilburn started to help the students in my group. I'm glad that she didn't just stay with her group and that she gave me some assistance helping the students. I really see the students thinking about the numbers and what they mean in regards to place value. I can see them trying to do mental calculations. I like this game and I enjoyed having Mrs. Wilburn in the room. It turned out to be a good day.

Game Day – The Students' Perspective

Well, this is different. Mrs. Wilburn is in our room – what's this all about? Mr. Smith says that she is now a math specialist. Does that mean that she is giving us a test? Does this mean that she is going to be taking kids out of the room who need help? We never had a math specialist in the building before. She is

explaining two games that we are going to play. This sounds like fun. I wonder who I will get to play with.

Mrs. Wilburn is playing a game with the other group, it looks easy, but my game is hard. How should I decide which cards to use to make my number? Are there any strategies that I can be using? We are supposed to find a sum close to 1,000 but I'm not having much success. I see Mr. Smith say something to Mrs. Wilburn and then she says to change the game to find sums of 100. This is much easier but I still have to use my brain. It isn't easy but I like the challenge. This is a good game.

Part Three – Back for an Investigation

Later in the month, Don asked me if there were any *Investigation* activities for money. As I read through the curriculum guides, I was reminded of an activity in which students plan a Halloween party. They would use an ad from a local grocery store as their "store" to buy drinks, treats, and decorations for the party. They were given a budget of $100 and they were told to spend as close to the $100 as possible (see Appendix L). Don was happy with the activity. The students were using skills that they had learned from the text to solve an engaging problem. A bonus from this activity was that we had the students using calculators and as we observed their work, we realized that there was a need to review how to use calculators, especially when adding money.

Near the end of my study, I was having a chat with Don. I asked him about his style of teaching and if he normally used the types of activities we did in his classroom. He said that these activities were very different from his normal way of teaching. He went on to say that he is not against using this sort of activity and he was glad to have the opportunity to learn something new. Don is also learning more about inquiry through an after school study group that is looking into how to use inquiry methods in science. When I asked Don to clarify why he did not previously use more activities similar to the ones we did in his classroom, he said that in the past, he felt comfortable following the sequence of the book to ensure that he did not miss teaching any skill. He also said that, until this year, he did not know where to search for this sort of alternative activity.

Other Experiences: Some Highs and Lows

The stories of Ellen and Don are just two types of classroom experiences I had as I began to explore my new role as a math specialist, specifically as a math specialist introducing a new method of teaching. Throughout my study there were certainly highs and lows. As I began to learn more about *Investigations* across the grade levels, I was surprised to see that some of the games were previously being taught in the classrooms. The teachers had found the games in other sources and were using them as centers or extension activities. In some cases, the teachers were also doing activities in their classrooms that were similar in nature to those found in *Investigations*. Teachers in every grade level were asking me to come

into their room and teach their classes the games from the program. This was when I was the most satisfied with my new job. When I would enter the classroom, there would sometimes be a cheer because they knew that it meant that it was game day!

However, I knew that the program was a lot more than games. The games were merely a secondary component of the program. The important parts of the program are the activities in which the students would explore concepts in problem-solving situations with their peers, either as partners, or as a small group. At times I was frustrated that I was not finding activities in *Investigations* that matched our curriculum and would suggest activities that were similar in nature to *Investigations* but were not found in the books.

The first follow-up professional development occurred in mid October. I still was not comfortable getting up in front of a group of teachers and leading discussions, but that was my role for this meeting. The college professor that led the in-service in August was working with half the group talking about classroom routines, ten-minute math, and other aspects of the program. The other math specialist and I were reflecting with teachers in another room about how the program was progressing thus far. Even though I was nervous, I was looking forward to this session. In an article about policies that support teacher development, Darling-Hammond and McLaughlin (1995) said "Professional development today also means providing occasions for teachers to reflect

critically on their practice and to fashion new knowledge and beliefs about content, pedagogy, and learners" (p. 597). In the same article they stated, "Teachers need firsthand opportunities to integrate theory with classroom practice. Teachers learn by doing, reading, and reflecting (just as students do); by collaborating with other teachers; by looking closely at students and their work; and by sharing what they see" (p. 598). I was anxious to hear what the teachers had been thinking and doing.

When the teachers were given time for sharing, there was nothing but silence and blank stares. This was horrible! I asked the teachers that I knew had done some of the games to share and that generated some discussion, but it was still strained. I could tell by the body language that some teachers were obviously only there because it was required. Gradually more teachers began to speak. One teacher from another school asked if it was okay if they did not follow the book. *Yes!!!* We assured her that this was fine. When we say that we have a standards based curriculum, then the book is just one of several resources that can be used. Our curriculum should be driven by what concepts the students need to know and how well they know these concepts. A short time later the Assistant Superintendent joined our meeting and she agreed. She said that the activities we want students to experience do not have to come from the book, or even from *Investigations,* we just want students to be actively involved with constructing their own meanings. I was so glad to hear this because this was one area that I was

trying to rectify in my own mind. The Assistant Superintendent also said that next year she is ordering more books so that everyone has a curriculum guide. I again was glad to hear this because the lack of curriculum guides was hampering the incorporation of *Investigations* into classroom practice.

As I reflect back on those early months of being a math specialist, I realize that speaking at a meeting was one of my weak points. I was often afraid of how the teachers would react to what I had to say. I realized that some of the problem occurred because teachers were being asked to do more and more in their classrooms, and every meeting brought even one more thing that they were being asked to do. I am confident that many of the teachers saw the value in what was being suggested, however, they were faced with the reality of trying to get it done.

As October turned into November, I was struggling in my role as a math specialist. In addition to having the teachers try some of the games from *Investigations*, the math committee asked them to give their students monthly "Mini" tests, which were short test with one question for each standard. The teachers cooperated, but they expressed their displeasure with the test. We also asked the teachers to have the students practice writing explanations when problem solving at least once a week. I had copies of the scoring rubric used by the state of Pennsylvania made for each student in the school, but when I gave these to the teachers at the November faculty meeting, the reaction, for the most part, was stony silence. From the body language and from the comments

mentioned, I could tell that the teachers were feeling more and more burdened. I realize that these meetings have nothing to do with *Investigations, however,* they do play a part in how I eventually came to an understanding of how I wanted to carry out my duties as math specialist. The November faculty meeting was my lowest point. A short time after meeting, one of my friends asked me if I was glad that I had taken the job as a math specialist. On the outside I smiled and said something about how I was still learning the job. On the inside I could almost feel my eyes tearing up. I missed being part of a team of teachers and I was concerned about being looked up to as someone in administration – because I am not. I was anxious when I did not know the answers to the teachers' questions. I did not like adding to their burden. I was unsure that they were using the information from *Investigations* that I was giving to them, and I was uncertain that I was getting into the classrooms enough to make a difference. On the inside I was not at all confident that I had made the right decision.

A Turning Point

The First "Aha" Moment

To learn about *Investigations*, two teachers from my school, Ann and Tracy, had taken a college course during the summer called PRIME (Partners Realizing Improvement in Mathematics Education). This course had a follow-up session in November to give teachers a chance to reunite and discuss their use of *Investigations* in their classrooms. I was invited to attend with them because of

my role as a math specialist. Three college professors led the class, one of whom was the professor working with my district doing the professional development for *Investigations*. The day started with a mental warm-up, then we were asked to take part in an investigation into "Calculators, Measurement, and Estimation." This was so much fun. Each small group was given a plastic ping-pong ball shooter. We were told to estimate how far the ball would go when holding the shooter straight, to take a measurement, and then to repeat this three times. We then repeated this same activity, but changed the angle of the shooter to 45 degrees, then 60 degrees. When we were finished, we were supposed to find the averages and draw a conclusion. When all the small groups were finished, we joined together again as a large group to share our findings. The leaders concluded the activity by saying that this was the model of an investigation, the teacher sets the premise of the activity, allows small groups to work and talk together, allows students to form their own conclusions, then the groups join together to share what was learned. I had heard it all before, but somehow it was like I was hearing it for the first time. I was trying to share activities with the teachers, but what I *should* have been sharing was the method behind the activities. At the follow-up professional development conducted by my district, we had told the teachers that it was okay to use investigation type activities, but we never defined what we meant by an investigation! No wonder we were getting those blank stares!

During the afternoon, other characteristics of an investigation were modeled. One investigation, in particular, used the book *Mailing May* to set up a variety of measurement and writing activities. This was important because investigations are often multi-disciplinary. The second activity used marshmallow shooters; these are toys that shoot marshmallows similar to blowing a spitball through a straw. The challenge we were presented with was to design an investigation around these shooters. We had a lot of fun and I realized that another aspect that I needed to bring back to the teachers was that an investigation could evolve through literature, classroom themes, interesting scenarios, or even toys. Teachers could design investigations around almost anything. The important thing is that the students are actively engaged in their learning with small groups, and then brought together in a whole group for sharing and clarification of what they had learned.

Once again, I was getting excited about my job!

A Paradigm Shift

As I proceeded with my action research into the relationship between my position as a math specialist and the implementation of *Investigations* into the curriculum, I was also involved with college coursework. Around the time that I was starting to reevaluate my approach to helping teachers, we were given the assignment to read Paulo Freire's book *Pedagogy of the Oppressed* (1970). Freire worked to change the social conditions of the poor in Brazil, and much of his

work concerned the role of education. His work had a lasting impact on the educational system of Brazil and other third world countries.

I felt that Freire (1970) had much to say related to my research. At times when I would go into a classroom, I would watch as the teacher stood at the front of the room or at the blackboard instructing the class while the students sat inattentive and unconnected to the lesson. Freire calls this "the banking concept of education." The teacher is the depositor (hopefully) and the students are merely receptacles for "receiving, filing and storing the deposits" (p. 72). Freire goes on to say:

> But in the last analysis, it is the people themselves who are filed away through lack of creativity, transformation, and knowledge in this (at best) misguided system. For apart from inquiry, apart from the praxis, individuals cannot be truly human. Knowledge emerges only through invention and reinvention, through the restless, impatient continuing, hopeful inquiry human beings pursue in the world, with the world, and with each other. (p. 72)

We need to have our students fully engaged in our lessons, and we need to encourage them to make their own meanings and connections.

Educators are often reminded that the amount of information in the world increases at an astonishing rate. We can never hope to teach our students everything. Rather, it is our commission to teach students "how to think." We are

being challenged to prepare our students for jobs that may not as yet even exist. The lecture method used by teachers will not prepare our students for the future. As Freire states:

> The more students work at storing the deposits entrusted to them, the less they develop the critical consciousness which would result from their intervention in the world as transformers of that world. The more completely they accept the passive role imposed on them the more they tend simply to adapt to the world as it is and to the fragmented view of reality deposited in them. (1970, p. 73)

Freire (1970) proposes that teachers adopt a "problem-posing" method of education. An important part of the students' problem solving is dialogue with the teacher. The students make contributions to the learning and both the teacher and the students learn. I found this to be very relevant to my research. The *Investigations* method of teaching uses a discovery approach in which the students construct their meaning, but it is also inquiry based in that the teachers and the students work together to solve questions that arise from their studies. The *Investigations* method is very close to what Freire is suggesting:

> The students - no longer docile listeners - are now critical co-investigators in dialogue with the teacher. The teacher presents the material to the students for their consideration and re-considers her earlier considerations as the students express their own. The role of the problem-posing educator

> is to create; together with the students, the conditions under which knowledge at the level of the *doxa* is superseded by true knowledge, at the level of the *logos.*
>
> Whereas banking education anesthetizes and inhibits creative power, problem-posing education involves constant unveiling of reality. (p. 81)

I was excited to read Freire. My vision for math instruction in my school is being able to walk into a math classroom and see students working on problem-solving projects, discovering concepts, and interacting with their classmates. I thought that I had captured the meaning of Freire's writing until my professor started to question me about my role as a math specialist. "How was I interacting with the teachers in regards to Freire?" All along I had applied my readings of Freire to the math teachers in my school, never considering how the reading pertained to my own method of dealing with the teachers. I sat in stunned silence as I recalled the faculty meetings in which I presented information to the teachers and wondered why they sat there just staring at me. I thought about the packets of information that I had duplicated and "deposited" into their hands. I thought about the workshop in which teachers were asked to reflect on their practice and how I had such limited success in leading the dialogue. I was embarrassed to admit that thus far I had pursued my job in a very un-constructivist manner. It was time to

seriously reflect on what I had done thus far and reconsider how to perform my job in the future.

The DaVinci Study Group: The Final Aha!

The day after I was jolted into examining my performance as a constructivist math specialist, I was attending a meeting of an after school study group in which I participated. The leaders of the group, Ben and Rich, were sharing what they had learned during the summer at the Da Vinci Science Institute. The first purpose of the group was to promote the use of inquiry methods in the classroom, and secondly, to design an integrated unit based on a particular science topic that would be presented to other DaVinci study groups at the end of the school year.

Our first meeting began with a discussion about what it means to teach using inquiry methods. Ben and Rich started with a mini-lesson about sound. We were then led into an inquiry about the characteristics of sound. The room was filled with a variety of objects that we were encouraged to use to think about sound. As we would explore different ways of making sound, Ben would ask leading questions such as, "Why do you think that happened?", or "What if....". Often if we would ask him a question, he would have another exploratory activity ready for us to perform so that we might find our own answer, or come to our own conclusion. We ended the first session by dialoguing about what this would look like in the classroom. Ben said that true inquiry is when the students' questions

totally lead the direction of instruction. This usually isn't practical because of the constraints of time and a prescribed curriculum, but teachers can still approach their instruction based on the inquiry method.

During our second meeting we started to talk about our unit of study. Ben and Rich had chosen the topics of Color and Light. As we explored the possibilities of activities, I was to consider ways of incorporating math, Rena was to think about how to incorporate social studies, and Ellen was to consider including language arts and writing. The dialogue flowed smoothly with idea sharing and an occasional experiment to clarify concepts for those of us that were not strong in science.

During one part of this meeting, I was sitting back and observing what was happening when it suddenly occurred to me that this was exactly what Freire was trying to promote. We were finding ways to teach an integrated themed lesson using methods of inquiry. But before we could take it into the classroom, we, the teachers, had to first understand for ourselves the inquiry method and discuss the possibilities of where our students might take us so that we were ready to help them reach that next level of understanding. I had trouble containing myself because I just wanted stand up and shout – "This is it! This is the model I need to follow with the math teachers!"

The Next Step

The next day I could hardly wait to talk to Olivia, our technology specialist. We had talked previously about presenting some after-school workshops for teachers. We knew that we wanted to combine math and technology in some way but we were unsure about how to progress. I told Olivia how I liked the model of the DaVinci group, and also the model from the PRIME workshop (see p. 50) that I attended.

Through the following weeks, we prepared to offer three classes, each class lasting for two hours. Each of the classes would focus on one math topic: measurement, geometry, or fractions. The plan was to begin with a mini-lesson about using inquiry based methods in the classroom. We would then break into two groups; one group would be teachers who taught grades Kindergarten through second and the other group would be for teachers of grades three through five. Olivia would provide web sites for the teachers to explore, and then they would choose one of the web sites to explain to the rest of the group how they might incorporate technology into a math lesson. I would start with an investigation that was integrated into another subject area, or theme based. I would allow teachers some time to explore the activity just as they would have their students do. While they worked, I would model questioning that promoted higher thinking skills. Finally, I would bring the teachers back for a dialogue to discuss the experience and to talk about how they might incorporate similar activities into their

curriculum. I would share with them investigations that other teachers have used, and encourage them to try some of the activities themselves, or to come up with their own activity based on the model we had used.

The After School Workshops

Olivia and I named our after school workshop "Inquiring Minds Want to Know." As the date for the first class arrived, only five teachers had registered, so we decided to change the format of the class. Instead of dividing into two groups based on levels, we would do the activities whole group. This turned out to be a better idea because as a group we looked at all the different activities and discussed how they could be adapted for a variety of grade levels. Olivia and I decided that I would begin with the investigation activities and she would end with the technology component. As an introduction to our course, I presented a Power Point that outlined what is meant by an investigation based on the inquiry method (see Appendix M).

The topic for the first workshop was measurement. As teachers arrived, I had stuffed animals set on the tables, along with various tools of measurement such as rulers, tape measures, scales, balances and many items that could be used for non-standard measurement (e.g., a paper clip). One element of an investigation is that it might be related to other subject areas or it might be theme related. To model this, I used a book called *Measuring Penny* (Leedy, 1998), which could possibly be used with a pet or animal theme. Penny is the pet dog of

a young girl named Lisa. She has a homework assignment to measure something of her choice at home, so she measures her dog. My intention was to have the teachers measure the stuffed animals in a number of ways, similar to the story. After I began my lesson, I felt uncomfortable asking the teachers to actually do the measurements, so we discussed together the different ways that they thought the students would find to measure stuffed animals that they would bring from home.

In addition to the Measuring Penny activity, I gave the teachers a folder that contained several other investigative type activities. I went through each activity, giving a short synopsis, and applicable grade level. I later told Olivia that I was not very happy with the lesson. I spent too much time talking, and I had hoped to have the teachers actively engaged in some sort of activity. As we talked, I realized that what I had enjoyed during the PRIME workshop was that I was asked to work through an investigation that challenged me as an adult. I realized that I changed my mind about asking the teachers do the measuring activity I had planned because it was at a level for the students; I should have found something to challenge the teachers as adults.

Don was one of the participants of the inquiry workshop. One day following the workshop, I happened to go into his room while he was teaching a lesson on measurement. I was very excited to see that he was using something with his class that we had talked about in during the workshop. He was discussing

the concept of using a benchmark when estimating length. A benchmark is something that can be related to a given measurement, for example, a small paper clip is about an inch, a milk carton at lunch is a cup, a door is about three feet wide, and so on. It was very gratifying to see that he was using some of the concepts that we had discussed.

The next week's topic was fractions. One of the activities I chose was to use a rope to demonstrate a number line. I prepared cards that had pictures and symbols of fractions that would be hung on the rope in the appropriate position. The first fraction I passed out was 1/2. When I challenged the positioning of the card on the rope, I asked how we could prove that it was at the one-half position. We then proceeded to fold the rope into half. Immediately the teachers realized the value of the activity. Students often do not connect the study of fractions and the study of measurement. You cannot fold a ruler, but by folding the rope, the students would see how a line could be divided into equal parts. To make this activity challenging to the teachers, I used difficult-to-place fractions such as 10/12, and we added a second rope so that improper fractions could be incorporated into the activity. Don especially liked the activity and said that he wanted to use the activity in his classroom the next day! I concluded the workshop by going through the teachers' folders of resources that I had prepared. These folders contained the materials they would need to do the rope activity and several other activities that were investigative in nature.

I felt much better as I reflected on this second workshop. The teachers were actively involved and were challenged. The information was timely to what they were teaching and they would be putting it to use right away. I feel that these are all important considerations for successful professional development.

The final week's topic was geometry, specifically perimeter, area, and volume. One of the activities we used was to make a fence for a garden using 30 Cheese Nip crackers. The garden could be any closed shape. Over and over the teachers counted their squares in order to get a perimeter of 30. I pointed out that that they had repeatedly practiced the concept of perimeter during the activity. We talked about how this activity compared to a worksheet. They agreed that the Cheese Nip activity was a lot more fun and meaningful than doing problems on a worksheet. A second activity had the teachers predicting what would happen to the volume of a tray made out of centimeter paper as the height increased (see Appendix N). They were all surprised to find that their estimations were not what they expected. I again had several handouts for the teachers. I asked them if they found the information valuable. They said that they appreciated what I had given to them because the activities were unusual in that they were investigative in nature. They liked the idea of having a file of useful ideas that they could use in their classrooms. The part that they liked the most was that these were activities that they would be able to use within a short amount of time, because these were some of the same skills that they were teaching in their classrooms.

introduce teachers to the concept of an investigative or inquiry based method of teaching. Next year, even though I will not be doing a formal action research, the work of answering my research question of how a math specialist can facilitate the incorporation of *Investigations* into the enacted curriculum will continue.

FINDINGS

Interpretation of the Data

The process of analysis was ongoing from the very beginning of my research. Arhar et al. (2001, p. 186) suggest, "Interpretation is an ongoing process that begins as soon as we decide to study our own practice." This interpretation of the data drives a study through the repeating cycle of forming a theory, acting on this theory, making observations, analyzing what we have learned, and then refining or reforming the theory. My primary tools for interpreting my research were 1) coding of my journal, 2) coding of my observer comments, 3) using analytic memos, 4) analyzing the data from surveys, and 5) compiling and analyzing information from teacher interviews.

The use of codes and bins was one of the most useful tools for analysis. Codes are assigned to data that began to emerge as I reread my data. These can be words, phrases, behaviors, and ways of thinking, events, patterns, or even lack of patterns (Arhar et al., 2001). As I analyzed these codes, I was able to group them together into categories called bins. By analyzing these bins, I was able to see my study from a number of perspectives. These bins all centered on the focus of my research, which was to look at my role as a math specialist in facilitating the integration of the *Investigations* math program into the existing curriculum. I arranged my bins by common themes. These themes were: the district requirement, teacher concerns, teachers' knowledge of *Investigations*,

professional development, experiences using *Investigations,* and the constructivist point of view. Even though the bins each have their own theme title in regards to *Investigations*, they all are intertwined with my evolution from classroom teacher to math specialist.

To ensure the accuracy of my interpretations, I used frequent participant checks throughout my research process to verify my own observations of what the teachers were doing and feeling. As I was writing my thesis, I would share my drafts with those teachers mentioned, and I asked for their clarifications and comments.

Teacher Concerns

In the beginning of the school year, I knew that adding elements to the curriculum would be a difficult task. I used the narrative device of poetry to help analyze some of the teacher's responses and concerns.

Teacher's Lament

You want me to add more to what I already have to do?
and
I have to attend after school professional development?
No time, I need time! It's just one more thing to do!

I have to share curriculum guides with my team members?
I can't read all those curriculum guides!
No time, I need time! It's just one more thing to do!

I'm being required to use these games with my class?
and
I have to duplicate student sheets, game boards, and game pieces?
No time, I need time! It's just one more thing to do!

What do you mean the program is more than games?
Where are the student texts?
No time, I need time! It's just one more thing to do!

Next year you want me to do MORE?
I need your help!
No time, I need time! It's just one more thing to do!

The poem makes clear that time is a major concern with classroom teachers. The integration of *Investigations* was just one of several innovations that teachers were being asked to do this school year. Throughout the year, their conversations were often filled with frustration. They felt that every time someone had an idea, it eventually came down onto the shoulders of the classroom teacher to carry out. To their credit, they did what was asked of them, and some even exceeded what was required. As the teachers began to use the games in their classroom, their anxiety lessened and they became more accustomed to integrating portions of *Investigations* into their classroom instruction.

I found that the Stages of Concern were not as evident as I had expected when I designed my study. I did find elements of different stages. For example, during the initial professional development, Mona expressed concerns about time and materials (SoC2) and Steph had concerns about classroom management (SoC3). George was helpful in that he would evaluate an activity and offer adaptations (SoC4). Even though teachers would exhibit some characteristics of a certain stage at some point in time, it was difficult to assign them to a Stages of Concern category. I anticipate that next year when they are asked to incorporate a

full investigation into their instruction that I will see teacher exhibit more characteristics from each of the stages.

Knowledge of *Investigations*

During the first week of school, teachers were asked to fill out a survey indicating their knowledge of the *Investigations* program (see Appendix B). Of the teachers responding to the survey, 71% had little or no prior knowledge of *Investigations,* 20% had tried some of the activities from the program, while 8% would often look for activities from *Investigations* to complement their curriculum. A similar survey was given at the end of the study (see Appendix C). Of the 18 teachers who responded, 6% felt that they still had little knowledge of *Investigations,* 94% said that they had tried the games or activities from *Investigations* in their classrooms, 94% of the teachers plan to use *Investigations* in the future, and 47% expressed an interest in learning more about *Investigations*.

There are two important considerations when looking at these data. The first is that the district set a requirement that teachers use some elements of the program during this school year, and they will be required to use even more of the program in the next school year. The data show that the district met the goal of introducing the teachers to the *Investigations* program.

The second consideration is that even though the surveys were anonymous, some teachers did sign their name. The teacher who indicated little

knowledge of the program and who did not use elements of the program in her classroom is planning to retire at the end of this school year.

Using the categories of Remillard and Bryans (2004), I see the teachers still at the early stages of implementation. Their use of the materials was still intermittent. They used the materials as a resource, but still relied mostly on the routines and activities that they had used for years. They did not yet see *Investigations* as philosophy of education, but a collection of classroom activities.

Professional Development

One of the key strategies to educate teachers about the *Investigations* program was the use of professional development. There was a three-hour introduction during the teacher meetings that precede the opening of school, a three-hour follow-up in the fall with time for discussion, and three hours in the spring to introduce the investigation activity that would be required the following year. These last three hours are not considered part of this study.

Lieberman (1995) supports this model of professional development. She states,

> People learn best through active involvement and through thinking about and becoming articulate about what they have learned. Processes, practices, and policies that are built on this view of learning are at the heart of a more expanded view of teacher development that encourages teachers to involve themselves as learners (p. 592).

I was disappointed that, when the teachers in my study were given opportunities to share during professional development, the discussion was strained. Few teachers volunteered to share what was happening in their classrooms. As I reflected on this meeting, I thought that perhaps teachers were uncomfortable sharing with teachers across the district in a large-group setting. It is also possible that the teachers were seeing this as yet another in-service in which you come, put in your time, and then leave. Lieberman (1995) suggests that professional development is the most powerful when it is viewed as an integral part of the life of the school. She goes on to say,

> For example, some organizational and pedagogical changes in these schools (e.g., common planning periods) put new and experienced teachers together to learn from one another, to make connections across subject area, to use staff expertise to provide leadership for "in-house" workshops or meeting, to form self-contained teams in which the organizational structure (a team) encourages constant staff learning, or to develop curricular changes that encourage interdisciplinary studies in short periods of time (p. 592).

As my study progressed and I began to lead the after-school workshops, I began to relate to what Lieberman was saying. During these workshops, the teachers were comfortable and willing to share and discuss. The group was small and the atmosphere was non-threatening. The purpose of attending was not so

much a fulfillment of an obligation (several of the teachers attending had already fulfilled their district requirements), but rather they were interested in learning. It was coincidental that the material I was presenting was the content that some of the teachers were doing in their classrooms at that time, but I feel that this added to the value of the workshops.

Experiences of Using *Investigations*

I asked 18 teachers how their teaching has changed as a result of using the activities from *Investigations* in their classroom. Two teachers said that they are using more activity centers in their classrooms; two said that they use *Investigations* as a resource, and five said that they use *Investigation* activities for review. Other comments were that there are more days where they are not solely using the textbook, the teachers felt that they are being more creative in their lessons and that, because of the district focus on *Investigations,* they are being reminded to keep the students actively involved in their learning. One teacher stated that he is now more aware of the importance of students being responsible for their learning.

My next question to the teachers was to ask how these changes in their teaching have affected the students. Ten teachers said that the students are very interested in math and find the activities enjoyable. Five teachers said that the students are thinking more critically, that they are making their own connections and understanding of the concepts. One teacher said that his students are

demonstrating a greater understanding of number concepts compared to his students from previous years.

Finally, I asked them how the *Investigations* workshops have benefited their growth as a teacher. Most stated that they gained knowledge of the program and were able to use it as a resource. Two teachers said that they enjoyed sharing ideas with other teachers, and one said that he liked looking at problem solving from a student's perspective.

I have related many of my personal experiences of using *Investigations* in the narrative section of this thesis. When I first began, I looked at *Investigations* as another math textbook to be used in the classroom. There was a certain amount of frustration in this because the two texts did not always have a one-to-one correspondence. It was not until after I had a true understanding of the definition on an investigation that I was able to come to the conclusion that *Investigations* is more of a method or a philosophy of teaching rather than a concept or skill to be taught. Now I am able to view *Investigations* as a resource and a model, rather than a script.

My Role as a Math Specialist

As the year progressed, my role as a math specialist became more clearly defined. The teachers primarily saw me as a resource person. They came to me to ask for materials, lesson ideas, or suggestion for a particular student. In regard to *Investigations,* they asked me to come into their classrooms to model a lesson, or

to team-teach a lesson. Based on the comments from the interviews and surveys, teachers felt that a major responsibility of the math specialist position was to work with students. They did not want to see the math specialist position turn into more administrative duties than teaching duties.

Through the year, I could see myself changing. As the year progressed, I was more self-confident and relaxed when working with teachers. I became more familiar with the entire continuum of the curriculum, including the resources and supplemental materials such as *Investigations*, problem solving, and PSSA (state testing) preparation. As I began to gain an understanding of the inquiry method, I also began to be more confident in my dealings with teachers, especially in regards to *Investigations*. I became more assertive, and instead of waiting for an invitation to the classrooms, I set up a fixed schedule so that I was in the classrooms assisting teachers throughout the entire school day. My major finding was the realization that I need to approach my work with teachers in a constructivist manner. The same philosophy that I am trying to convey to teachers also pertains to me. If I do not want the teachers to just lecture to their class, then I cannot just lecture to the teachers, or lecture to their students when I am modeling a lesson. If I want them to learn something new, I cannot just say, "Here is the book – study it." I need to guide them through activities that will help them gain their own understanding of the material.

I also learned that it takes time to build a good working relationship. Even though I had a relationship with all but the newly hired teachers, it took time to form the new relationship of math specialist to teacher. I tried to do this by listening to teachers' concerns. Ben told me that he appreciated it when I did not just tell the teachers to do something, but rather would say, "Here is something that has to be done, how can I help you?" or "This is how I would like to help." Several teachers told me that it was strange at first when I would come into their room. One day Steve stopped me in the hall just to tell me that he is very comfortable with me coming into his room and that he found it very non-threatening and helpful. He said that he could see a difference in the students' work since I had been helping and coming in on a weekly basis.

THE NEXT STEP

As I reflected on the workshops that I presented with Olivia, I began to plan the next cycle of where the research was leading me. Next year I would like to form small study groups of teachers who would come together to learn, to reflect, and to plan. Teachers would have an opportunity to share with one another, to discuss what was working in their classrooms and what was not working, to discuss processes and assessments, and they would also work together to plan future math investigations or integrated units that are inquiry based. By meeting frequently, the work would be relevant to the work they are would be doing in their classrooms.

An alternative would be for me to attend grade-level team meetings so that I would have the opportunity to contribute to planning lessons or units of study. I would act as a resource person, encouraging the use of the inquiry method whenever possible.

CONCLUSION

At times during this research project, I doubted the wisdom of the district to have teachers just use the games and routines from *Investigations* during this phase of the implementation. However, as I studied my journal entries, I realized that the year began with some resistance from the teachers. By having the teachers use a small part of the program, they became accustomed to using *Investigations* as a resource. The next step will be to ask to teachers to use more of the program by conducting a full investigation. I predict that this will be met with less resistance. There will be several months to prepare the lesson, there will be opportunities to talk with other teachers, and many of the teachers are seeing the value of using the activities from the *Investigations* program.

It was helpful that the district allowed the math specialists a great deal of autonomy in establishing our roles. Each of the math specialists in the three buildings approached the role in a slightly different manner, based on the personality of the math specialist, the teaching staff, and the administration of each of the buildings. We were given many opportunities to increase our knowledge of the pedagogy of teaching mathematics. I realize that the journey to becoming a constructivist math specialist has not yet come to an end, but rather has just begun. I realize that each year I will learn more about the art of teaching mathematics and I will learn more about working with the classroom teachers and

administrators. Most of all, I never want to lose sight of my primary duty, which is to continue to pursue the best way to serve the students of my school.

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APPENDIXES

Appendix A: Human Subjects Internal Review Board Consent

1742

MORAVIAN COLLEGE

September 21, 2004

Rosemarie H. Wilburn
687 Concord Road
Nazareth, PA 18064
rwilburn@nazarethasd.org

Dear Rosemarie Wilburn.

The Moravian College Human Subjects Internal Review Board approved your proposal: Facilitating investigative approaches in K-5 math instruction. Given the materials submitted, your proposal received an expedited review. A copy of your proposal will remain with the HSIRB Chair.

Should any other aspect of your research change or extend past one year of the date of this letter, you must file those changes or extensions with the HSIRB before implementation.

This letter will be e-mailed and snail-mailed to you. Best of luck with your research.

James Barnes
Chair, Human Subjects Internal Review Board
Moravian College
610-861-1672 (voice)
610-861-1657 (FAX)
barnesj@moravian.edu

Appendix B: Professional Development Survey

(to be used after the initial professional development workshop)

1) Rank your knowledge of *Investigations* before this in-service.

a) I was not aware of this program
b) I had heard the name but knew little about this program
c) I've looked through the books but did not attempt any of the activities
d) I had tried at least one *Investigations* activity
e) I tried to use *Investigation* activities from time to time.
f) I always look for an *Investigations* activity to relate to my lessons
g) I solely use the *Investigations* program.

2) Now that you have had a chance to experience some of the activities from *Investigations,* how willing are you to try these activities in your classroom?

a) I will only do the activities that I have been told that I must do.
b) I'm anxious to learn more *Investigation* activities.
c) I can't wait to become an *Investigations* teacher!
d) other:

3) In what ways would you like to have assistance from your building math specialist in order to implement the activities from *Investigations*? (check all that apply)

a) I will be fine by myself
b) I would like help with planning
c) I would like the math specialist to model a lesson
d) I would like the math specialist to team teach a lesson with me
e) I would like the math specialist to work with a small group
f) other:

Appendix C:
Survey or interview questions to be used midpoint and at the end of the study

1. In what ways has your teaching changed as a result of using activities from *Investigations* in your classroom?

2. In what ways have these changes in your teaching affected your students?

3. What value have the *Investigation* workshops benefited your growth as a teacher?

4. Rank you knowledge of the *Investigations* program.

h) I had heard the name but know little about this program
i) I've looked through the books but have not attempted any of the activities
j) I had tried at least one *Investigations* activity.
k) I tried to use *Investigation* activities from time to time.
l) I always look for an *Investigations* activity to relate to my lessons
m) I solely use the *Investigations* program.

5. Now that you have had a chance to experience some of the activities from *Investigations,* how willing are you to continue using these activities in your classroom?

e) I will only do the activities that I have been told that I must do.
f) I liked what I saw but I doubt if I will use many activities from *Investigations.*
g) I will probably use some activities from *Investigations* from time to time.
h) I plan to learn how to do more of the activities from Investigations.
i) I can't wait to become an *Investigations* teacher!
j) other:

6. In what ways have you received assistance from your building math specialist in order to implement the activities from *Investigations*? (check all that apply)
    g) I was fine by myself
    h) The math specialist helped me with planning.
    i) The math specialist modeled a lesson for me.
    j) The math specialist was a team teacher in my classroom.
    k) The math specialist worked with a small group of students.
    l) other:

7. In what ways have you used the math specialist as a resource?

8. What recommendations do you have for the math specialist?

9. Other comments:

Appendix D: Interview Questions

Name of teacher:

1) What was your overall impression of the *Investigations* math program?

2) Will you continue to use activities from *Investigations* in the future? Explain.

3) Was it beneficial to you as a classroom teacher to have a building math specialist available to use as a resource? Explain.

Appendix E: Principal's Consent

August 23, 2004
To whom it may concern,

I give my consent for Rosemarie Wilburn to conduct a research study involving the teachers of [redacted] Elementary. It is my understanding that the research is supported by educational literature and is a requirement for the completion of her Master's Degree program through Moravian College. Further, I understand that consent for the study will be obtained from all participants and that participants have right to withdraw from the study at any time. Pseudonyms will be used in discussion of the data collected to protect the teachers' identities. The data from this research study will be held in the strictest confidence, kept in a locked cabinet in Mrs. Wilburn's home, and destroyed by shredding at the completion of the study.

The teachers of the district will be asked to attend professional development in-services devoted to the *Investigations* math program. Teachers will be asked to participate in surveys, interviews and keep a lesson log of activities used from the *Investigations* program. The research of Mrs. Wilburn will document the integration of *Investigations* into the math curriculum, particularly the role of the math specialist.

Teacher participation in Mrs. Wilburn's research will be completely voluntary and teachers may exit the study at any time without consequence. Participation in this study will not have an impact on teacher evaluation reports.

Finally, I am aware that questions regarding this research should be directed to Mrs. Wilburn at [redacted] or rwilburn@[redacted]org. Questions may also be directed to her Moravian faculty sponsor, Dr. Joseph Shosh 610-861-1482, jshosh@moravian.edu

Sincerely,

Mr.[redacted]
Principal [redacted] Elementary School

Appendix F: Participant Consent

August 23, 2004

Dear Staff of [redacted] Elementary,

As many of you know, I am currently working on my Master's Degree in Curriculum and Instruction through Moravian College. Moravian's program requires that I conduct a systematic study of my teaching practices. My research project will focus on the role of the math specialist, especially in the relation to the implementation the *Investigations* activities presented to you through in-service workshops.

As a research participant, you will be asked to complete surveys and interviews and maintain a lesson log documenting the activities used from the *Investigations* program.

By signing this consent form, you will be giving me permission to use information from surveys, interviews, workshops, and discussions in my research report. No teacher will be identified in my report. I will be using pseudonyms and I will mask any detail that may identify you in the report. Every participant will have an opportunity to read my report before I submit it to Moravian College. You may resign from this study at any time without consequence and participation in this study will not have any relationship to any formal teacher evaluations conducted or written by [redacted]

All information collected will be held in the strictest confidence. All names including those of students and teachers will be kept confidential. All research material will be kept in a locked cabinet at my home and will be destroyed at the conclusion of my study.

If you have any questions, please contact me, my home phone is [redacted] Your may also direct any concerns to [redacted] or my faculty sponsor, Dr. Joseph Shosh. Dr. Shosh can be contacted at Moravian College by phone at 610-861-1482 or by e-mail at jshosh@moravian.edu.

Please consider being part of my study and thank-you for your time.

Sincerely,

Rosemarie H. Wilburn

_____ Yes, I agree to be a participant of this research project.
_____ No, I would prefer not to be a participant of this research project

Signature:_____

Appendix G: Array of Dots Investigation

Session 1

Arrays of Dots

Materials

- How Many Dots? (3–5 sheets per pair, and 1 transparency)
- Scissors (1 per pair)
- Tape (to share)
- Stick-on notes (1 package)
- Student Sheet 31 (1 per student, homework)
- Student Sheet 32 (1 per student, homework)
- Calculators
- Overhead projector
- Overhead pens and blank transparencies (optional)

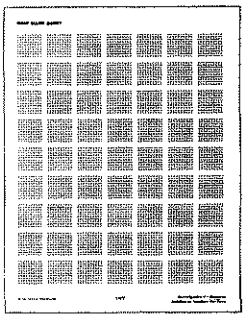
What Happens

Students determine how many dots are on a page that contains a 7-by-9 array of blocks of 100 dots. They use sheets of this paper to construct rectangles of 10,000 dots. As they share their strategies for making the rectangle, they explain what they know about 10,000, its factors, and its multiples. Student work focuses on:

- using a rectangular array model to represent factor pairs of numbers 10,000 and larger
- developing a sense of the size of 10,000

Activity

How Many Dots on a Page?



Distribute one How Many Dots? sheet to each pair.

Some of the problems you've been solving in the last couple of weeks have involved large numbers. You've worked with numbers like 2415, 4500, and 15,480, and some even larger. Now we're going to use dots to show how big those numbers really are.

How many dots do you think there are on your sheet of paper? How could we find out?

Students work in pairs to determine and record how many dots are on the sheet. Encourage them to work without calculators, but allow calculators if students feel they need them.

As students work, circulate to observe how they approach the problem. If some students are having difficulty counting the number of dots in a block, you might tell them that each block contains 10 dots across and 10 down. If some students think the page shows 700 dots across and 900 down, help them to see the page is composed of 7 rows of 900 (or 9 rows of 700, or 70 rows of 90). You might circle the first row of 900 and ask how many in that row; circle the second row of 900 and ask how many in the row and the total circled so far, and so on. Encourage students to imagine how much larger a page with 700 rows of 900 dots would be.

Students who finish early try to "prove" they have accurately found the number of dots on the page by finding the answer a different way.

How did you figure out how many dots are on the page? Did anyone do it a different way?

Invite students to come to the overhead and use the transparency of How Many Dots? to demonstrate their solution strategies. They might use overhead markers to show how they grouped the dots in order to solve the problem (for example, in rows or columns). On a blank transparency or on the board, they record any calculations they made. Possible student strategies include these:

- Finding the total number of blocks ($7 \times 9 = 63$) and then multiplying by the number in a block ($63 \times 100 = 6300$)
- Finding the number of dots in a row of blocks ($7 \times 100 = 700$) or a column of blocks ($9 \times 100 = 900$) and then multiplying by the number of columns ($700 \times 9 = 6300$) or rows ($900 \times 7 = 6300$).
- Finding the number of dots across the page ($7 \times 10 = 70$) and the number down the page ($9 \times 10 = 90$) and then multiplying them together ($70 \times 90 = 6300$).

As students give their explanations, listen for the way they say numbers in the thousands and hundreds. That is, some students may say 6 thousand 3 hundred, while others may call the same number 63 hundred. Ask students if both names represent the same number, and how they know.

Activity

Rectangles with 10,000 Dots

We're going to use this dot paper to make rectangles that have 10,000 dots. Can you see in your mind how many dots that will be? What can you tell me about 10,000?

Take a few minutes for students to share what they know about the number 10,000. Those who have worked through the *Investigations* unit *Mathematical Thinking at Grade 5* will have had experience with factors and multiples of 10,000. Encourage students to think about characteristics of 10,000 like these: How much larger is 10,000 than 10? how much larger than 100? than 1000? What are the factor pairs of 10,000? Is 10,000 a square number? Record students' ideas on the board.

How many of these sheets of dots do you predict you will need to make a rectangle filled with 10,000 dots?

Making the Rectangles Distribute scissors and two additional How Many Dots? sheets to each pair. Have extra sheets available for students who need them. Distribute rolls of tape to share. As students begin work, remind them that it's hard to count lots of little dots accurately, so they should be sure to doublecheck before they cut. On the back, they record the size of their rectangle: the number of dots across and the number of dots down. They also write about how they know the rectangle they made has 10,000 dots. Students who finish early can make another 10,000-dot rectangle with different dimensions. You might challenge them to use some blocks cut so that they contain fewer than 100 dots.

Displaying the Rectangles When every pair has completed one rectangle, discuss the rectangles they made and their strategies for making them. Record the dimensions of rectangles that students suggest. Then ask for volunteers to share their strategies for making them. Possible strategies include these:

- Choosing a factor of 10,000, and then figuring out the number of times we need to count by that number to reach 10,000.
- Building on factor pairs of 1000, 100, or 10 (for example, finding a factor pair of 1000 and multiplying one of the factors by 10).
- Using a calculator to find numbers that divide 10,000 evenly.

As students explain their strategies, listen for how they make sense of multiplying by numbers such as 10 and 100. Some students may talk about multiplying by "adding on" 0's, or dividing by "taking away" 0's:

> 10,000 is 100 × 100 because you multiply the 1's and then add on the 0's.

Ask these students to show why this procedure works by finding the answer in a different way:

> 100 × 100 is 10,000 because 10,000 is the same as one hundred 100's—ten 100's make 1000, and ten of those make 10,000.

Point out that the dimensions of rectangles with 10,000 dots are factor pairs of 10,000. Ask if anyone can think of factor pairs of 10,000 for which no one has made rectangles.

Display the students' rectangles on a bulletin board, wall, or section of the classroom floor. As students circulate to look at them, they post stick-on notes questioning any they do not understand or agree with. Take a few minutes to discuss any such questions with the class.

Activity

How Many Dots in All?

Write 10,000 on the board. Direct attention to the 10,000-dot rectangles they just made and indicate two of the rectangles in the display.

How many dots are in these two rectangles together?

Ask how to write the corresponding number, and record it on the board. Continue asking students how many dots there are when more and more rectangles are added:

How many dots are in three rectangles? four rectangles? five rectangles? How many dots are in all the rectangles we made? How do you know?

Students find the answer with a partner, writing down the number they find. They may use calculators. As students work, circulate to see how they write the total number of dots and how they say that number.

Ask for volunteers to explain how they found the total number of dots. Some students will add 10,000 repeatedly; others will multiply 10,000 by the number of students in the class; still others will use what they know about smaller numbers to find the answer. For example, a student might say that because 10×16 is 160, 10 *thousand* times 16 is 160 *thousand*. Record students' strategies on the board.

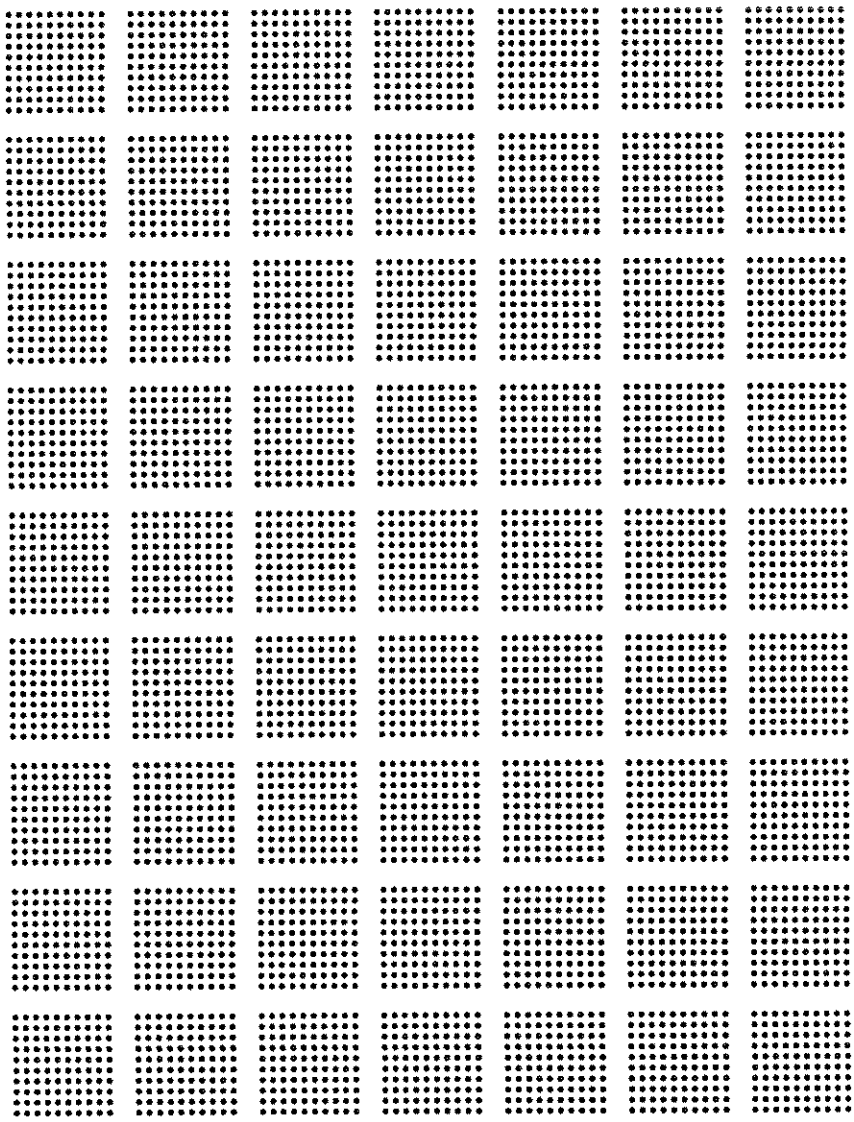
We have [16] rectangles with 10,000 dots each. That's 160,000 dots in all. Can that help us figure out what number we will end up on if we count around the class by 10,000? How would it help?

Some students may recognize that since the class worked in pairs to make rectangles, doubling the total number of dots in the rectangles gives the final number of the count. Others may use strategies similar to those they used for finding the total number of dots in the rectangles.

Counting Forward and Backward from 10,000 Count around the class by 10,000. Stop the count periodically and ask students how to write the number just counted. Record the number on the board.

When you have gone all around the class, start the count again. Begin at 10,000 and count *forward* by a multiple of 100 or 500, such as 200 or 1000. For a third count, begin at 10,000 and count *backward* by the same number. Again, stop the counts periodically and ask students how to write the number just counted, then record it on the board. If time permits, stop partway through each count, asking the class how many students have counted so far and how they know.

HOW MANY DOTS?



Session 2

How Big Is a Million?

What Happens

Students begin making the class display of one million dots, putting together sheets of paper containing 5000 dots each. They label the "start" and "end" numbers of the dots on each sheet to keep track of how many dots are posted in the display. Student work focuses on:

- skip counting by 5000 to 5- and 6-digit numbers
- beginning to develop a sense of the relative size of 1000, 10,000, and larger powers of 10

Materials

- Million Dots Display Sheets (200–250 total; at least 50 to start with)
- Student Sheet 33 (1 per student, homework)
- Tape (1 roll)
- Calculators
- Chart paper (optional)

Activity

How Big Is a Million?

When we put together all the rectangles of 10,000 dots we made, do you remember how many dots we had altogether? That was lots of dots, but now we're going to put together even more. Over the next couple of weeks, you'll be spending a little time almost every day working on a display of a million dots. Can anyone tell me how we write the number one million?

Record students' suggestions on the board. If no one gives you the correct way to write the number, supply it yourself.

What can you tell me about a million? What things do you know that come in millions? Are there a million pencils in the school? Are there a million blades of grass in the park?

How much larger is a million than ten thousand? How many ten thousands make a million? How much larger is a million than a hundred thousand? How many hundred thousands make a million?

Students talk briefly with their neighbors about what they know about a million, then share their ideas with the class.

Most students will know that a million is a very large number, but only some will be able to suggest things that there are millions of, or will know how much larger a million is than 10,000 or 100,000. Some students may at first assume that it is just as far from 1 to 100,000 as it is from 100,000 to 1,000,000. As students work on the million dots display, they will gain a better understanding of the relative sizes of ten thousand (10,000), one hundred thousand (100,000), and one million (1,000,000).

Activity

The Million Dots Display

As you introduce the million dots display and discuss it throughout the rest of the unit, do not give away information such as the size of the completed display or how long you think it will take to finish it. Many students are surprised to discover just how large the final display is and how long it takes to create. Some students may calculate exactly how many sheets of paper will be needed for the display, or the size of the completed display. Encourage them to explain their reasoning, but do not tell them whether they are "correct."

Distribute a copy of the Million Dots Display Sheet to each pair.

We'll be making our display of a million dots from copies of this sheet. How many dots are on this one page?

Pairs may use calculators as they determine and record how many dots there are. Circulate to see how students are writing the number 5000 and to observe the strategies they are using. After a few minutes, call the class together briefly to share strategies.

Do you think our display of a million dots will fit on the bulletin board? on the chalkboard? on the longest wall of the classroom? along the hall?

Allow only enough time for quick estimates. Record students' predictions on a piece of chart paper or on a part of the board where they can remain for a couple of weeks.

Tell the class where the million dots display will be located and how the sheets will be posted. Then explain how they'll be keeping count of the dots so they know when they get to a million. Hold up a Million Dots Display Sheet.

You figured out that there are 5000 dots on a sheet like this. So we'll fill in 1 for the start number and 5000 for the end number. Since this is the first sheet, we'll number it 1.

Fill in the start and end numbers, the sheet number, and today's date on the sheet. Then hold up a second sheet.

Here's the second sheet in our million dots display. We went up to 5000 on the last sheet. This sheet has 5000 more dots. It starts at the number after 5000. What number comes after 5000? What should we write for the start number? What do we end at? How do you know?

Some students may find their answers by adding 5000 to the start and end numbers on the first sheet. Others may observe that just as there are 5000 numbers from 1 to 5000, there are 5000 numbers as we go from 5001 to 10,000.

If some students think that the end number is 5000 more than 5001, or 10,001, you might suggest that they think about more familiar numbers: When we count from 1 to 50, we say 50 numbers, and when we count from 51 to 100, we say 50 more numbers. Some students may find it helpful to think about the number of dots on two sheets: if there are 5000 dots on one sheet, there are 10,000 on two sheets.

Again, fill in the start and end numbers, the sheet number (2), and the date. Repeat until you have filled several sheets and are confident that students understand the task. Then, post all the sheets you have labeled as students gather around to observe.

At this point, students return any Million Dots Display Sheets that they have not written on.

Activity

Are We Close to a Million?

With just the first sheets posted, students compare the number of dots in the display to one million.

Are we close to a million? How many more do we need?

After students discuss this with a partner, a few volunteers share their thinking with the class.

Would we have a million if we made about twice as many? About ten times as many? How do you know?

Do you want to change any of your predictions about how much space a million dots would take up? Do you want to change any of your predictions about how long it will take us to make the display? Why?

Students give reasons for any changes; they may want to change their predictions because they recognize that a million is much larger than they thought.

Update students' recorded predictions. If students are interested and if time permits, they can explore some of the predictions. For example, students could estimate about how large the display is so far and use that as a basis for refining their predictions about the final size of the display.

Launching the Project Explain the procedures you have established for the project, as discussed in the **Teacher Note,** The Million Dots Display (p. 113). For example:

- How are pairs to take turns working on the display? (in a specified order, or when they finish an activity early)
- How much does each pair do during their turn at the display? (they work for a certain amount of time, or complete a certain number of sheets)
- How will the sheets be posted? (by pairs or by the teacher)
- Where do students find blank sheets, and what do they do with completed sheets?

Explain that at the start of each turn, a pair determines the number at which they are to begin labeling by checking the last sheet completed—either on the display itself, or in a box you have set aside for sheets that are ready to be added to the display. You might suggest that students look through the last 2 or 3 sheets completed to be sure they agree with the way they are labeled. They discuss any disagreements with the pair that completed those sheets (or with you), and if necessary, relabel them.

This ongoing project continues until the display is complete, even as you proceed with Investigation 5. Refer to the **Teacher Note,** Have We Reached a Million Yet? (p. 119), to plan how students might share their thinking about the display as it grows.

Session 2 Follow-Up

Homework

Our Million Dots Display Distribute Student Sheet 33, Our Million Dots Display. Before students leave for the day, they fill in the total number of dots already in the class display. For homework, they answer the questions on the sheet.

Extension

How Long Would It Take to Count to a Million? Each student estimates how long it would take someone to count to a million. Students begin by planning what information they will need in order to make their estimates. For example: How many numbers can they say in a minute? Does it take them longer to say some numbers than others? How long does it take them to count to 100? Would it take them just as long to count from 99,900 to 100,000, or longer?

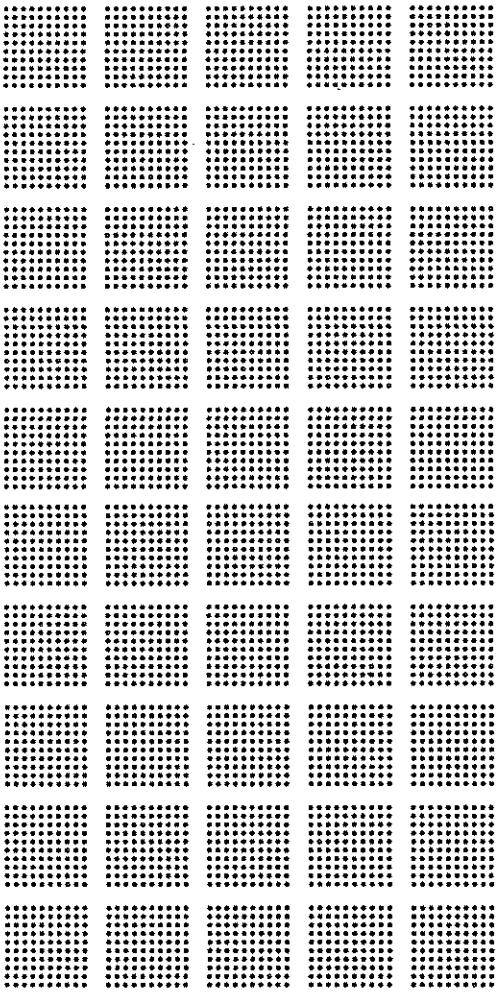
Different students, pairs, or groups might approach the problem in different ways. Once students develop their plans, they gather the information they need, make their calculations, and write about how they arrived at their answers.

MILLION DOTS DISPLAY SHEET

Names _____

Sheet number _____ Date _____

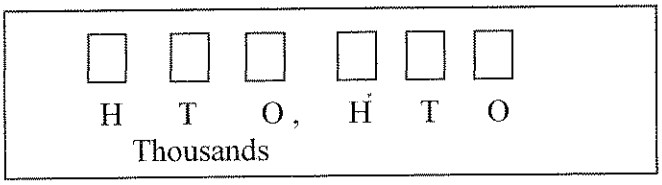
Start _____ End _____



Appendix I: Biggest Number Wins

Materials:

- Number Cards
- Place Value Sheets for each player. (Papers labeled with the place values being studied. The labels should be sufficient space apart to allow for placement of the number cards.)
  For example:



Recording card. This is not a critical element to the game, but it is useful is having the students get practice in using the <, >, and = signs.

Students play in pairs.
The first student turns over one of the number cards and places it on the game board. Once the card is placed, it may not be moved. The second student then turns over a card and places it on his game board. Play continues until all spaces are filled. The students write their numbers on the recording sheet and decide which number is the biggest. The cards are removed from the game board and the next round begins.

Variations:

- Play that the least number wins.
- Students play in groups of 3. The recording sheet would need to be modified.

Appendix J: Close to 1000

Materials:

- One deck on numeral cards
- Close to 1000 score sheet for each player.

Players: 2

How to play:

1) Deal out eight numeral cards to each player.
2) Use any six cards to make two numbers. For example, a 6, a 5, and a 2 could make 652, 625, 526, 562, 256, or 265. Wild cards can be used as any numeral. Try to make two numbers that, when added, give you a total that is close to 1000.
3) Write these numbers and their total on the Close to 1000 score sheet. For example: 652 + 347 = 999.
4) Find your score. Your score is the difference between your total and 1000.
5) Put the cards you used in a discard pile. Keep the two cards you didn't use for the next round.
6) For the next round, deal six new cards to each player. Make more numbers that come close to 1000. When you run out of cards, mix up the discard pile and use them again.
7) After five rounds, total your scores. Lower score wins.

Scoring Variation:
Write the score with plus and minus signs to show the direction of you total away from 1000. For example: If your total is 999, your score is -1. If your total is 1005, your score is +5. The total of these two scores would be +4. Your goal is to get a total score fro five round that is close to 0.

Appendix K: Close to 100

Materials:

- One deck of numeral cards
- Close to 100 score sheet for each player

Players: 1, 2, or 3

How to Play:

1. Deal out six numeral cards to each player.
2. Use any four of your cards to make two numbers. For example: 6 and 5 could make either 56 or 65. Wild cards can be used as any numeral. Try to make numbers that, when added, give you a total that is close to 100.
3. Write these two numbers and their total on the Close to 100 score sheet. For example: 42 + 56 = 98.
4. Find your score. Your score is the difference between your total and 100. For example: If your total is 98, your score is 2. If your total is 105, your score is 5.
5. Put the cards you used in a discard pile. Keep the two cards you didn't use for the next round.
6. For the next round, deal four new cards to each player. Make more numbers that come close to 100. When you run out of cards, mix up the discard pile and use those cards again.
7. Five rounds make one game. Total your scores for the five rounds. Lowest score wins.

Appendix L: Halloween Activity

You Have Won a Halloween Shopping Spree!

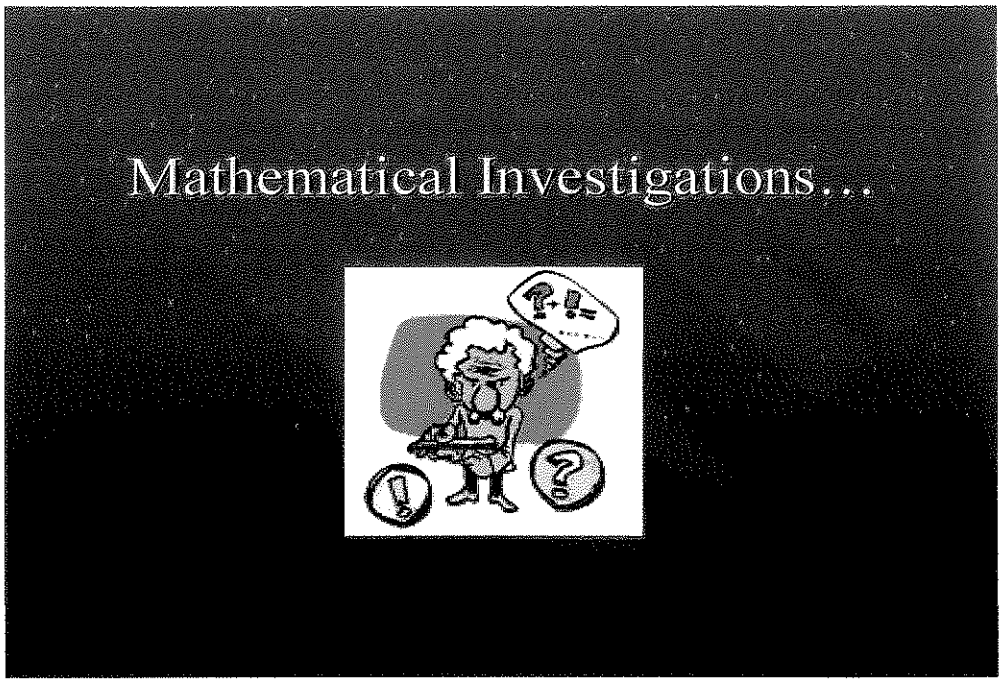
You have won a $100 shopping spree at the local supermarket to purchase items for a Halloween party for you and your friends! Use the weekly advertisement from the store to plan your purchases. Follow these guidelines:

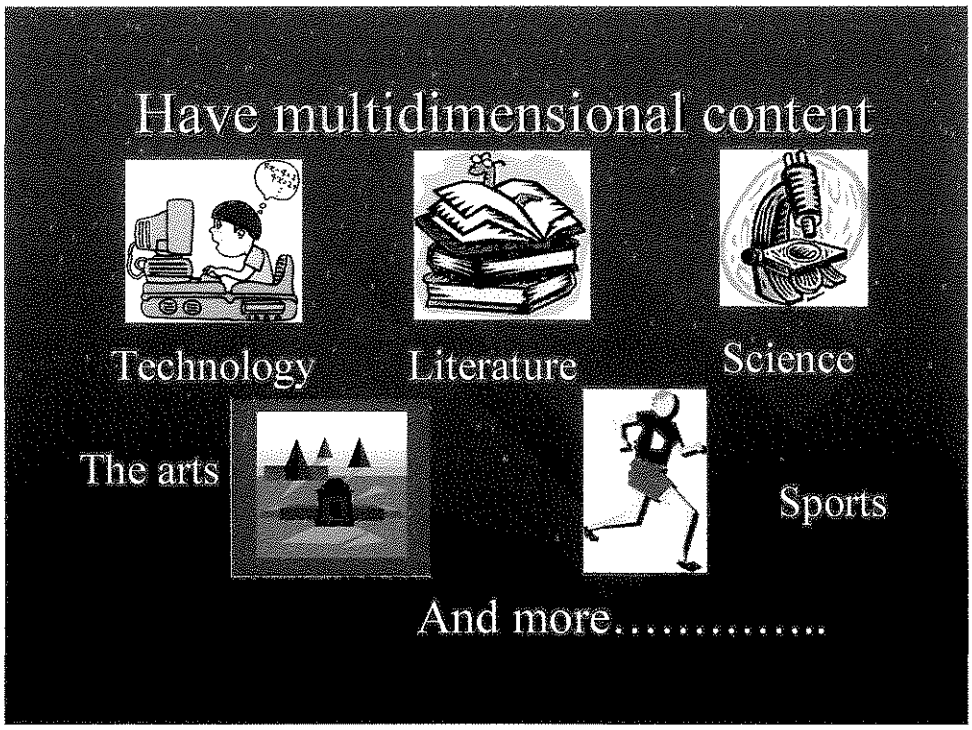
1. You need to plan a party for 6 people (you and 5 friends).
2. You want to spend as much money as possible, but you may not go over $100.
3. You must buy at least two items in each category.
4. Use the blanks for your own choices.

Category	**Item name**	**Unit Cost**	**Quantity**	**Estimated cost**	**Actual cost**
Snack					
Snack					
Fruit					
Fruit					
Candy					
Candy					
Beverage					
Beverage					
Decoration					
Decoration					
Total					

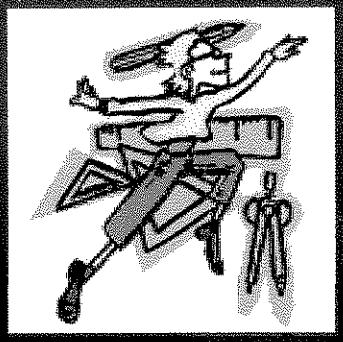
How did your estimated cost compare with your actual cost?

Appendix M: Inquiry Power Point Presentation



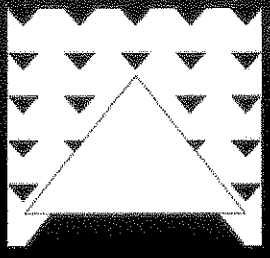


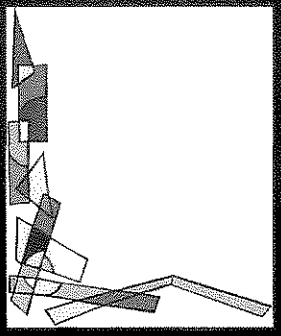
Mathematical Investigations…

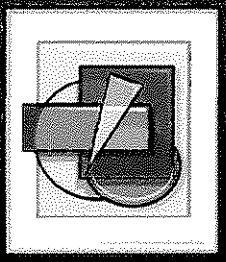


Are Open- Ended

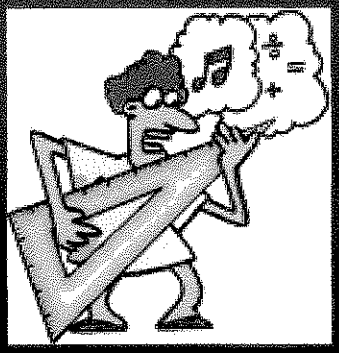
There may be several acceptable solutions……





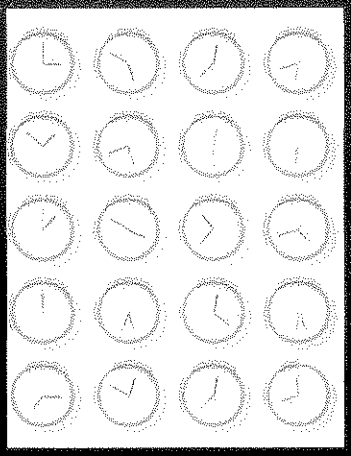


Mathematical Investigations….



Take time

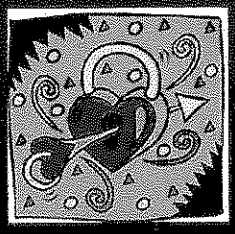
They may involve a full class period

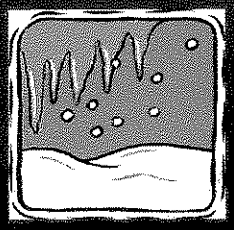


or longer…..

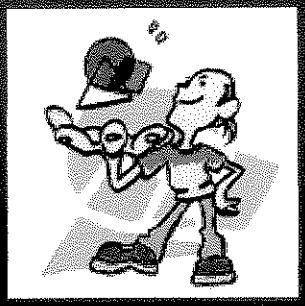
Mathematical Investigations…

Can be centered on a theme

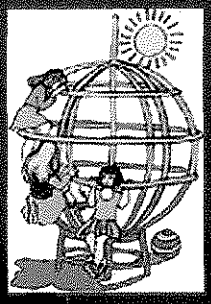




Mathematical Investigations….

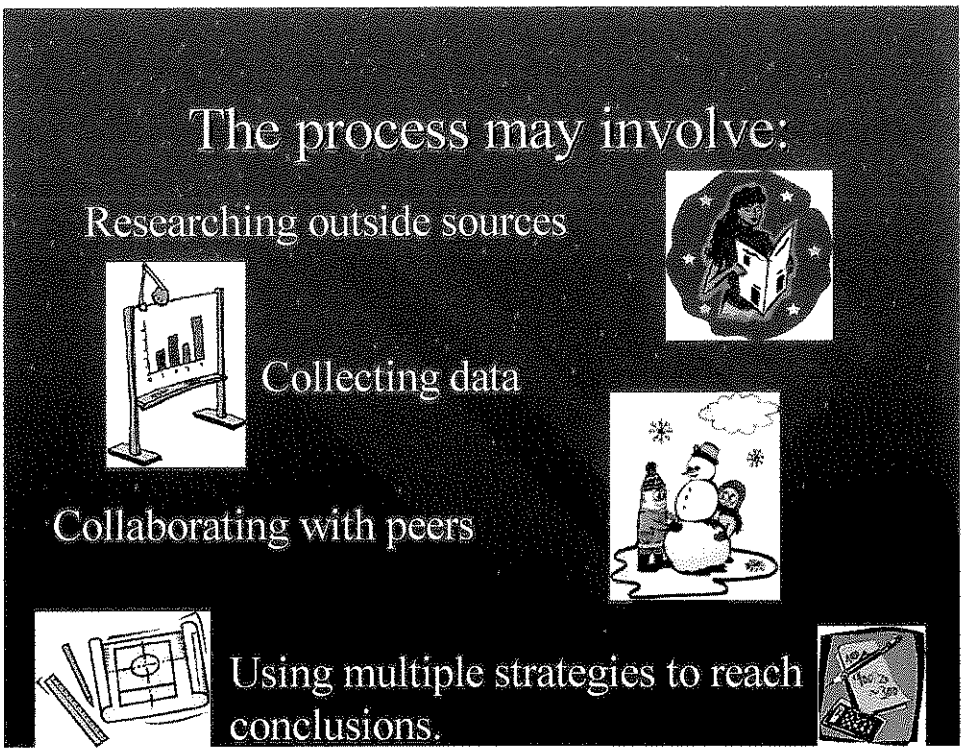


Can be embedded in a focus or driving question.



Your school needs new playground equipment.

Design a new piece of equipment for your school.


The process may involve:
Researching outside sources
Collecting data
Collaborating with peers
Using multiple strategies to reach conclusions.

Appendix N: Making Trays Activity

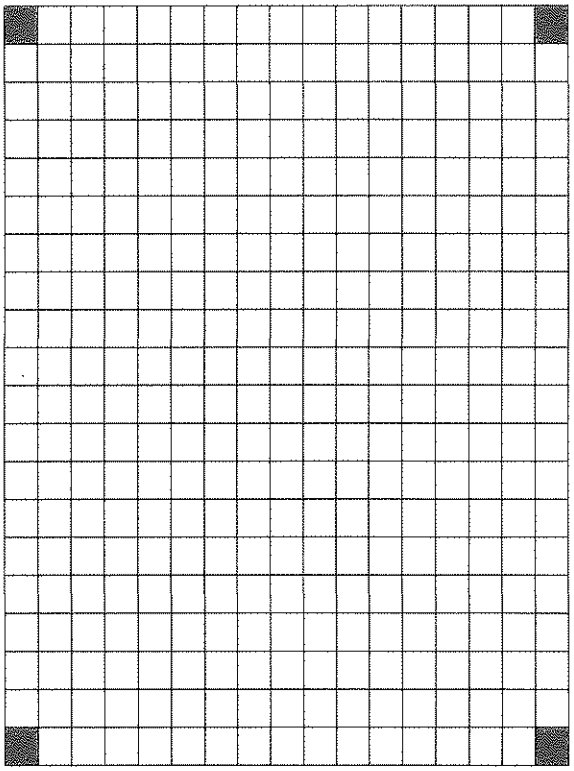
Making Trays

Materials:

centimeter grid paper (pre-cut to dimensions listed below)
container of centimeter cubes for each pair of students
tape

Procedure:

1. Cut out a 1cm x 1cm section from each corner of a grid paper.
   Cut out a 2cm x 2 cm section from each corner of a grid paper.
   Cut out a 3 cm x 3 cm section from each corner of a grid paper.
   Cut out a 4 cm x 4 cm section from each corner of a grid paper.



Sample of grid paper with 1x1 square removed

Making Trays Activity

2. Instruct the students to fold the grid paper to form a tray. The paper with the 1 x 1 square cut from the corner will have a wall of 1 cm. The paper with the 2 x 2 square cut from the corner will have a wall of 2 cm. and so on.

3. Challenge the students to predict which tray, though made from the same grid paper, will hold the most cm cubes. Record student guesses on chart paper and solicit reasons for their choice as to which try will hold the most cm cubes. You will refer back to these guesses at the end of the activity.