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Influencing Pedagogy and Belief: A Case Study in the Professional Development of Teachers of Mathematics

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INFLUENCING PEDAGOGY AND BELIEF: A CASE STUDY IN THE
PROFESSIONAL DEVELOPMENT OF TEACHERS OF MATHEMATICS

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ABSTRACT

This study forms a holistic, rich description of the way a professional development experience transformed teachers of mathematics. This professional development targeted teachers from six underachieving schools in a southern state who trained for a week in inquiry techniques of instruction. The method used to study the impact this experience had upon participants is a case study design in which three of the high school teachers were the subjects of analysis. Additional data were incorporated from project administrators and other teachers and assistants involved with the professional development experience. Data sources include highly structured questionnaires, observations, semi-structured interviews, documents, archival records and e-mails. Data were gathered before, during and after the experience to compare findings. Themes were developed from the data sources to assess the way that the professional development transformed the pedagogies and the beliefs of the subjects. Four rival conjectures on how this experience affected the subjects were drawn from the data and current literature. The levels of teacher employment of the themes vary and were dependent on the previous experience of the teachers, the amount of discussion on the themes, content and pedagogical knowledge and perceived professional needs of the subjects. Results suggest that designers of professional development take into account the previous experience of the participants, especially their perceived professional needs and beliefs. Designers also need to be aware of participant's content knowledge and pedagogical skills. The findings of this study impact the planning, execution and evaluation of professional development programs in education and other fields.

DEDICATION

This dissertation is dedicated to

Venna Ann Howard

1941 - 2007

My mother was so proud when I began this journey.

I wish she were here to see me finish.

ACKNOWLEDGMENTS

This dissertation would not be possible without the patient guidance of my committee. Dr. Robert Horton was always there to guide me. Without his continuous help and encouragement, I would not have been able to finish this endeavor. The process of writing this dissertation has been enlightening and educational beyond my wildest expectations. To Dr. Horton and to all of the other teachers in my life, I owe a great debt.

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CHAPTER ONE

OPENING VIGNETTE AND INTRODUCTION

Opening Vignette

"Teaching this way has changed me as a teacher," Dray begins the first meeting.

She is referring to inquiry teaching methods that are an integral theme in this week of

professional development called Project Inquire.

However, before the participants can ask about what has changed her, Philip stops

the teachers and requests introductions. The Inquire teachers go around the room stating

their names, where they teach and how many years of experience they have. David has 20

years of experience teaching at the high school and technical college in the area. Amy,

also from David's school, is a 13-year veteran. Wendy has just finished her first year

teaching. Sarah, from the same school as Wendy, has taught four years in middle school,

but has taught the last three at the high school level. Sue has been teaching for 14 years

and hails from a middle school. Rudy has four years of teaching under his belt and also

teaches at the middle school level. Charley will be teaching her first full year at the

middle school level in the coming year. Shay is a seasoned veteran of 20 years in a high

school. Two others will join the group later. Johnny, from a middle school, will come in

late and state he is content to be here, but not happy. Randolph, not present, will be

joining the group in the morning. He also teaches in a middle school. These ten Inquire

teachers are a contingent from the schools that feed students into the Academic Camp at

the university where Inquire is held. Terry is an Inquire alumnus and joins the group for

the first couple of days. Philip and Dray then welcome them and introduce themselves, as does the researcher.

Immediately, Philip stages the first problem. He says, "Where should we put a distribution center if we want to service five restaurants on a highway at mile markers 2, 4, 16, 28 and 50?" The center will house five trucks, and each one can service only one restaurant. He explains that the distribution center needs to be on the same highway and that we want the shortest distance to drive for the restaurants' trucks. He stresses to the teachers that they should solve the problem, but also monitor and assess the thinking behind the solution. Dray says, "You may not know for sure. It's okay. Some may be lost."

In groups of three, the teachers begin to work studiously to see where the distribution center should go. Wendy, Charley and Amy are in one group. Terry, Sarah and Sue are in the center group. Rudy, David and Shay are gathered around the back table. All are working with a low chatter of ideas and uncertainties. A couple of questions can be overheard as the groups discuss the problem for several minutes. Suddenly, Philip stops the discussions and asks, "Are you thinking about your thinking? Are you disappointed in yourselves?" The teams say that they are trying the mean, splitting the range and trying trial and error.

David needs a clarifying question answered. He asks, "Can you hit more than one in a trip?" After no answer, the teachers continue to work.

"STOP!", Philip exclaims, "Was thinking scary?" To this question, the teachers sit still for a second in thought. Almost as a relief, Johnny comes through the door late

and introduces himself and says that he is not happy. No explanation for his unhappiness is given.

Back to the problem, Philip states that he has given this same problem to college students and students at all levels. Some of the students that have missed it are graduate students in math.

Dray asserts that you need to "make the kids hungry to solve the problem." She says that most teachers do "skill-skill-skill, and then skip the word problems. What we need are reality-based problems in school." According to her, these types of problems are appropriate at many levels and teachers should let the students find the approach. "This kind of interaction, discomfort goes on in my class all the time. I've heard them talking about it in the lunch room."

Philip says that we will talk about the problem, "but not now." Explanations and housekeeping are in order for the smooth handling of the small group. Commuting, parking and some agenda items are discussed.

Then, the topic turns to the Academic Camp, with students who will join the teachers Wednesday. The teachers will have opportunities to interact with students and try the teaching skills that will be discussed in the meetings. The Academic Camp is composed of high school students who attend the schools represented by the teachers. They are chosen to come to Clemson from the various districts to experience the college life and atmosphere with hopes that they will see that college can be in their future. They are students who show promise, but are not the best performing students in their respective high schools. They are the ones that may benefit most from a summer

experience at a college and who may change their life plans for the better. Philip states, "We encourage you to have interactions with students, but you don't have to. The middle school teachers will recognize problems as middle level."

Philip describes a class of Dray's students one year that completed 22 to 24 problems over the *entire year*. He explains that they did not do 30 to 50 problems a night as many teachers assign. Dray adds that they took the toughest kids and all 13 passed the state high school exit exam the first time. She says, "I know it's powerful. My students' test scores, I'd hold up against everybody."

Philip explains that two of the main aims of Project Inquire are to build a network of teachers and introduce inquiry teaching into the classroom. He says, "Math Education is horribly broken."

Johnny says that for a long time there have been more drills and skills, no relevance. He says, "We take a paper with a 25% discount. I've used that inquiry method. How do you get the answer? What do you do?"

Dray and Philip say almost in unison, "That's exactly what we're talking about."

Philip continues, "There are lots of wrong ways too. The teacher has to guide the class."

Dray adds that her kids could name each problem they did over the course of the year and then talk about the math behind them.

Philip tells the teachers how the kids made their own textbooks that year. "We had them write problems to work on." he says.

The participants will be given a $1,000 stipend and $1,600 to spend in their classrooms. Sarah wonders if there is a deadline for her to order classroom materials. Philip explains that there is not a deadline. He says that some teachers have taken years to spend all of their money, though he would prefer they spend their money more quickly.

At this point, each teacher is given a graphing calculator and the administrators lead a brief discussion of how the calculators can be used in an inquiry environment. The Sunday evening session ends with Philip telling the teachers that he will be out in front of the hotel at 8:15 the next morning. "Let's fill cars....."

Introduction

       This type of interaction began a week of on-campus professional development in mathematics. It became common place before the teachers left for home on Friday. But, what did this experience give them? Did it give them the tools they needed to better engage their students? Did it give them more confidence to try an effective new way of teaching? Did it confirm their current teaching methods? Or, was it just another week of professional development that was nice, but not very useful?

       This study follows three teachers of varying levels of experience throughout the process of this particular professional development and weaves a holistic view of how they reacted to this weeklong, intense program. Data were gathered from them both before and after Project Inquire week in the form of semi-structured interviews, questionnaires, classroom observations and artifacts from their teaching such as tests and lesson plans. These data are linked to the themes that they experienced during the week of Project Inquire. Any traces of the teaching methods and resources the teachers used from Project Inquire are noted and compared. The qualitative method of case study is used to describe the effects of this professional development experience and gives the designers of professional development insight into the variables that should be considered when planning, executing, and evaluating a program. These results may be useful in the planning and implementation of professional development for mathematics teachers as well as professional development in other areas.

       Project Inquire is the lens that this case study uses to observe the factors that influence teachers of mathematics and to focus on the factors and themes that emerge

from the data and are triangulated by the current literature. Project Inquire illuminates the intended changes, supports and barriers of influence for the teachers. The beliefs and practices of the subjects are then studied and compared to what did or did not happen as a result of the week of training.

In Project Inquire, teachers from schools in economically disadvantaged areas of a state in the Southeastern U.S. were brought to a major research university to work with Philip, a professor of mathematics education, and Dray, a master teacher from a local high school, for a week at the beginning of summer break. The teachers were given a stipend of $1,000 and an additional $1,600 dollars to spend in their classroom. Each teacher was also given a graphing calculator and instruction in its use. The participants were included in a growing body of teachers in a community that shared skills in inquiry and sought to build on the experiences of Project Inquire and to create an online discussion of their successes and failures during the school year.

The teachers not only worked with each other throughout the week, but also were engaged with actual high school students from the schools in which they taught. Some of the students knew the teachers from class. This was a rather unusual aspect of Project Inquire. The teachers observed and attempted the techniques being taught to them with real high school students. It was a working laboratory of sorts where the teachers could see inquiry in action. They participated in and learned the techniques of inquiry teaching, and they practiced the use of technology to foster inquiry thinking. These aspects are all important to the factors of change and confirmation that this research studied.

According to an article in an online newspaper, Polowczuk (2007) reports:

The program better prepares minority students from across (a Southeastern state) to pursue college degrees. The gift (from a major corporation) is the fourth installment of a $500,000 grant that spans five years. Project Inquire enables teachers to prepare and motivate minority students in the state to improve math skills and to pursue technical degrees in college.

The program is a comprehensive initiative for K-12 that brings together the strengths of three ongoing outreach efforts to maximize the impact in transforming math education in key schools. The program focuses on math curriculum development, teacher training and targeted student exposure to inquiry-based math materials.

Six school districts... partner for Project Inquire. Over the five-year period of the grant, Project Inquire will impact approximately 350 (Academic Camp) students and 38 teachers from six high schools. Through the (Academic Camp), students visit the college campus to experience college life. The program encourages high school students in economically challenged counties to give college strong consideration (p.1).

It should be noted that Inquire is just the mathematics portion of the Academic Camp. The student program also engages the students in English, physical science, social science, computer science, and art over the three years, though English and math are the only subjects they take all three years.

The students of the Academic Camp give parts of three summers to the program. The first part is a weeklong Academic Camp between their freshman and sophomore years in high school. They experience college life, go to classes, live in dorms and become acclimated to the atmosphere of higher education. The second summer is much the same, but with two weeks dedicated to college life. In the third and final summer between their junior and senior year, they experience the college life for three weeks. The math teachers from the camper's high schools are also invited for one week during the summer to improve their pedagogy so they will be more effective in the classroom. This is one of the three weeks which the rising seniors attend.

According to documents provided by the administrators of the program, the primary goal for Project Inquire is to increase student achievement in mathematics in economically disadvantaged schools. Students that are selected by teachers and counselors for the Academic Camp are chosen for their potential to be successful at the college level. These are the students that are deemed to be on the edge of deciding to pursue a college degree. They are not the top students in the school, but must have obtained at least a C average in Algebra I. The camp provides these students with enrichment and ongoing instruction at all levels, striving to increase the number of minority students attending college, with special preferences for majoring in engineering, information technology and mathematics-based business disciplines. In order to achieve these goals, teachers are brought in from the same schools as the students to learn and foster inquiry learning and effective use of technology in their schools.

According to an e-mail sent to the teachers before Inquire week, the Philip stated:

My goals for this year are to:

1) Continue to build our network of teachers, with at least one new

teacher from each of our Inquire high schools or feeder middle schools

2) Find a better vehicle for staying in touch with everyone on a much

more regular basis during the academic year

3) Solicit feedback from each of you on how you're using the

purchases you've made with Inquire money

4) Build a database of inquiry-based problems organized by course

that will be available to everyone. (p. 1)

These teacher goals are a means to achieve the student goals by way of enhanced instructional methods. The belief is that if the teachers are taught to use techniques from research-based pedagogy, form a network of support and given resources for their classrooms, then the students will benefit and accelerate their performance. This study is meant to assess the factors of teacher transformations and confirmations as a result of their training. It is not meant to assess the student goals.

These goals are supported by the Project Inquire website that states:

[The] university is the host of Project Inquire, which works toward

improving the mathematics achievement of all students enrolled in Inquire

schools. Professional and curricular developments are key facets of

Inquire. …In addition to funding the mathematics portion of [the

Academic Camp], Inquire brings the mathematics teachers from the

Academic Camp schools to [the university] during the summers, who then

work to invigorate their curriculum and their teaching during the academic

year. Our goal is to enrich the mathematical experiences in the [Academic

Camp] schools by promoting inquiry in the math classroom. To do this,

we engage the teachers in experiencing inquiry themselves, and then have

them join us during some of the [Academic Camp] sessions. We are

developing problems and other materials to help students learn at deeper

levels than usually occurs in the typical classroom. Inquire is, of course,

steeped in the process standards, yet rooted in the reality of the classroom.

   In addition to an intense week of inquiry training, teachers participate in

electronic discussions throughout the school year, implement inquiry

lessons in the classroom and share their successes and failures, and

encourage other teachers to become involved. In return, they receive a

stipend and money that they can spend on classroom supplies.

   As a result of Inquire, dozens of inquiry-based problems are made

available to teachers, problems which they can adapt to their own classes

in order to achieve their particular objectives. These problems will be

made available to the general public through this website (Inquire

Administrators, p. 1).

It should be noted that the original website where the discussions were to be

posted and where the problems were to be shared was hacked and is not usable. The

discussions have been by e-mail and the problems have been posted on Philip's website.

The factors of the transformations and confirmations that occur in the subjects are evident from the data and emerge through the themes of the experience. Inquiry teaching and learning is a major part of this experience. It is mentioned throughout the articles on the program as well as in the stated goals. Other major concerns that are explicitly stated are the building of a community of teachers and monetary support for the teachers and their classrooms. Other main themes that emerge during the week are established and discussed on how they influence the teachers through personal and program factors. These factors affect the transformations and confirmations that occur in the subjects of analysis.

It would be prudent at this point to note that the researcher's doctoral committee chair is the head of Project Inquire, and the researcher was involved with Project Inquire for three years as a graduate assistant prior to this study. Also, two of the subjects of analysis are professional colleagues of the researcher. Access and rapport for this study have been gained through these relationships.

Specifically, this study seeks to answer two main research questions:

RQ1: What personal and program factors influence teachers as they progress through a professional development experience?

RQ2: How do these personal and program factors influence teachers as they progress through a professional development experience?

And, the more detailed sub-questions:

RQ2a: How are teachers' beliefs influenced by the personal and program factors of professional development?

RQ2b: How are teachers' pedagogies influenced by the personal and program factors of professional development?

Definitions of Terms

The terms that are used in this study are:

Participants – The participants were the ten teachers who were in the class of Project Inquire and other teachers who had previously attended. Teachers are identified as past or present participants.

Administrators – Philip and Dray were the administrators of Project Inquire.

Subjects of Analysis – There are three subjects of analysis. They are 3 of the 10 participants: Wendy, Amy and Sarah. These subjects are the basis of assessing the influence of the factors of the professional development.

Inquiry – A method of teaching in which the teacher is a facilitator of student learning. In inquiry as it applies to this study, the students work to answer contextual problems and gain experiential knowledge of mathematical concepts while the teacher challenges the students to provide rationales or proofs of their conclusions.

Barriers and Concerns – These were obstructions and apprehensions that deterred teachers from implementing the main goals of Project Inquire. These were primarily, but not exclusively, issues related to the implementation of inquiry in the participants' own classrooms.

Monetary Influences – The influence of the money that Project Inquire provided to the participants. There were two types of monies that were provided. They were a $1,000 stipend and $1,600 provided for the teachers to spend on their classroom needs.

Professional Community – This was the network of administrators and participants, both past and present, which was created to discuss and support one another in their attempts at inquiry and other techniques acquired during Project Inquire.

Amount of Discussion on Themes – The amount of discussion on themes was measured by the analysis of the 333.5 inches of transcripts of the week of Project Inquire. Each day used 12-point double spaced font in its description. The amount was measured in inches of the columns of transcript that is dedicated to each theme. The more discussion that occurred per theme was directly related to the column inches of transcript for that theme.

Influence of Professional Development – The influence of professional development refers to the extent that the subject's beliefs and pedagogies were either transformed or confirmed. The influences are measured through analysis of data that were gathered before, during and after the week of professional development.

Professional Development Experience – This refers to any experience that transforms or confirms a participant's beliefs related to teaching and/or the participant's pedagogy.

Effective Instruction – Instruction that is likely to enhance student understanding.

CHAPTER TWO

REVIEW OF THE LITERATURE

The professional development experience attended by the teachers in this study was intended to train the participants in inquiry teaching while it also focuses on the way the participants share their successes and failures in the classroom. How do teachers experience this professional development? What factors might determine its effectiveness? The experience incorporates added resources for the teacher and training in technology use in an inquiry classroom. These aspects of the experience have been researched in the past. The research base is broad in some areas, and narrow in other areas on which this case is based. A review of the literature adds insight into the purpose and scope of the factors of change of different professional development experiences.

Many issues must be considered when designing a professional development experience. The intent of the experience may influence instructional methods, such as a change to a more inquiry-based classroom. The experience may change the level of resources that a teacher has at her disposal. It may change the way the teacher communicates with colleagues. It may target all of these aspects. The list of concerns about the structure of professional development is long for developers.

This literature review focuses on the aspects of professional development that are prevalent in this study. These aspects are general professional development research, inquiry-based teaching methods, building professional communities, monetary influences on the educational process and technology use in the classroom.

The first section explores professional development in general and looks at the research in some of the many factors that can influence teachers. The next section explores inquiry teaching, which is a major theme in the professional development lens that this study uses for researching the factors that influence teachers of mathematics. Other themes from Inquire are then explored, specifically building community, monetary influences and technology use in education.

Professional Development

What aspects of professional development are effective? What aspects of professional development support the learning that teachers need in order to accomplish the goals stated by the administrators? Effective professional development changes teachers. It either sends teachers back to their classrooms with different ways of teaching and reaching their students, or strengthens and supports them in their practice. New methods, added resources and technical training can influence the way teachers run their classes.

As countries across the world look to reform their educational systems into more efficient models, teacher training and development is being pushed as a major vehicle for student gains. A more effective teacher in the classroom can make a difference for many students at a time. A teacher with limited tools and experiences may be much less effective (Darling-Hammond, 2005). While this concept seems logical and obvious, there are many systems that do not pursue teacher development with the same vigor that others do. In Japan, teachers go through a rigorous system just to be accepted in a teacher program in college. They are required to intern with a master teacher for one full year just

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as medical students intern with established professionals in the United States. Upon successful completion of the degree and training, a teacher in Japan can expect wages and professional status comparable to that of engineers. With such commitment instilled in the profession, it is no surprise that some of the very best and brightest of Japan strive to become teachers. By contrast, the teaching profession in the United States is dogged by perceptions of low pay and poor working conditions that tend to keep more able students from considering teaching as a viable career option. In fact, some in the political oppose raising the standards of teachers and their profession because it is difficult to find teachers as it is. They feel that any more barriers to becoming a teacher would make the high rate of vacancies and turnover in schools that much more difficult to fill (Darling-Hammond, 2005). Thus, the professionalization of teaching is a two-edged sword for politicians. It can be the wave of reform and a means to higher student achievement that will facilitate economic growth and sustainability through a more educated and skilled populace. But, to get to those long-term goals, politicians and citizens must make a major investment in the culture of education. A major part of that culture is the attraction, education and development of a highly qualified, motivated teaching force to lead the way.

Professional development (PD) can encompass more than just what happens in a day or even week-long seminar. Fraser et al. (2007) used three frameworks to try to understand the complexities of continuing professional development. The frameworks looked at different aspects of professional development. They are a framework on the personal and social aspect of teacher learning, one on the nature of professional learning

and a framework that compares the dichotomies of how learning is transmitted. When they are put together, they form a more comprehensive picture of what professional development means.

The personal and social aspect of the teacher learner that Fraser used is addressed in Bell and Gilbert's (1996) framework. The framework contends that previous experiences and teacher beliefs are what ultimately influence change from any professional development experience. Bell and Gilbert found that if previous experiences or beliefs are inconsistent with the intent of the experience, then the influence of the current experience might not be realized. These beliefs and experiences can determine to what degree teachers will transform their teaching after training. Learning in isolation is seen as problematic and communities should be formed to aid teachers in new techniques. Without support, teachers who become frustrated with the difficulties of a new teaching method will not be influenced by the professional development. Bell and Gilbert formulated the framework from a three-year professional development study of 48 teachers in New Zealand. The teachers met for two hours each week to share experiences and activities.

The second framework that Fraser et al. employed is used to analyze the nature of professional development. Professional learning opportunities can be categorized as transmissive, transitional or transformative in nature (Kennedy, 2005). Transmissive PD tends to be less learner-centered and is generally given by an expert to the participants. An example is a lecture on a learning strategy given by a speaker. At the other extreme, transformative PD suggests a strong link between theory and practice. It tends to be the

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most effective at changing teacher beliefs and practices. For example, an institute that immerses teachers in a teaching method could be transformative if the teachers change their methods. In the middle is transitional PD. It can support either transmissive or transformative models. Support mechanisms such as professional communities fall into this category. Kennedy formed this framework from a meta-study in current literature on continuing professional development. This continuum of types of professional development is useful when trying to decide what type of PD could be most useful for a developer's goals.

The last framework used by Fraser et al. is Ried's quadrants of teacher learning (McKinney et al., 2005). This framework compares two dichotomies in PD, planned versus incidental and formal versus informal. Planned PD is normally what we would think of when considering a professional development in-service or course. Incidental might be discourse in a staffroom or an unplanned encounter with a colleague at a teacher network meeting. Formal would be a class or a meeting, and informal would be a staffroom chat or a web-based network. These three frameworks together, the personal and social aspect of the teacher, the categories of transmission and the dichotomies of teacher learning, form a more complete picture of professional development than just a single one alone.

A professional development experience can be shaped and categorized by these frameworks. For example, consider Project Inquire, a weeklong course in inquiry teaching where the participants learn a new method of instruction. They can observe and practice in a small group setting with actual high school students. Interactions such as this

could build community, foster a transformation toward inquiry teaching and have a range of planned and incidental learning in both a formal and an informal environment. All of these are included in the three frameworks. Afterwards, when the teachers tell others of their experiences, incidental learning by others may also occur. The use of these frameworks together can be a useful tool in categorizing and gauging the capacity of a professional development program.

There are several design aspects that are endemic to good professional development. Loucks-Horsley and others identified several aspects that are essential for effective professional development. They include experiences that foster collegiality and collaboration; promote experimentation and risk taking; provide time to participate, reflect and practice; supply rewards and incentives; have designs that incorporate knowledge bases; and integrate goals of districts and schools. The results in this book are gathered from a range of sources and literature as a project for the National Institute for Science Education. The book is intended as a reference for designers of professional development and not meant to be a step-by-step manual (Loucks-Horsley, Hewson, Love, & Stiles, 1998). Abell and Lee found similar design aspects in a meta-analysis. (Abell & Lee, 2008).

Certain aspects of effective professional development have been found in several studies. Community collaboration, time to plan and implement change, program administrator support and clear vision are recurring themes in good professional development design. These parts of designing professional development work together and need to be complete in order to ensure that efforts in teacher training are not wasted

(Chval et al., 2008; Knapp-Philo et al., 2006; Welch, 2007). For example, if a teacher's needs and concerns are not addressed, or mismatched in a program, the change that was intended by training may be small, or non-existent. Chval et al. (2008) found these results from a survey of science and math teachers from Missouri. Out of 1,000 surveys, 250 were returned. Teachers' perceived needs in PD were consistent regardless of years of experience and subject taught. Knapp-Philo (2006) used a meta-study to find how organizations use Professional development to sustain change. In an article by Welch (2007), she reviews studies that have similar findings.

Zaslavsky and Leikin (2004) studied teachers' practices and reflections on professional development in a program for mathematics teachers of junior and senior high school students. The researchers designed opportunities for teachers in a professional development program to experience mathematics in different ways and reflect on these experiences together as a community of learners. They placed this program in a three-layered framework with teachers and students in the center and teacher educators outside of that sphere. In their conceptual framework, they found that learning is regarded as an ongoing process of an individual or a group trying to make sense and to construct meaning based on their personal experiences and interactions. The staff of the professional development provided teachers opportunities to learn math in ways that they were expected to teach and to engage them in alternate forms of teaching. There were numerous problems presented so that teachers could experience mathematics in different ways to increase the depth of understanding that secondary math teachers need in their day-to-day teaching. The number of participants was 120 mathematics

teachers in six groups of 20 teachers each. The mathematical experience added to the content knowledge of the participants. However, the authors made no mention of the differentiated effects from one participant to another as a result of previous experiences or beliefs.

Jehlen (2007) described six professional development experiences. Three were rated as well implemented professional development experiences and three were rated as poorly implemented experiences by teachers. Although the article addresses only six experiences, the main ideas of teacher choice and differentiation in what is offered to teachers and teacher collaboration are well made. The more input and choice teachers have, the more buy-in they will have to the goals of the experience. Hammel (2007) also found teachers prefer to have input into their professional development. In a synthesis of several studies, Hammel found that teachers are concerned about the lack of communication in education and with the "one size fits all" approach to professional development where learners have little input. Hammel found that educators value professional development experiences that are longer, more focused on individual interests and needs, and contain support structures for implementation of classroom strategies. While both of these articles offer only anecdotal evidence, they provide insight into the beliefs and preferences of teaching professionals.

Designing a professional development program with a myriad of experiences can be an effective means of addressing the various needs of the teacher learners in the program. But, it is a shotgun approach (Hammel, 2007). It scatters different experiences to the learners with the hope that at least one or more will fill the needs of any particular

participant. Still, some teachers may come away from a PD course or seminar with useful information depending on the needs and previous experiences of the individual. For example, a more experienced teacher may sit through a seminar and gain little new knowledge from the experience because the information may be a part of her teaching already. During the same seminar, a novice teacher may gain a whole new avenue to reach students. The difference in previous experiences shapes the effectiveness of the seminar for a teacher. Although it may be a difficult task, gauging the needs of learners is recommended for effective teaching to take place on many levels (Good & Weaver, 2003; Jehlen, 2007).

Congruent to this line of logic in professional development design is the notion of pre-existing ideas that are often shaped by teachers' previous experiences. Teachers' beliefs and the way they teach are often set and not easily changed by the time they enter a particular PD experience (Hammel, 2007). If the ideas and methods are out of line or in contrast to a teacher's beliefs, then the goals of the professional development may not be reached or implemented only partially, if at all. A well designed and implemented PD experience should take into account these contrasts and make efforts to address them (Good & Weaver, 2003; Tillema, 1995; Hammel, 2007; Moeini, 2008). However, Tilemma (1995) found that providing PD designers with information on teacher beliefs was not always an effective means of making connections to the learning that takes place. Some teachers prefer more practice-oriented PD experiences to help them gain confidence that they can take learning to their classrooms and transform their teaching. It is a common occurrence for teachers to believe that a method or lesson will not work for

them because of variations in their teaching style, student population or other reasons. When a PD experience is incongruent with teachers' beliefs, the chances of the experience being fruitful are diminished. Tilemma found these results from 146 elementary teachers in a training study in special education topics. Three training models were provided to the subjects. It is not clear if the same results would hold for other populations.

Effective professional development experiences share several common characteristics. A proven, researched methodological base for teaching is one of the main aspects of good PD. A community of professionals, who can exchange ideas, suggestions and successes, builds knowledge and improves chances that learning will lead to transformations in pedagogy (Loucks-Horsley, Hewson, Love & Stiles, 1998). Teachers' needs and pre-existing ideas need to be addressed in some manner in order to overcome challenges and barriers that may block the goals of professional development and hinder the transformations that are sought (Tilemma, 1995). The proper use of resources and available technology is essential in transformative PD. These issues and challenges are paramount in considering the design of effective professional development.

Inquiry

The National Council of Teachers of Mathematics (2009) suggests that teachers employ methods that enable students to solve interesting, contextual problems. The organization states that "students must learn mathematics with understanding, actively building new knowledge from experience and prior knowledge. (p. 1)" With inquiry,

questions are posed and not immediately answered, giving students significant time to ponder and explore. Having difficulty coming up with an answer is celebrated rather than viewed with disdain. A safe environment for discussion should be provided to share ideas and pose possible methods for solutions. Inquiry learning is based on constructivist theory where learning mathematics at deep levels is seen as a sociocultural practice of sharing ideas and constructing one's own meaning (Cobb & Yackel, 1995).

Immersion into inquiry is essential if teachers are to gain the experience they need to become comfortable enough to employ inquiry in their classrooms. The content of the mathematics is mastered through the teachers' experience and the methods of inquiry need to be experienced by a teacher in order to become a competent inquirer (Loucks-Horsley, Hewson, Love and Stiles, 1998). As teachers work through problems together they realize how students might perceive or misperceive some details in the problems. When teachers are aware of what the students might think, they are better able to anticipate misconceptions and are more capable of answering student questions in a meaningful, helpful way. The learning community should be such that teachers and students are both the learners and the teachers of each other (Jaworski, 2006). Immersion into a new method of teaching and communication between teachers and students are factors that can influence how teachers change their style. It is a widely held belief that the best way to learn is to teach. But, the converse also seems to hold that the best way to teach is to learn (Jaworski, 2006; Loucks-Horsley, Hewson, Love and Stiles, 1998).

In a study by Tzur, Hagevik and Watson (2004), a constructivist framework was used to analyze a two-hour interview with a prospective math teacher. The prospective

teacher solved an open-ended question on 3-D landforms. In the course of her problem solving, the prospective teacher acted the problem out, reflected, interpreted results and reorganized her conceptions of the problem. The prospective teacher had several "Aha" moments and illustrated how meaningful conceptualizations could take place. Even though this case study had only one subject of analysis, the prospective teacher, it showed essential moments that can take place in a person's learning curve in a constructivist setting. Constructivism is a main theoretical framework in inquiry learning. However, the study did not delve into the relevant factors that can influence a teacher to change her methods in the classroom. For example, the authors did not determine if different prior experiences would change the teacher's reactions to the scenarios. Perhaps the "Aha" moments would come in different areas or in different amounts. The study did not determine if the experience transformed or confirmed her knowledge or practice. Perhaps other prospective teachers would bring different knowledge and would react differently to this experience.

The social aspect of inquiry is also critical. Social relationships should be used to enable students and teachers to learn mathematics in greater depth. Interactions between all people in a classroom are important in an inquiry learning environment. The evolving social context of the mathematical development of students is documented in "The Evolution of Mathematical Practices: A Case Study" by Bowers, Cobb & McClain (1999). In this study, the researchers worked from a social constructivist perspective to understand what might be going on in a mathematics classroom. They found that students' constructions do not arise by themselves, but are a result of the students'

participating as a community of learners where ideas could be shared. This case study is limited to the one class. It is not clear if the results can be generalized to all learners. However, teachers become students when they learn new methods and can possibly benefit from the same social relationships seen in this case study.

Having a rich discourse and a community of inquiry is a key factor in inquiry teaching and learning (Cobb, 2000; Groves & Doig, 2004). Interactions between students and students, between students and teachers, and between teachers and teachers are at the foundation of inquiry in the classroom. Groves and Doig (2004) looked into the progressive nature of the constructivist discourse that occurred as Japanese students completed addition problems at the elementary level. The students found several ways to add each set of numbers and discussed the findings in an atmosphere of collegiality. The discussion and experimentation fostered the feeling of safety that is so important in an inquiry classroom. They also observed a lesson on triangle area in an Australian classroom of only female students. The teacher reminded the students that they were not allowed to contradict others. The students were allowed to ask clarifying questions only. These interactions allowed for the progressive solution of problems from the cumulative discourse of the whole class. The safe, gender specific environment of the Australian class and the elementary enthusiasm of the Japanese class may have contributed to the feeling of safety and ability to take risks by the students, but they both illustrate the importance of creating a safe, friendly environment to enable meaningful mathematical discourse. These studies did not examine whether these factors are true no matter what

the prior experiences or beliefs of the teacher may be, but they did illustrate certain elements that are important to consider.

In a study of three high school teachers, Valsiner's zone theory was used to interpret classroom discourse (Blanton et al, 2005). The capacity to listen actively to students is a strong indicator of the propensity that a teacher has to running an inquiry-based classroom. If a teacher can really hear what the students are saying about the mathematics at hand, then that teacher will have greater insight into the difficulties that students have. If a teacher allows little interaction and makes the class do mostly seat work, then there will be little opportunity for the teacher to discover what her students really know.

Blanton uses Valsiner's zone theory to describe the barriers, such as allowing little interaction that some teachers may put up to create environments that seem structured and organized. But, those barriers also destroy the essential opportunities for meaningful mathematical discussions that are so important in an inquiry-based classroom. Valsiner's zone theory encourages teachers to allow zones of free movement and thinking in order to foster deeper understanding. Students must be free to explore and discuss their ideas with one another. An inquiry-based classroom may seem to be more chaotic than others, but if the noise and movement are mathematically centered, then there could be great gains in student learning. The time spent on mathematical discourse may well be a more representative variable of classroom efficiency than the amount of noise and movement that may occur (Blanton et al, 2005).

Letting go of some control is a barrier to many teachers' ability to engage students in inquiry (Blanton et al, 2005; Jarrett, 1997). The teacher may be unwilling to have a "noisy" classroom that would seem ineffective to an unknowing observer. To be sure, a teacher must be in charge of the class, but that does not necessarily mean that the noise is unproductive when learning through inquiry is occurring. Sometimes in inquiry teaching and learning, an observer may see the students up and working and carrying on conversations that sometime do and sometimes do not involve the math at hand. A teacher's concern about classroom control during inquiry lessons is an obstacle that must be overcome in order to break through the inertia that resists change. As a teacher becomes more comfortable with the inquiry method, she will be able to plan for the students to be engaged in a more meaningful way that does not allow for many off-task behaviors. This experience in gaining comfort and knowledge in inquiry is a large factor in overcoming a teacher's hesitance to employ inquiry. With more practice and immersion, a teacher will become more confident and willing to attempt a new practice (Blanton et al, 2005). Blanton studied the classroom discourse from three teachers. While three teachers is a small sample, the findings provide insight to gauge the potential for inquiry development.

Denise Jarrett with the Northwest Regional Education Lab addresses many of the challenges and strategies of inquiry teaching (1997). In the guide, she says that teachers should provide students with the time, space, resources and safety needed for learning. Teachers also need to arrange for active learning and have many tools, such as measuring devices and technology, at their disposal. Some challenges can be avoided altogether if

the teacher takes some time to plan for an inquiry classroom. A few strategies that Jarrett suggests are to demand respect for diverse ideas and abilities, to model and emphasize the skills for inquiry, to nurture collaboration of ideas, and to structure the discussions. These strategies can be modeled and practiced, but may be difficult for some teachers to internalize.

Another main challenge to inquiry that Jarrett (1997) addresses is the demand on teacher content knowledge. When investigating a topic using inquiry, it is often the case that the line of discussion and discovery will diverge from an expected path. For example, a discussion on quadratic relationships may end up becoming a discussion on maximizing and minimizing functions. While both are closely related, they have their own nuances and teachers may not have the knowledge to link the two effectively. From Jarrett, it becomes obvious that the teacher must have as broad a content base as possible in order to prepare for such diversions. Indeed, a teacher needs content knowledge that can give students multiple representations of a topic on different levels of sophistication. Only then can inquiry be truly effective in helping students construct their own knowledge. Jarrett draws these conclusions through a review of current literature in science education.

Pedagogical challenges of inquiry teaching can interfere with the implementation of inquiry as well. Jarrett (1997) indicates that teachers must have the ability to provide guidance to students to get the most from inquiry. They need to know when to ask questions, how much to lead the students and when to leave them alone. What should happen when a teacher doesn't know the answer? Perhaps she should admit that she

doesn't know and offer paths of exploration. This is a part of the art of inquiry teaching. It comes from knowing the students in the class and feeling their level of frustration. A teacher may find students giving up. Perhaps the teacher can use a hint or two to jog the action in the classroom back to math. Perhaps a short discussion of a part of the problem is in order. This art can be practiced by the teacher during the immersion in inquiry that occurs with students. A teacher can try her own questioning techniques and attempt to overcome and refine these challenges.

The amount of practice that a teacher has in inquiry or another new practice can be influential in how comfortable she is in implementing it in her classroom. Jarrett (1997) found the amount of support that a teacher receives and access to materials can also be important factors. The challenges of introducing a new teaching method have significant factors such as teacher comfort with the method, administrative support for her teaching and resources for her classroom. These conclusions are drawn from a review of articles on inquiry. Jarrett does not provide details about the literature referenced in her article.

Many teachers find that students resist inquiry. They have been in school for years and are accustomed to a certain way of learning. They have come to expect that a math teacher will follow certain routines and assign work to be done in class and at home after a review and a lecture. When students encounter a math class that is not so structured, they often do not know how to act. Setting modest goals at the beginning and having perseverance are key. Many of the teachers have been indoctrinated into the traditional math class (Klein, 2004; Silver, Kilpatrick, and Schlesinger, 1990). The teachers must

first acclimate themselves as well as the students when starting inquiry lessons. The natural tendency for both teacher and student is to fall back on the old routines of homework review, new material, new work, and new homework. Teachers must be willing to fail at times. Although Klein, Silver, Kilpatrick and Schlesinger provide mostly anecdotal evidence, they point to teachers as the agents of change. They have to try to move past their own fears and practice what is essentially a new type of teaching. Which teachers in a professional learning environment will actually try new practices is not known at the beginning of a professional development experience. Some teachers may try new practices in different amounts, while others may change little. Others may find that they are already using many of the practices and find confirmatory value in the experience. Whether a professional development experience introduces new methods or validates current practice, the influence on teachers is constructive.

Change is difficult and scary to many, especially to those who require more content knowledge and pedagogical skills. The movement of the teachers and students in math classes may start slowly, but progress is achieved as all participants become more comfortable.

Building Community

A primary purpose for building professional networks is to build knowledge (Good & Weaver, 2003; Loucks-Horsley, Hewson, Love, and Stiles, 1998). When creating networks in a professional development program, designers of professional development often intend that the teachers will attempt what they learned in their

classrooms and discuss their successes and failures via e-mail or some other means in order to become better at their craft. In discussing the successes and failures of teaching, the communications between the teachers need to be sufficient in both quantity and quality. The discussions might be prompted by the administration on several occasions throughout the year, but responses from the teachers have to be regular. Professional networks can be fragile. If a teacher is separated from the community by her own fault or by the fault of network breakdown, then the desired effects can evaporate before they have a chance to grow into her repertoire (Stephens & Hartman, 2004). These results and suggestions were based on a two-year study of an in-service professional development project for secondary mathematics teachers that attempted to foster online discussions of teaching mathematics with technology.

In a study of a professional development project in classroom technology use, Stephens and Hartman (2004) documented the difficulties of forming a professional dialogue between participants of the project through e-mail collaboration. The authors hoped that through collaborative intellectual exchange, teachers would support one another's professional development as they built a community. Also, the teachers that took part in the professional development were very positive about their experience. It was judged highly effective by the participants (Stephens & Hartman, 2004). Nevertheless, the responses for the first year of discussions in the technology program were almost nonexistent even though there were specific tasks generated by the program. All of the teachers had e-mail accounts, and they knew that peer dialogue was supposed to be a part of their professional development.

Stephens and Hartman used a theoretical framework for effective online community building (Riel & Levin, 1990) to evaluate the successes and failures of the online discussion piece of the program. Riel and Levin studied the design structures for several network communities that were set up in the late 1980's. The critical design features of the successes and the failures of the networks were recorded. Even though the authors did not account for individual teacher qualities and e-mail was still in its infancy, their general findings are still pertinent in the design of community networks. There were five structures that were viewed as necessary in the framework for online community building to be effective: organization of the group, types of activities in which the participants were to engage, access to technology, response obligations and requirements, and assessment of the quantity and the quality of the exchanges.

According to the framework, all parts need to be addressed to ensure a quality dialogue. If some of the parts are incomplete or just partially imposed, communication breakdown can easily occur. For example, sometimes response to e-mail discussion cues can be sparse and do not continue a strand of thought and concerns for very long. The technology program studied by Stephens and Hartman (2004) instructed the teachers to post discussion about anything, anytime. The authors determined that the instruction provided was too general to elicit responses. The teachers in the technology program did not have enough expertise to formulate a specific subject of discussion. One suggestion that also may aid programs in the future is to pose scenarios or specific questions to the participants. Benefits may be gained from a more structured requirement and evaluation process for online dialogue. Clear procedures and requirements should be made to insure

that the discussions are not dropped or fall into disarray (Riel & Levin, 1990; Stephens and Hartman, 2004).

Time was also cited as a major obstacle in generating discourse (Riel & Levin, 1990). Many teachers feel time pressure during the school year, not only in professional responsibilities, but also in personal ones. In many instances in the study, the teachers did not feel they had time to reply to e-mails. The framework used in the study addresses this factor indirectly by way of the importance of clear expectations and evaluations. If specific times and topics of discussions are made clear and expectations on the quality and quantity of discourse are firmly established, more robust and meaningful discussions are more likely to take place. A lack of time to participate in a discourse can be a factor that blocks good communication in a professional community. Time is a factor that can prevent any professional from contributing no matter what level of experience the teacher has or how much she could add to discussions.

While online dialogue is important, it is not the only mechanism that is important in building community. A lasting in-service effect is strongly influenced by the collegial experience of the participants. LaChance and Confrey (2003) studied a professional development intervention in which there was an attempt to start a community of teachers around the introduction of mathematics teaching through problem solving and technology. Their original intent was to improve teacher content knowledge through professional development, but they found that the new learning and techniques were themselves a catalyst for community building. Also, the switching of working partners was another catalyst for community building. The authors found that the willingness for

teachers to be critiqued by their peers is a means to build community. When the teachers

work together in different groups and also present findings and conclusions to the whole

group, trust and respect are fostered and a willingness to take risks is secured. The

teachers in this study were from a single high school and its feeder middle schools and

results may not hold for other populations. But, this ability to open up to others in the

learning group and to listen to the way other teachers solve problems is an essential asset

to feelings of community.

Other issues in community building are the proximity of the teachers and the

teacher turnover in the schools (LaChance & Confrey, 2003). If teachers in a community

are spread out over a state and have a high turnover rate in the schools, the only efficient

way of continuing the dialogue between them is by electronic means. The authors

concluded that whole departments be trained together to form a better symbiotic

relationship between teachers. The authors found that if only some teachers in the same

building are trained, often some teachers did not use or were not comfortable with the

training or they would leave the school or profession the following year. This lack of

synergy can be a major obstacle in getting the most from a professional development

experience, especially if trained teachers are expected to train and help others in their

school.

A support network is important in building a lasting in-service effect of short-term

professional development (Watterson, 1994). Whether it is by e-mail, visits or follow-up

workshops, the process of continued learning by teachers needs to be maintained in order

for reform to be sustained. The advent of other electronic means of communication such

as internet conference calls or video conferences may provide more effective means of staying in touch after teachers leave a workshop. However, these means of communication can have their difficulties, such as availability and scheduling.

Building professional communities, however it is done, is an important aspect of modern teacher professional development, one in which the administrators and participants equally share responsibility. With good planning and communication, the discourse and community can have a greater opportunity for success.

Monetary Influences

Although cash and bonuses are widely regarded as universal incentives for performance, using such incentives can be complex. Personality types and needs become lurking variables that may complicate the incentive process. In some cases, providing stipends as an incentive to retain teachers and invigorate pedagogical experimentation may be less effective than providing resources (Ascher, 1991). However, Furnham (2003) found the opposite in an experiment involving 170 participants from a wide variety of backgrounds. Money and time benefits were rated as high motivators for workers. Furnham did note that the results were highly dependent on individual differences in his subjects. For example, higher income subjects were more likely to place value in recognition than lower income subjects. Stipends and recognition of superior pedagogical knowledge were both found to be effective incentives for teacher motivation.

Having the proper resources to run a classroom is also critical. If a strategy, such as inquiry, is heavily dependent on having the proper resources to use during lessons,

then it is imperative that any participants be furnished with the required resources or the means of acquiring them (Jarrett, 1997). Also, when professional development is voluntary, time may be taken away from second jobs during the year and during the summer. With this in mind, professional development administrators can offer incentives to relieve both of these concerns. Stipends for attending and taking part in the community of learners, if available, could address this obstacle at least in part. Also, funds for the purchase of resources could make the difference in the teachers' successes or failures in a lesson. For example, if a teacher needs calculators, five beakers and sets of marbles to explore the linear relationship of the level of water in the beakers when a certain number of uniform marbles are added and there are no funds to purchase these materials, then the lesson will go undone and the students may have to resort to doing bookwork only.

Frase (1989) found that the ratings of job enrichment and recognition were much higher in teachers who chose to take incentives in professional travel and seminars, rather than in cash. Thirty-eight high-performing elementary and junior high school teachers were selected to participate in the study. While this study failed to take into consideration overall job fulfillment, it illustrates the potential long-term motivation that professional development can have over monetary incentives. One of the conclusions this study found was that teachers who chose professional development over a stipend enjoyed being viewed as having more expertise in their field by their peers. This conclusion could point to how a professional development program could leverage its overall potential for motivation of teachers. If teachers were to receive a certificate indicating their

accomplishment to take back with them to their schools, they could have the credentials to be inquiry experts in their mathematics departments.

Planners of professional development should be cautious when using monetary incentives to affect performance. Feedback is essential in an individual acquiring skill. In one study, feedback was both necessary and sufficient in attaining large increases in skill performance while monetary incentives did not affect performance (Roscoe et al, 2006). These results were from an experiment involving four trainees, all female, as they performed preference assessments with clients. Since money is not always a strong motivator, the attachment of a stipend to online discourse may only slightly increase online communication.

Unfortunately, the research base on monetary incentives in education is limited. Few articles on monetary influences on educators' actions and motivations can be found in a search of ERIC, the Educational Resource Information Center, and other major research data bases.

Technology

There is tremendous variation in the skills, knowledge and background that teachers have in regard to instructional technology. Some are proficient in many of the technologies used and some are not. Professional development in technology can help educate teachers in how technology can be used to enhance an inquiry classroom. Teachers can be trained on how each type of technology works. For example, many teachers have had at least some experience with Excel©. However, they might not realize

that Excel$^{©}$ has an impressive statistical package add-in that can be useful in the teaching of linear relationships and modeling. When a teacher has more experience and training with technology and how it can be used to enhance a classroom, she has a much better chance of using it to increase learning. The research base is mixed in the value of technology.

The proper use of technology in the classroom can be invaluable in an inquiry environment and much research has been completed in technology use in many areas. Many jobs that were once low-skill now involve complex technology. It is essential for students to be technologically literate in a modern world. Students who are not may be "doomed to second-class economic status in our increasingly technological society" (Schoenfeld, 2002). Graphing calculators are used often in the exploration of problems. These graphing calculators are essentially small hand-held computers since they contain a great deal of computing power. Geometer's Sketchpad$^{©}$, Microsoft Excel$^{©}$ and interactive boards that interface with computers are becoming more and more common in the modern classroom. If students are technologically illiterate, they may have trouble learning in a technologically enhanced classroom.

Some studies show how technology is employed as a tool to improve scores on high stakes tests. A study in remedial high school mathematics showed significant gains using technology, but more than half of the students in the sample still needed some remediation. The study was of 73 ninth grade students in New Jersey who were placed in experimental and control groups randomly. The computer instruction was specifically tailored to improve scores on the state mathematics proficiency exam (Schalago-Schirm,

1995). This study indicated that the software used was a tutorial that did not use inquiry methods or contextual learning in a way that would be consistent with the National Council of Teachers of Mathematics standards.

In another study, ninth grade students were taught with technology to improve basic skills and the more difficult task of dimensional analysis. The results showed that the students who mastered the basics were the ones who understood the dimensional analysis section. This paper suggested that until students master basic skills they do not have the resources to perform well on higher-order thinking skills (Sinclair et al, 2004). The skills that were assessed were not delineated. The study did not consider different uses of technology, however, and the results seem simplistic and difficult to generalize to other forms of technology in education.

A study on at-risk adult learners in Canada found that technology was effective only if the learners had basic skills. Only then could the students be placed in a constructivist environment (Li & Edmonds, 2005). Although this study does not show gains in higher-order thinking, it does show gains in more basic skills. It suggests that instruction with technology is best used for basic skills, but it does not explain the program in enough detail to determine whether or not the software made use of good, inquiry-based examples and problems. The teachers using this program may or may not have been trained in the potential use of technology as a means of giving students a richer, more diverse educational experience.

In the myriad of the research about the use of technology in education, a few studies acknowledge that the real power of a calculator, computer or other form of

technology-aided instruction is in its ability to create a situation where the student can carry on meaningful dialogue with the teacher and other students and discover mathematical solutions in context. McClain and Cobb (2001) studied students' ability to reason about data with the help of technology. The data were taken from two middle school teaching experiments conducted in 1998 and 1999. Twenty-nine students were studied. The importance of the data creation process and what counts as mathematical discourse were considered. Computer-based tools were a part of an instructional sequence that allowed students to "engage in genuine data analysis." Here, technology was shown to be a part of sound teaching practices. Technology was not separated into its own unit void of teacher interaction. In fact, the computer was viewed as a critical means of support to the lesson. The power of the technology was in how the teachers employed it. If teachers are trained in using technology to enhance the experience of learners, technology has the potential of becoming a major factor in good instruction.

Bull (2005) stated that technology can be used to rethink teaching and learning. He concluded that technology can and should be used to involve the student in mathematics, not just present it to them. Involvement is a key factor to unlocking the true potential power of new technology in education. When a teacher is unclear about its potential, the computer and other technologies, like an interactive whiteboard, may be relegated to an expensive projector. When a skilled teacher can take a lesson and involve the students in the learning process, technology can be used to foster discourse. These conclusions were drawn from Bull's review of several articles on technology use in the classroom.

There is evidence that technology can be effective in providing contextual situations for students. A.C.K. Leung (2003) of Lingnan University in Hong Kong has identified four contextual issues for effective learning to take place. Although no experimental evidence was offered, the issues were identified from a review of the literature on constructivist learning practices. The contextual issues for effective learning to take place are topic selection, authenticity, complexity and multiple perspectives. These issues are important for ensuring that any use of technology is effective. These contextual issues are in reference to stand-alone computer programs. When knowledgeable about how to use technology to augment different teaching methods, the teacher can ensure that they are used to their potential.

Indeed, teacher interaction is necessary for some students. Technology can be intimidating for some learners. Steele surveyed students in technology classes and found that some students do not want to let go of the student-teacher relationship (Steele et al, 2002), and they think the computer would interfere with this relationship. Also, many students rely too much on the results of a calculator. They will not question the solutions they get because they believe the calculator must be correct. Once again, the factor of how teachers use technology is paramount in realizing the potential of technology in the classroom. The learning that the teachers experience in technology will ultimately decide if they are comfortable enough to attempt new methods of instruction using it.

Summary

The aim of any professional development experience is to change or reinforce teachers in some meaningful, positive way. Professional development can have many effects. A new method for teaching, such as inquiry, might be introduced and a community of professionals formed. A new way to use technology in the classroom might be experienced. Or, perhaps money will be provided for resources and incentives. All of these factors of professional development add to how teachers are influenced when they are back in the classroom. However, teachers may respond to training differently depending on their level of comfort with technology, their previous exposure to alternative teaching methods or their expectations and needs. Each teacher is a student when she enters a professional development experience and she will react differently than others.

We know that professional development is a means to influence teachers in some significant way. The level of effect can vary from teacher to teacher and depends on many factors. What those factors are and how they influence the effectiveness of professional development is an area in need of exploration. This study follows three teachers through a professional development experience to identify what factors influence their beliefs and their practice.

The vehicle of the study of these influences is an experience that immerses mathematics teachers in inquiry and technology while beginning to build a community of professionals for support during the school year. There is a two-tiered monetary incentive, one personal and one professional. The monies are meant to be a catalyst for

resources and motivation. How the individual subjects of analysis are influenced by the

experience is the focus of this research. The research questions and method of this study

of influence are detailed in the following chapter.

CHAPTER THREE

RESEARCH QUESTIONS AND METHOD

The purpose of professional development is to influence teachers. However, teachers are individuals. And, as individuals, they react differently to their environment even when they have the same experiences. These different reactions are considered using a case study of how three subjects of analysis are influenced by a professional development experience. Additional data for triangulation are drawn from other participants, administrators and literature on the themes that emerge. This chapter delineates the method and measurement instruments used in this study.

Research Questions

RQ1: What personal and program factors influence teachers as they progress through a professional development experience?

RQ2: How do these personal and program factors influence teachers as they progress through a professional development experience?

In order to answer these questions, other sub questions must be considered because the influence could be in different areas. Some teachers believe that certain pedagogical practices are better than others and they also claim to be enthusiastic about them. When teachers attend a weeklong, intense professional development workshop, there can be a tendency to buy into the ideas and methods being proposed in the

workshop. But, when the teachers begin their year, they may fall back into the same routines and their lesson plans are not affected. So, two additional questions should be considered.

RQ2a: How are teachers' beliefs influenced by the factors of professional development?
And

RQ2b: How are teachers' pedagogies influenced by the factors of professional development?

These two sub questions take into consideration that teachers may believe a certain teaching method, inquiry in this case, is beneficial to students, but they may not employ it for various reasons. They may also think that the teaching method is not beneficial and practice it only to fulfill their professional obligation and receive a stipend or other external reward.

Case Study

The issue is how professional development affects teachers of mathematics. Project Inquire, like most professional development opportunities for educators, was an experience that is bounded by time. The time that the teachers spent learning about inquiry teaching, practicing techniques in questioning and technology and interacting with peers and students was a week that was meant to have effects beyond its bounds.

This study is meant to form a holistic description of this bounded unit and to understand what effects this bounded unit had on the teachers who participated in it. A case study is warranted (Johnson and Christensen, 2004; Merriam, 1998; Stake, 1995; Yin, 2003).

Case study research can be used to explore explanatory research questions (Stake, 1995; Yin, 2003). In this case, an explanation of how a professional development experience affects teachers of mathematics is formed. This research method makes generalizations to an entire population impossible, but it has utility as a guide for developers of programs for teachers and as an example for other research in the future. The choice of case study research is dependent on several factors. First, it is impossible to draw a large enough random sample from the pool of participants in Project Inquire to form quantitative generalizations to larger populations. The number of participants that were involved in Project Inquire over the five-year grant did not allow for such sampling to be feasible. Second, the number of lurking variables in individual teachers and administrators and in the professional development week made the research questions impossible to study by quantitative means alone. The purpose of this research is to determine how teachers are differentially influenced. The holistic view of the teachers as they progressed through Project Inquire required qualitative methods. Third, and foremost, the questions that are being posed are qualitative in nature, although the answers to them can be aided by some quantitative methods. Case study design, unlike some other forms of qualitative research, can make use of some quantitative means such as descriptive statistics in theme measurement. This study measures the amount of discussion on emergent themes to gauge relative importance during the week of Inquire.

In a qualitative design, researchers should ensure that many types of qualitative data are gathered to aid in the triangulation of themes (Flick, 2002). The types that are used in this case are observations, video transcripts, interviews, lesson plans and assignments from teacher pedagogy, archival records, e-mail correspondence, and questionnaires. The investigator gathered observations or videos, documents and e-mail correspondence from participants. The researcher collected archival records on the goals of Project Inquire from the administrators, and conducted interviews with two of the subjects of analysis, all of the principal administrators and two past participants. Five participants completed questionnaires. All present participants completed highly-structured Frayer models with a few additional questions on inquiry teaching toward the end of Inquire week to gauge the basic understanding of the teaching method. These diverse data sources aid in the discovery of themes before, during and after the week of Project Inquire. As themes were discovered, their recurrence of the themes throughout the data sources formed the bases for triangulation and the method for forming naturalistic generalizations of the development seen in each of the subjects of analysis.

Sampling

The sampling methods employed in this case study were purposeful sampling of the three subjects of analysis and the administrators of the professional development. The researcher employed convenience sampling of other participants in the present and past years of Project Inquire. The three subjects of analysis were chosen because of their teaching experiences and backgrounds. The researcher chose Wendy because she was a

beginning teacher who was finishing her first year in the classroom prior to the summer in which she attended Project Inquire. She had experienced very little professional development in her short career and might bring fewer preconceptions of what to expect than more experienced teachers would. Sarah had experiences in her seven-year professional career in a variety of professional development and might bring the teachings of those experiences with her into Project Inquire. Consequently, Sarah likely would have a different view of what Project Inquire attempted to accomplish. Amy was even more seasoned. She had thirteen years to hone her craft and may have had more rigid beliefs about effective teaching. From her questionnaire completed before the week began, it was clear that she was no stranger to the inquiry method of teaching as well as others methods. The interactions of the factors of influence through the subjects of analysis led to results that could be valuable to designers of professional development.

Data Collection and Analysis

The researcher gathered data during the semester before the summer of Project Inquire to establish a baseline of their teaching methods. The researcher conducted observations using two distinct instruments that are described below. Documents were gathered, including lesson plans, handouts, unit plans, and assessments. The researcher conducted semi-structured interviews in which the teachers gave descriptions of their teaching and beliefs. The researcher interviewed the administrators of Project Inquire to establish their beliefs and hopes for the week. Observations were conducted on Dray, master teacher and Project Inquire administrator, in order to establish the differences in

actual classroom practice of the subjects of analysis and the model that the teachers were

to emulate. Documents were gathered, detailed below, from Dray. Data were collected

from past teachers who had already experienced the training including interviews,

observations and documents. The researcher used these data to establish some

representation of past participants for possible triangulation of themes.

The data sources listed above, and described in detail below, originated from

seven types of sources. They were from three subjects of analysis, two administrators,

and nine past and present participants. There were six different types of data:

observations/video transcripts, interviews, documents, archival records, e-mails and

questionnaires. Table 3.1 shows 29 points of data from the combination of types and

sources.

Table 3.1

Data Matrix

	Subjects of analysis			Administrators		Other Participants		Totals
	Wendy	Sarah	Amy	Philip	Dray	Past Participants	Present Participants	
Observations/ Video	X	X		X	X	X	X	6
Interviews	X	X		X	X	X		5
Documents	X	X	X	X	X	X	X	7
Archival Records				X				1
E-mails	X	X	X	X	X		X	6
Questionnaires	X		X		X		X	4
Totals	5	4	3	5	5	3	4	29

Certain points of data had multiple occurrences. For example, there were two interviews for Wendy and Sarah, and there were two questionnaires for Amy. The questionnaires and interviews for the subjects of analysis addressed the same issues. The purpose of the data matrix is to illustrate the diversity of data and to aid in the internal validation of findings.

The classroom observation protocol, borrowed from the Texas Collaborative for Excellence in Teacher Preparation, was developed through the National Science Foundation grants for teacher improvement. The instrument has observation points that include background information, classroom demographics and context, a place for coded class description in five minute intervals, and overall class rating descriptors. The

protocol sets high student engagement at 80% or higher and low student engagement at 20% or lower. The observation protocol was constructed through the selection of items from several classroom observation forms. Items selected were those that had been shown to be predictive of standards-based instruction and positive student outcomes. Sources used included Horizon Research, Inc.; the Arizona Collaborative for Excellence in Teacher Preparation; Evaluation of the Long Term Effect of Teacher Enhancement project; the Constructing Physics Understanding Evaluation project and the Systemic Initiatives Evaluation project (Lawrenz, Huffman & Appeldoorn, 2002). See Appendix A. The other observation instrument was created by a member of the researcher's committee. It has points of observation for teacher information, classroom demographics and set-up, instructional strategies being used and time allocated for them, organization of the lesson, content, examples, materials used, questioning and assessment techniques, teacher conception of mathematics and a place for the classroom management plan. See Appendix B. Though no information was gathered on the validity of this second observation instrument, these two observation instruments together formed a detailed picture of the events in a classroom and gave a holistic, detailed account of classroom interactions and instructional methods.

The semi-structured interview protocol used for the teachers in the study contains ten questions and was administered before and after the professional development experience. The questions touch on the beliefs and philosophy of education of the teachers, their past experiences, expectations of Project Inquire and their ideas of effective pedagogy in the classroom. The researcher developed the questions to explore

the participants' beliefs and practices in the classroom. See Appendix C. The interview was semi-structured in order to allow the interviewer to follow the tangential thoughts and concerns of the interviewee as they arose. The researcher used the same protocol during the semester after Inquire. Other questions and concerns voiced by the participants were probed during the interviews based on the developing knowledge of the research. These interview questions are triangulated through observations, documents, e-mails and questionnaires.

The interview protocol for the administrators of Inquire consisted of eight questions which also probed their beliefs and pedagogy, along with their experiences and hopes for Project Inquire. The researcher derived the administrators' protocol through his insight and experience with Project Inquire. The questions are parallel to the participant questions in the areas of pedagogy and philosophy in order to explore any disparity between participants and administrators. There were also questions regarding expectations and areas for improvement for the professional development experience. See Appendix D. These interview questions refer to the beliefs and goals of the administrators and are triangulated through observations, Inquire video transcripts, documents, archival records, e-mails and questionnaires.

The documents from the subjects of analysis, past participants and the administrator, Dray, are varied pieces from their teaching practice. For example, Wendy contributed tests, quizzes, practice sheets and lesson plans. Dray contributed a curriculum map and unit plan that she uses in her teaching. Tests, quizzes, practice sheets and lesson plans were gathered from three other participants. A Frayer model provided evidence of

the understanding that the participants gained about inquiry. In it, they gave a definition

of inquiry and examples and non-examples. A question and comment blog that was

circulated at dinner one evening allowed participants to write whatever they wanted about

Project Inquire and the inquiry method of instruction.

Documents from Philip consisted of pages from the Inquire Website that

described the project and states the project's objectives, an introductory letter to the

Inquire Participants and articles from a university-sponsored online newspaper. The

Inquire website was no longer used because of hacking, but it added to the holistic view

of Inquire and its history. Much of the information remained on Philip's personal

website.

The archival records from Philip were official documents from the grant that

established Project Inquire in conjunction with the Academic Camp. These records gave

an official record of the goals of Inquire and aided in the triangulation of the project's

overall goals.

The e-mails from the administrators and participants were of varied content and

were mostly correspondences on the attempts at inquiry throughout the following school

year. One of the stated goals of Project Inquire was the creation of a community of

learners that can discuss inquiry successes and needs. The e-mail correspondence was the

main avenue of communication for this community following the summer program and

became a major theme of Inquire. There were some e-mails that discussed other matters

such as spending the classroom money made available to the participants and other

administrative needs and concerns.

The questionnaire completed by Amy and other participants of Inquire was highly-structured in nature and parallel to the semi-structured interview protocol for the other participants of Inquire. The questionnaire consisted of the same researcher-generated questions asked in the semi-structured interview protocol. It explored areas of expectations of professional development and allowed the participant to elaborate on issues of professional development. The additional topics, added after the initial protocol, were used for the first two interviewees, Wendy and Sarah. Most of the questions were repeated in the questionnaire for the semester after Inquire week. See Appendix E. The protocol was highly-structured because it allowed for participant deviation from the question topic in only one out of ten questions. This structure allowed for some comparison of beliefs and practices between subjects, administrators and participants.

The questionnaire sent to Dray was via e-mail at the end of the first semester after Inquire and concerned the building of community and how the teachers were utilizing classroom money. See Appendix F. This questionnaire provided vital triangulation in the perceived successes and needs of Project Inquire during the following school year.

The transcripts and data from the events and discussions during the week of Inquire were analyzed to measure the amount of discussion that occurred on topics by measuring the column length of transcripts that were gathered during the week. All transcripts were in 12 point font and double spaced for uniformity. The researcher compared total column lengths of the themes to gauge the amount of discussion spent on each one. The researcher compared the themes from the week, and the teaching and beliefs of the three subjects of analysis discovered during Inquire. The researcher

compared the differences in the teaching and beliefs from the subjects from before the week and after the week. This comparison through the data types gauged how the factors from the teachers and the experience came together to influence teachers of mathematics.

All of these data types from the varied sources of Project Inquire worked together to form a holistic picture. They intertwined and described this time-bounded experience. The researcher compared themes and findings across the sources of data, and developed rival conjectures of how teachers are influenced by professional development. The conjectures arose from the data. The researcher compared the conjectures to the current literature and found conclusions and answers to the research questions presented in this chapter.

Limitations

The purposeful sampling of the subjects of analysis should not be considered representative of all beginning and experienced teachers. This research provided a study only in this case. The researcher chose convenience sampling of the past participants from teachers that were in close proximity to the researcher's place of employment or were visiting Inquire during the week. The past participants who contributed to this study visited Project Inquire at some point during the week. This group represented teachers who felt an affinity for Project Inquire strongly enough to take personal time to attend some part. This affinity could affect the data that were gathered in the interviews and add bias to the findings.

The data gathered from all subjects of analysis are not all equal. The researcher observed two of the subjects, Wendy and Sarah, and gave Amy a highly structured questionnaire to attempt to assess the same topics that emerged in the interviews and observations from the other two subjects. This inconsistency in the data collection method might have been a source of limitation in subject comparison.

The questions generated by the researcher in the interview protocols were not validated by an external source. The researcher derived the questions to explore the aims of the study. The researcher's lengthy experience with Project Inquire and with teachers before and after they participated was the only validation used for these questions.

The researcher developed the data analysis technique of measuring the column length of the transcripts to gauge the amount of discussion on the dominate themes that were presented during the week. While measurement and some statistical methods are allowed and are useful in case study design, external sources for case study design did not refer to this particular method of measurement.

All of these limitations can be a source of concern for the validity of the findings of this case study in professional development. However, these limitations are mitigated by the fact that these findings are from a case study in the professional development of three teachers with a wide range of experience. The findings may not generalize to a population, but they give reason provide evidence that may be important for those designing and implementing professional development experiences for teachers. The triangulation of themes with the current literature and the data from the pre and post Inquire subjects form a depiction that is not without flaw. The researcher addresses these

limitations in the conclusions and these limitations should be considered when using this

case study to make professional development decisions.

CHAPTER FOUR

DATA ANALYSIS AND DISCUSSION

The data analysis and discussion in this chapter are mostly chronological according to how the experience of Project Inquire unfolded. The data analysis and discussion begins with the administrators and flows to each of the three subjects of analysis before the week that Inquire began. The data gathered during the week is then described in detail. The data from the past participants are presented to obtain a perspective on how others perceive the training a year or more later. After that, the researcher discusses the data from the three subjects of analysis after Inquire week. More views from the administrators and e-mail correspondences from other stakeholders form a more holistic view of the influences of the training. Finally, the researcher compares the data from the three subjects of analysis from both before and after Project Inquire with possible conjectures on how the factors of professional development influenced teachers of mathematics.

Administrators

Philip

The observations of Philip came from the week of Inquire when he led the teacher participants and when he led the students of the Academic Camp. In both, he modeled inquiry teaching techniques and questioned the answers that the learners gave him. For

example, in the opening vignette of this case study, the first thing Philip did after a brief introduction was to pose the first problem to the teachers. The teachers worked through the problem with minimal guidance from Philip. He continually asked the participants what they were thinking. He asked them to question whether an answer made sense. There was no giving away of answers. Philip stated that the thought process is more important than the answer and that that is what teachers should be paying attention to in the classroom. The learners must be able to defend their answers and be able to give at least an informal proof of why they believe their answers are correct. The administrators modeled the inquiry technique throughout the week in problem after problem.

When the teachers were with the Academic Camp students later in the week, they saw Philip continue this technique. They now were not students of the problem, but they were students of the method. They observed actual high school students' reactions to the same techniques to which they have been students. Then, Philip compelled them to assist the students and helped them through a problem using the inquiry techniques that they had observed and experienced. This immersion into a new method was meant to have a greater impact on teacher beliefs and confidence than a seminar or lecture on it would. The teachers could see the students' misconceptions and confusion more easily because they had experienced it.

In addition to modeling inquiry, Philip modeled collegiality at all times as well. He made jokes, fostered friendly competition between the participants, particularly between those in the same school like David and Amy, and he made the participants feel as if they were part of a team. These interactions helped the teachers feel that the

environment was safe and they could make mistakes without feelings of inadequacy. A safe environment is essential in inquiry learning and in building community. Wrong answers were greeted with the same amount of enthusiasm as right answers as the teachers work through problems during the week.

At several points during the week, Philip modeled inquiry techniques with various types of instructional technology. First and foremost, he introduced the teachers to the graphing calculator and modeled how to foster inquiry learning. The way a calculator is used in the classroom may lead to learning through inquiry if the teacher has insight into the power of the technology. For example, Philip showed how to use the dynamic feature of a calculator to show the effects of slope on the way a linear function looks. The inquiry-questioning technique was modeled to lead the teacher learners to conclusions and generalizations that were constructed in their own minds, not given to them up front the way so many have taught and experienced. The inquiry method was also modeled in lessons that utilized dynamic geometry software and spreadsheet applications. The main point was that it wasn't the particular technology that was useful in teaching and learning, but the way in which it was employed.

These ideas were evident in an interview with Philip before the week of Inquire. On the way to visit the schools from which the Inquire teachers were recruited, the researcher posed a series of questions to Philip. Several interesting points were raised.

In the interview, Philip envisioned a good math lesson as one that lets the students come up with the questions to be answered. But to get to that point, the teacher needs to provide the stimulus in many problems. Some student control generates interest and

motivation. The role of the teacher should be to lead the students to the underlying ideas. According to Philip, a problem should not end with the solution. He stated that students and teachers should talk about the solution and what it means. They should reflect on the process and decide what underlying concepts existed. The teacher should start with the standards and big ideas and compose the problems around these. A good problem should strike many standards.

In discussing the major goals of Project Inquire, Philip saw developing a network of teachers that can discuss ideas as paramount. He stated "so they don't just get in the classroom, close the door, and do to their students what has been done to us all … in the classroom." Inquiry in the classroom is another main goal Project Inquire. Getting students actively engaged in learning and discussing findings are main tenets of inquiry. Inquiry is a method that gets the students thinking and promotes reflection on how students think. Philip stated that teachers should teach better after Inquire and feel like they are part of a team. He wanted them to be comfortable using inquiry to help students think and learn. Another accomplishment he would like for Inquire to achieve is a course-specific problem bank for standards in math classes. Philip envisioned a place where teachers can look up a problem to build a lesson around for Algebra 2 or any other class.

Philip believed that students are naturally curious and our jobs as math teachers is to make the non-intuitive intuitive. Math applies to every subject from music to the social sciences. He says that it is our job to foster inquisitiveness in our students and continue to learn effective methods. This vision was how Inquire grew from the Academic Camp program.

Despite the apparent effectiveness, there was room for improvement. Since the original website was hacked, the dissemination of good problems for teachers and a forum for professional exchange was hindered. The problems have since been available on Philip's own website and teacher collaboration was relegated to e-mail exchanges. These problems could be one reason why communication has been poor during the school year. He stated that it has been difficult to get teachers to respond to e-mails.

Another difficulty has been teacher turnover at the target schools. The Inquire schools are in low income counties where the tax base is small. The schools have a difficult time recruiting and retaining teachers. Many teachers, recruited from overseas, have limited English speaking skills. This made it very difficult to reach students that are already at an economic disadvantage. Most teachers from overseas were on a three-year visa. A three-year commitment was seen as long term to some schools that have a very high turnover rate. Yet, teacher sharing and communication are not able to grow when almost the whole math department turns over quickly. A culturally diverse teaching staff can bring different perspectives to the classroom. However, if the retention rate is low, then mentoring and collaboration among teachers are lost.

The interview with Philip concluded with a question about others involved in the administration of Project Inquire, but it became clear that the people in direct contact with the teachers of Project Inquire were Philip and Dray. Other people involved in the grant and administration at higher levels would not have a direct impact on teacher beliefs and pedagogy.

The researcher gathered other evidence of the goals of Project Inquire from the hacked website developed by Philip. The site stated that the goal was to increase student achievement through teacher improvement. The training involves getting teachers to attempt inquiry in the classroom, have electronic discussions throughout the school year, share successes and failures and get other teachers involved. These goals from the site that has been largely unused since the third year of Inquire show how the aims have been constant throughout the life of the grant.

In official archival records from the original grant for Academic Camp and Project Inquire, the primary goal of Project Inquire is to increase student achievement in mathematics by enrichment and exemplary math instruction. Through these improvements, the administrators hoped that the students in the Academic Camp program will attend college in engineering or some other math-based discipline. This official record provided by Philip set the goals that are still in place half a decade later.

Difficulty in e-mail communication was a recurring problem throughout the program. It began in the recruitment of teachers to attend the weeklong professional development and continued throughout the year after the summer. Project Inquire began in the second full week of June. In the closing days of the preceding April, Philip sent the researcher an e-mail stating that he was unable to get commitments from teachers to come to Inquire and was planning a trip to the schools to talk to teachers face to face. He had not received any response to e-mails at this point which was a little over a month away from the program. In mid-May, he had had minimal luck and visited the schools. During and after the visits, he was able to achieve greater success in getting

commitments. Just three days after the school visits, Philip sent an e-mail confirming the commitment of ten teachers to the program. He expressed concern about the inability to communicate effectively via e-mail. With a more than three-hour drive to most of the schools, good communication can be difficult. This difficulty is a point that also has consequences on the collaboration throughout the year between Inquire teachers as they use e-mail to communicate.

In a letter attached to an e-mail, Philip spelled out the specifics of Project Inquire to the teachers. The main points he discussed are establishing a network of teachers, establishing a base of inquiry problems to use during the year, exploring instructional technology, monetary stipends and instructional supply money. All of these were recurring themes during the week.

Dray

Dray was a master teacher who worked with Philip on Project Inquire. She achieved National Board certification, and has been a district Teacher of the Year and a state finalist for the Presidential Award for Excellence in Teaching. She is passionate about her work and enjoys sharing past successes of her students. She also helped during the year in promoting the online collaboration of teachers through e-mail. Her teaching was referred to during the week of Inquire as an example of how to employ inquiry-based lessons. The researcher gathered observation and interview data, along with documents from her teaching and e-mails, to establish a base-line of what the teachers in Project Inquire were expected to exemplify.

Dray told the teachers of Inquire that, at first glance, her class seemed chaotic, something observers from her district office often commented upon. However, her classes only appeared that way because of the explorative nature of her inquiry-based lessons. During the researcher's visit, Dray was leading a tenth grade college prep geometry class through the use of trigonometric functions.

The class consisted of 20 students, 19 Caucasian and 1 African-American, and lasted 90 minutes. The class was arranged in groups of three desks apparently to encourage discussion and interaction. The first five minutes was used to get settled and gather materials that were in abundant supply. Then, the class had a 20-minute discussion with the teacher interacting with students about the lab on which they had been working. It involved using trigonometric functions to find the height of objects that were not directly measurable. After the discussion and review of the task, students went their own way to finish the lab and have small group discussions. Some students were outside of the classroom getting measurements with clinometers. Some students were involved in writing. The class as a whole was either highly engaged (80% or more on-task) or was mixed engaged (20% to 80%) in their task for the next 45 minutes. During this time, Dray had the role of leading the students, providing hints about the problems and keeping students on task, a guided inquiry model. The researcher highly rated key indicators, such as encouraging students to seek alternate modes of problem solving, conceptual understanding and real-world context. Only at the end of the period, Dray brought the class together to discuss and summarize the day. The responses to student questions were accurate and adequate, but did not give answers away; typically, she answered students'

questions with questions of her own. The assessment techniques used were formal in the individual write-ups of the lab and formative in the observations of the students as Dray was circulating through the room and providing feedback. The lesson was skillful and effective.

During her interview, it was apparent that she had a firm grasp on the issues and goals of Project Inquire. She began by describing a good math lesson as one that begins in context and has students actively engaged and gathering their own data. Interestingly, she stated that she was not taught this way as a student and that, in teaching with inquiry, she has learned a great deal of math that she didn't realize was out there. She learned the way things worked. The learning she has experienced as a teacher in inquiry has changed her conception of what mathematics is. She now sees math as a user-involved process that allows for experimentation and investigation.

Dray described the goals of Inquire as connecting teachers with each other and giving them an avenue for trying contextual, reality-based mathematics. However, she realized that the communication between the teachers in the past had not been what they had wanted. The teachers spent one intense week at Inquire and then they did not keep in touch. Some of the teachers would meet at state and national conferences, but that wasn't enough. She wanted teachers to realize that there is too much lecture in the classroom and not enough student interaction. Teachers needed to bring more contexts into their teaching.

She believes that all students can learn and it is the teacher's job to help them. A teacher needs more than content. A love for the whole child is needed. When a teacher

starts there, she finds out what the child needs. Our goals of teaching math need to be different to reach students at all levels. They should be student-centered. Our goals should be to immerse the students in math and guide them as they work toward solutions, not just present problems out of context.

When asked about the structure of her classroom, Dray said that it looks messy, but all students were mostly engaged. She began with an introductory problem that led students to the concept to be taught. Then, after they had gathered data, she asked them what they noticed. Dray led them toward the math, but did not give it away. Her method gave her students an experiential base first. For example, in the introductory problem to the observed lesson, Dray described how GPS systems worked in order to give the students some reference of application. She described her class as one where the students were doing the work and gathering data.

Dray assigned and led around 50 problems the whole year in her Geometry class, instead of the 30 to 50 a day found in many math classes. She believes that there should be fewer problems, but more extensions in context. Many teachers introduce a problem out of context and have the students practice a skill many times over with little or no contextual reference at all.

The interview ended with Dray agreeing to allow access to some of her planning material and unit plans. The good rapport she had with her students was obvious as she worked with them. Her methods were effective and Dray said the standardized test results for her students were very good.

The unit plan for linear functions that Dray provided covered nine weeks and was not highly detailed. It listed eight inquiry-based problems with two quizzes, a vocabulary booklet, a vocabulary poster contest and a test at the end. It also stated that brain teaser problems would be on-going throughout the nine weeks. The curriculum map provided for her Algebra 1B class had a year's worth of units listed. Each unit had an essential question, the content addressed, skills covered, assessments used and resources needed. The linear unit was the first one on the map. The planning for Dray was rich in inquiry-based problems, but allowed for some amount of flexibility in time management by her.

Dray had stated that some teachers from previous Project Inquire years had trouble with the process of running an inquiry-based classroom and needed help during the year. The e-mails by Dray sent during the school year were meant to encourage discourse between the teachers. When there hadn't been any communication for a while, Dray sent a request for teachers to reply about what they had been trying in their classes. Responses come sporadically, if at all. Or, if a teacher had begun a thread of discourse on a problem or subject, Dray responded in an attempt to keep the conversation rolling. However, the e-mail discourse was infrequent and random at best. This Inquire group was the first group to have half of their $1,000 stipend dependent on at least two e-mail correspondences being placed. Dray and Philip both have expressed their disappointment in the quantity and quality of discourse that had taken place in previous Inquire classes.

The data gathered from Dray painted a picture of quality inquiry-based teaching with her own students as well as with the Inquire teachers. There was genuine enthusiasm for the method and the aims of Project Inquire. Her idealism and energy were apparent.

Both Philip and Dray have goals and plans for Inquire that were stated in the literature as essential for an influential professional development experience. The aspects of fostering collegiality and collaboration; promoting experimentation and risk taking; providing time to participate, reflect and practice; supplying rewards and incentives; having designs that incorporate knowledge bases; and integrating goals of districts and schools (Abell & Lee, 2008; Loucks-Horsley, Hewson, Love, & Stiles, 1998) are all stated or modeled by the Inquire administrators. Designing a professional development program with a myriad of experiences can be an effective means of addressing the various needs of the teacher learners in the program (Hammel, 2007). Each subject of analysis in this study came to the experience with different backgrounds and beliefs and was influenced differently.

Subjects of Analysis before Project Inquire

Wendy before Inquire

Wendy had just finished her first year as a secondary mathematics instructor. She had graduated from a small mid-western college. She was not familiar with the techniques of inquiry teaching. During her first year of teaching, she often asked if she was doing okay as a teacher.

The researcher conducted two observations during the semester before Wendy attended Inquire. The first was a 50-minute observation of a Math Tech 1 class. This is equivalent to an Algebra 1A class in some educational systems, and is equivalent to the first half of an Algebra 1 college preparatory course. There were 16 African American

students, one Caucasian and one Hispanic for a total of 18 students. Students of all high school grade levels, ninth through twelfth, were represented. The classroom was arranged in rows with an overhead in the middle. The lesson being taught was a review of slope-intercept form of a linear function.

The lesson was largely teacher-centered with an interactive lecture with demonstrations of how to work problems on the board for the first twenty minutes of the class. The students were allowed to ask questions while Wendy presented examples. The conversation was largely a discussion of correct procedures. No contextual discussion was present. During this time, Wendy conducted a review of linear graphing as she was lecturing. Then, she gave a worksheet to the students to complete. The worksheet was centered on skill building, again with no contextual references. Some students put problems on the board and discussed them; however, others were off-task. Several students were talking about the weekend, roaming about the room, listening to music, etc. The researcher rated key indicators of effective instruction, such as seeking alternate modes of problem solving, reflection and connections to real-world contexts, very low. The engagement level of the students was mostly low, less than 20% engaged, to mixed, 20% to 80% engaged. There were some elements of effective instruction present, but the lesson was limited in its likelihood to enhance understanding.

The second lesson observed by the researcher before the summer that Wendy was to attend Inquire was also 50 minutes in length. This was a college prep Precalculus class made up of juniors and seniors. It was a class of 14 students, 13 African American and

one Caucasian. The classroom arrangement was in rows as before. The lesson was an exam review.

The students were working on an exam review worksheet and the teacher circulated to help students when needed. The worksheet was composed of skill problems only with no reference to any contextual situations. The students were allowed to work in small groups or independently as they completed the worksheet. Key indicators, such as respecting students' prior knowledge, collaborative interactions, and the teachers' display of content in dialogue with students were rated higher than in the previous observation, but other key indicators, such as encouraging students to generate conjectures and connections to other areas, were rated low by the researcher. This lesson received a slightly higher rating by showing the beginning stages of effective instruction, but still did not address the needs of many students in the class. The worksheet content was limited, but the circulation of the teacher was good. This lesson was somewhat limited in its likelihood to enhance student understanding.

These two observations show instruction that was teacher-centered and lacked relevance to real-world context. The teacher gave a lesson on a math procedure or two and the students practiced the skill. The lessons were heavy in drill and light on relevancy to the real world. The teacher was a purveyor of worksheets. The students were not given reasons or motivations for why they needed to learn math.

From the beginning of the interview, it was apparent that Wendy had no experience with Project Inquire and was unaware of its specific aims. She did know that

it teaches techniques that she would get to try during the week and she would report on her progress throughout the next year.

She described a typical lesson of hers: review previous lesson, give the students a new lesson and review the new lesson at the end of the day. Immediately after stating this, she said she doesn't like to lecture and she would like to have more project-based, hands-on lessons. She had a difficult time with her lower level students because they were used to lecture and resisted working independently. She said that the way she was teaching was not the way she would like to have been taught when she was in school.

Wendy said that she would like to ease into a different style where she may start off lecturing and work toward project-based lessons. She blamed her lack of experience on not knowing how to change her teaching style. She made no mention of any methods she had learned or used in the past other than the lecture style she exhibited during the observation. Her students were used to asking her and would not rely on a classmate for help on a problem. They only wanted to take notes and be taught directly from the teacher. Wendy said that that was what the students were accustomed to and she did not know how to switch gears with them. She hoped that Project Inquire would help her "push away from lecture" and would give her new ideas. It was obvious that she was aware of her inexperience as a first year teacher.

When Wendy discussed her educational philosophy, she spoke of helping her students think on their own and in context. She said that her philosophy had less to do with the content and more to do with her methods. She would have liked to teach more

with problem solving. She said she wanted to give them the tools that they would need in the real world other than what they would find in the textbook.

Wendy again said that her teaching consisted of mainly giving notes and having students complete worksheets. She wanted them to work together to figure out some concepts, but the students resisted. They wanted her to teach them directly. She assessed her students on a few levels. If she gave "a lot" of problems during a class, she would grade a few. She gave tests and quizzes. She was frustrated because the students did not think for themselves and she tested with mostly "drill problems." When she attempted to change her methods, students tended to get lost. So, she avoided word problems. The reading level of her students was low and this was one reason she cited for using mostly skill problems.

Wendy said that she hadn't had much experience in professional development. She said she had gone to a conference on analyzing data from her classes. She was disappointed in it because she received a great deal of information, but she wasn't told exactly how to implement it. She stated that teachers can't change just because they gain new information. She believed more hands-on professional development would be more effective. She said that, in most of her experiences in training, trainers lectured about what to do and told the teachers not to lecture. She wanted professional development that allowed her to try new techniques and practice them. Wendy said that hands-on was the way teachers learn as well.

The lesson plan Wendy provided on evaluating variable expressions was almost all skill driven. Out of five examples to be used, none was contextual in nature. The

assignment for the lesson was straight from the text and had four very simple problems in context. For example, one asked for the distance traveled of a train going 75 miles per hour for two hours. In another lesson plan, there were three contextual examples, but all were simplistic in nature. The quizzes and tests that Wendy provided were almost all skills with little contextual reference. One test contained three contextual problems out of 13. They were all multiple choice. In a teacher-generated quiz, there were 11 problems and all were skill-based with no context. About half of the assessments were from the supporting material of the textbook. There were few contextual problems here and some of those were not assigned. The instructor-generated assessments were all skill-based problems with no inquiry-based problems.

In the questionnaire that Wendy filled out before Inquire week, she stated that she would like to see hands-on activities in her classroom, but she hadn't had the opportunity to do so. She usually gave a warm-up problem, a lesson and then classwork. She hoped that Project Inquire would give her techniques to help her students enjoy and retain the math they learn. Once again, she expressed a desire for professional development that would allow time for feedback and time to practice new techniques.

These questions, lessons and assignments attest to the type of lessons observed and the types of problems worked in Wendy's classes. Her interview gave insight into her frustrations at this kind of teaching, but she was not sure how to change. She knew there were better ways of teaching, but she acknowledged that, in her brief career, she still hadn't been exposed to different teaching methods.

Sarah before Inquire

Sarah was in her seventh year as a math teacher. She received her undergraduate degree in education in India and had a graduate degree from a major U.S. university. She said in an e-mail that her undergraduate experience was void of project and group work. Success was measured only on tests and major exams. There were no project, class work or homework grades. She described her graduate experience as "wonderful", but gave no details to its content.

The researcher observed Sarah the semester before the summer of Project Inquire. She was in her sixth year of teaching and this was her second year at the high school level. She had taught in a middle school for her first four years. The class was made up of 27 students, 23 African American, 3 Caucasian and 1 Hispanic. The length of the observation was the entire 50-minute class. The student desks were arranged in rows and the teacher taught mainly from the overhead projector. The lesson being taught was a review using a worksheet copied from the textbook resource material.

The first five minutes of the class was spent attempting to get all of the students out of the hall. Many trickled in late because of a fight during class change. The students were excited and not willing to settle down very quickly. Sarah finally focused enough of the class on the overhead where there was a warm-up problem. It was all skill and the students spent five minutes completing this task with much chatter and low engagement. Sarah then gave the students a worksheet and led them through it problem by problem with some questions and discussion. There were no problems in context contained in the sheet. For a little over five minutes of the lesson, she was able to have high engagement,

greater than 80% on task, but for the rest of the class, approximately 45 minutes, there was medium to low engagement. The lesson was monotonous and lacked any kind of energy or enthusiasm.

During the lesson, the teacher had to resort to threatening some students with a disciplinary referral and suspension to keep them from talking and causing a classroom disruption. Sarah had to send one student out of the classroom because of his constant talking and noise making. She told the student to go to the office. About 10 minutes after the student left, a principal brought the student back because he found the student wandering the halls. The general lack of structure in the class was a major contributor to the difficulties in carrying on an effective lesson.

All of the key indicators of a successful lesson, such as collaborative working relationships and connections to other subjects and contexts, were rated very low. In the questions from students and the answers given from Sarah, there were some elements of effective instruction, but the content lacked a connection to the students. There were two attempts to connect the lesson to a real-world example, but they were brief and the students were uninterested. The lesson was quite limited in its likelihood to enhance student understanding.

During the interview after this observation, Sarah said that students think math is a boring subject and it is better to do hands-on activities with them. Using a graphing calculator was given as an example of a hands-on activity that interests them. When pressed for a specific example of a math lesson, she referred to using "Please Excuse My Dear Aunt Sally" as a tool to remember the order of operations, and she stated that

having the students make up their own memory trick was something that she has used in the past. She thought that this assignment was relating the topic to the real world. She also referred to a project she had used in the past where the students have $1 million to invest or spend. Sarah had used the order of operations memory aid with high school students, but not the spending project.

Sarah said that she didn't really use real-world type problems because the class used more algebraic problems, solving equations and graphing. The content of her math classes and the real-world applications of the content seemed disconnected from each other.

When asked about what she knew about Project Inquire, Sarah said that she had only heard that teachers got to interact with students. She thought at first that it was a workshop where the teachers would have to sit for the whole day. But, when she realized that it would be different, she changed her mind about attending. She hoped that teaching students effectively and how to differentiate instruction were the goals of Inquire.

Sarah's philosophy was that education is the path to the future and students should be prepared for the future. It came from a quotation from Martin Luther King, Jr. She stated that this was the most important part of schooling for students.

When asked for a typical lesson she teaches, Sarah responded that she asked some probing questions and she started from there. If the students didn't know the basics, she would start there and move toward more advanced mathematics. All examples given were non-contextual, skill problems. Sarah assessed by giving a quiz or test. There was no mention of contextual, real-world problems. She stated that her assessments were

basically class work, homework and test grades. Sarah said, "I don't give a lot of projects."

Other professional development that Sarah had had consisted of Masters level classes at a large college in Educational Leadership where she learned how to manage students with diverse backgrounds. She had not had any professional development from her current school system, but she had professional development on how to teach low performing students at her previous position. The classroom observation, where Sarah had quite a bit of difficulty with a few students, indicated that the professional development did not have the desired effect. She believed that staff meetings were not needed, but individual help for teachers was. For example, she wished she could get more help with the graphing calculator because she was unfamiliar with it. She related her frustration at having to sit through a meeting for an hour that really did not help her in any way. She believed that professional development should be relevant to what a teacher was doing in her classroom.

To end our interview, Sarah said that she would let the researcher have access to some of her lesson plans, units and assessments. She said that Project Inquire would be a great thing, especially since they were reimbursing the teachers for expenses. The monetary aspect made some impact on her outlook toward the training.

In the documents Sarah supplied, the test and the quizzes contained all skill-based multiple-choice problems that had no context. There was a chapter test where the students were asked to match six quadratic functions to their graphs, and answer 14 simple

quadratic equations. The two quizzes provided were of the same format. All three assessment instruments appeared to be problems from the same computer program.

The two lesson plans provided had been copied from the teacher resource material that came with the textbook used in the class. In the format of the plans, the teacher was supposed to check off the activities that she wished to use for the section of the book. There was a place to write the state objectives and places to check off what starting options, teaching options and assessment options that the teacher wished to employ. For Sarah, nothing on any of the lesson planning sheets was checked off.

The data from Sarah were a combination of believing and saying one thing and practicing another. Her experience in other professional development seemed to have had an effect on her beliefs, but she still struggled in her application to her pedagogy.

Amy before Inquire

Amy had 13 years of teaching experience. The data gathered from Amy before Inquire consisted of extensive answers to the questionnaire that was given to all present participants and many examples of her lessons, assignments and assessment instruments. These data gave deep insight into a teacher who had a wealth of experience and teaching methods.

Amy stated that a good math lesson should have a specific goal in mind. It should test for prerequisite knowledge and new concepts should be modeled. Moreover, Amy stated that lessons should be connected to the real world and concepts should be developed using real world applications. She said that the teacher should be a facilitator

and guide students through inquiry-based learning in a good math lesson. This was one of the stated goals of Project Inquire.

Amy was already familiar with Project Inquire. She stated that she had heard much about Inquire through her department chairperson and colleagues who had attended. She knew that it involved a collaboration of teachers from six different high schools and the week was spent with teachers and Academic Camp students. Teachers studied and practiced new methods of instruction. Amy hoped that Project Inquire would give her new insight into reaching students and she would leave with a collection of projects and activities that would help her better engage students. Also, she hoped Inquire would connect her with other teachers that could support her for continued professional development. This sentiment seemed to read right from the stated goals of Inquire. But, interestingly, no mention of inquiry was in this answer to this part of the questionnaire about prior knowledge of Inquire. She had heard much about Inquire, but was not thinking of inquiry.

When asked about her philosophy of education, Amy said that learning was a continual process. Her ultimate mission was to help children reach their full potential and maximize their talents. She had seen her role as a teacher shift from a lecturer and imparter of knowledge to a facilitator of interaction and learning in her classes. Her goal was to allocate resources, introduce strategies and assist students in making problem solving and mathematical thinking their own. Amy saw herself successful when her students could identify problems, choose the appropriate tools and methods and solve the problems on their own.

A typical unit for Amy was one that assessed prior knowledge, and then it introduced new concepts via real world connections. Exploratory learning followed by teacher instruction and modeling was next. Collaborative learning, collaborative assessment and procedural quizzes followed. A take-home assessment preceded a formal independent assessment at the end of the unit. The formal assessment took the form of a test or a project. Question and answer techniques were used as informal assessment throughout a unit. Test items for formal assessment were multiple-choice, procedural and constructed responses to real world applications. Amy was well-versed in differentiating instruction and had knowledge of inquiry and other instructional methods.

Her previous professional development experiences were numerous and varied as might be expected from a 13-year veteran teacher. The professional certifications she listed were National Board certified, New Bloom's Taxonomy certified, Gifted and Talented certified and ADEPT evaluator certified, which is an evaluation method for new teachers in the state. She had also worked on teams to revise State Standards and had served on other state and local committees. She believed that effective professional development involves professional collaboration and was connected to the classroom and to real world problems. She stated that professional development programs must be progressive, engaging and purposeful. They should give the teacher something that they can immediately use in the classroom.

Amy's responses to the questionnaire suggested that she was an experienced, effective teacher at all levels. She had a great deal of prior knowledge of Project Inquire, but, moreover, she had had a great deal of experience and previous professional

development. Her description of her teaching and her philosophy showed growth in her profession and a commitment to improve.

The documents that Amy provided with her questionnaire before Inquire began gave more evidence of the various teaching methods that she used. She provided two unit plans and several assignments to illustrate her teaching. The first was a unit on solving equations and inequalities. The lessons in the unit began with a pizza problem where the students had to write and solve an inequality to find out how many toppings could be ordered for a pizza with a set amount of money. This was the real world opening problem that was relevant and accessible to all students. The lesson plan included the topic, objectives and standards, activities and tasks, assessments and descriptions. It was teacher-generated and it was evident much thought had been put into the lesson. The lesson required students to explain their steps and to solve the problems.

The unit also included a comparison chart between equations and inequalities with problems and a reflective writing part for metacognition. The students were asked how "thinking about your thinking" and checking for accuracy affected their performance. It included a flowchart mind map, a worksheet with both contextual and non-contextual problems, a cooperative learning project, and self-evaluating rubrics. There was no bookwork contained in the unit. All of the assignments were teacher-generated, included different methods, had metacognitive and reflective pieces and were mostly contextual in nature. Out of the seven assignments submitted for the unit only three included non-contextual problems. Furthermore, all three of those assignments also had other contextual problems within them.

Other assignments and lesson plans Amy submitted included a lesson plan on operations with real numbers. The plan listed the grade level, objectives of content, objectives of technology, a springboard activity, group activities, reflection and sharing. Amy included a web quest to explore pi and a project to create a town using net design. All of these submissions were contextual and interactive for the students. The assignments for the students reflected her philosophy and thoughts on what effective instruction was. Amy's teaching was clearly well-shaped by her years of experience and her past training. She was strong on context and exploratory learning, but she did not ignore skill-building activities. However, the skill-building activities were accompanied by contextual references and metacognitive exercises. She showed true mastery of her craft.

During Project Inquire

During the week of Project Inquire, the researcher took notes and video of the teachers' day-to-day activities. Notes were taken when there were students from the Academic Camp present and video was taken when there were Inquire teachers present. The video and notes were transcribed and compiled to give a holistic view of what happened during the weeklong professional development event. A brief description of each day is given followed by an analysis of the major themes discussed during that day. A summary of the themes is provided at the end of this section.

Five major themes arose from the data. They are inquiry, the building of community, monetary influences, use of technology in the classroom and the barriers and

concerns that the participants had about implementing inquiry in their classrooms. Four of the themes were directly related to the goals and planning of Project Inquire. The themes were evident from documents and from interviews of the Inquire administrators, and were confirmed by the data gathered during Inquire week. The fifth theme, concerns and barriers, emerged as the transcripts were analyzed. Almost all of the discourse for the week can be easily placed in one of these five categories. The transcripts were cut and separated into the themes and the length of the columns of each theme category for each day was measured for comparison. Organizing the data into themes that can be quantified helped in determining how much emphasis was given to each theme (Flick, 2002; Stake, 1995; Yin, 2003). Each column inch of transcription was from twelve-point, double spaced type on 8.5" by 11" paper. Each page was cut to separate the themes and fit under each theme's heading. For example, for Sunday evening, 16.5 inches (56.4%) of the transcript was on the inquiry theme, 5.5 inches (18.8%) was on building community, two inches (6.8%) was on monetary concerns, there were no barrier concerns, 1.25 inches (4.3%) was about technology use and four inches (13.7%) was about other concerns, such as where to meet for lunch. Over the five days, only 6.2% of the week's transcripts did not fit into one of the five major themes.

Sunday evening was a brief introductory session for the participants of Project Inquire. The opening vignette of this paper described the events as they unfolded. Philip and Dray almost immediately exposed the participants to an inquiry problem. There was discussion on the building of a community of teachers, the money provided and the graphing calculators that were distributed. Other topics included some housekeeping

details, such as where to meet the next morning so that the teachers could make it to campus.

The inquiry discussion that occurred Sunday evening was the introduction of the problem on where to put a distribution center, given specified store locations. Philip and Dray immediately began modeling the process of inquiry teaching. Philip and Dray believed that a class should immediately begin work on a problem. Then, after the teachers worked on the problem a bit, Philip stopped them and asked about their thinking. He had the teachers shift from the role of being the students to the role of being the teachers. He wanted them to consider what students experience when they are taught by inquiry. All of this discussion went into the inquiry theme.

Later, when the topic switched to the e-mail exchange that was expected to take place, Philip and Dray explained that half of the $1,000 stipend for attendance during the week would be contingent on responding to or generating discussion at least twice during the upcoming school year. This part of the transcript was divided between building community and monetary influences of Inquire for placement into themes. The discussion about the $1,600 provided for classroom supplies by Inquire went into the monetary theme.

The discussion about the types of graphing calculators used in school and the comparisons of them were technology concerns and were placed in that theme. The discussions on how to use the technology to foster inquiry were also placed in the use of technology theme.

The photo below is of the theme breakdown from Sunday evening's Inquire meeting. From left to right the topics are inquiry, building community, monetary issues, barriers and concerns, technology use and other.

Figure 4.1 Sunday's Theme Breakdown

Monday was a full day without interaction with the students of the Academic Camp. So, after introductions again, the teachers continued the exploration of the problem introduced the previous evening. As they worked through the problem, Dray asked if the students would think this way.

Johnny asked, "Does the road curve? Does the distribution center have to be on the road?"

Dray and Philip interjected that that was the kind of discussion that showed student thought and that was what was missing from most math classes. He asked, "Haven't all of us had math teachers that wouldn't allow questions like that?"

With this type of interaction, the teachers spent Monday morning continuing this problem. Philip and Dray did not make it explicit but they modeled how to use these questioning techniques and how to let rich discussion take place among the Inquire teachers. For example, when teachers volunteered sixteen as an answer, Philip and Dray immediately questioned the validity of the answer and asked if the teachers were sure of that answer.

Kristen, a former Inquire participant, entered the room. Kristen joined one of the groups working on the problem as they began to wrap up their responses.

"This is not a lesson plan. This is a problem that you can turn into a lesson plan." Philip pointed out. He also drove home the fact that the teachers should use the problems as a part of a lesson plan, and that these problems could be used to teach multiple standards.

After a break, Dray began the second problem. It explored exponential growth by examining the thickness of a piece of paper as it is repeatedly folded. As they worked through this second problem, group management came up as a topic of discussion. She suggested that faster students need things to solidify and expand the knowledge they have gained. Helping others, writing about their findings and extension questions were suggested. This exchange was an example of concerns and barriers to inquiry implementation that became a theme of Project Inquire.

The rest of Monday continued in this way. The inquiry theme overwhelmed the others. When measured, the theme columns were 61.5 inches (64.7%) of inquiry, nine inches (9.5%) on building community, no discussion on monetary issues, 9.75 inches (10.3%) of barrier and concern issues, 10.5 inches (11%) of discussion on technology use and 4.25 inches (4.5%) of various other discussion.

Figure 4.2 Monday's Theme Breakdown

Figure 4.2 illustrates the emphasis on inquiry that took place on Monday during Inquire. The participants worked through in-depth problems and discussed them and how

to teach them to their students. Barriers and concerns of issues of implementation of inquiry began to emerge as a major theme.

Tuesday was also a day without the Academic Camp students. The second full day of Project Inquire began with the teachers briefly meeting the rising seniors of the Academic Camp. After a brief introduction, the teachers continued working on the *Dog Pen* problem that was given at the end of the day on Monday. It was a problem that sought to maximize the rectangular area of a dog pen given a fixed amount of fencing and one existing side. Though this problem was typically approached through calculus, teachers were encouraged to use strategies available to middle school and early high school students.

Dray led the teachers through the *Dog Pen* problem and through the calculator steps. And, once again, she helped them enter data albeit at a much quicker pace this time. She asked which of the teachers set up the problem as a table. Philip and Dray decided to set up a table for width and area. They asked the teachers what values would make sense to use. They chose to make the width of the pen vary from one foot to a hundred feet. Philip quizzed the teachers to see how well they remembered the menus of the calculator. This problem was an example of the technology theme of Inquire because it was heavily dependent on calculator skills and how to foster inquiry through technology.

Teachers in the group were also still bringing up concerns that could be a barrier to implementing inquiry in their classrooms. Dray noted that several teachers had asked how to use inquiry in a system where there are highly structured courses with benchmark

testing or in a school where direct instruction is stressed. Philip argued that math departments needed to identify the big ideas to teach and that trying to teach 150 standards in a single course is ridiculous. "We talk about cover, but what we really do is cover up the objective." He added, "I think we have to focus on eight to fifteen big ideas in a course. And then, I think that math departments can then say that these four or five big ideas should be addressed. Here are ways to address them. I can't stand it when math departments say, 'It's March 21st. You will be on section 8.2 in the book. Here is the assignment that you will give....' They're trying to 'teacher-proof' the curriculum. That's what they're trying to do."

The interaction on Tuesday flowed much the same way as Monday. The teachers worked through problems, discussed how to teach the students and talked about what questioning techniques would be useful. Technology use and barriers on Tuesday became more prominent as themes. 25.5 (36.6%) inches of the transcripts were discussions on inquiry, seven inches (10%) were on the building of community, once again there was no discussion of the money, ten inches (14.3%) of transcript were devoted to barriers and concerns, 24 inches (34.4%) were on technology use and 3.25 inches (4.7%) were on other issues.

Figure 4.3 Tuesday's Theme Breakdown

On Tuesday, the inquiry theme was not as prevalent as it was on Monday.

Technology and barrier concerns became more of an issue. Building community had

about the same amount of transcript, and there was still no discussion on monetary issues.

Wednesday was the first day with the senior Academic Camp. The day began

with thirteen of the Academic Camp students present in addition to the Inquire teachers.

Philip introduced *The Cricket* problem. The teachers sat in front and listened carefully to

the problem as did the students. The problem, from NCTM, was about a cricket trying to

jump to a tree. Rain was making the cricket wet and slowed it. So, it jumped only half of

the remaining distance on each jump. So, on the first hop, the cricket jumped half way.

On the second hop, it jumped half of the remaining distance. As it continued to rain, the cricket was always able to jump half of the remaining distance. To illustrate the problem, but without giving away the quantities involved, Philip had a student and a teacher act as the cricket and the tree.

This introduction to the problem lasted about ten minutes before the students were directed to work on the questions themselves, exploring the problem in as many ways as they could. The teachers slowly began to work with some of the students on the problems. There was almost a one-to-one ratio of teachers to students. Dray said to the teachers that this high level of student engagement was typical in her room. Soon, some teachers began to observe and disengaged from helping the students. Some teachers returned to their seats and worked on the problem. This interaction continued with the second group of students.

After lunch, the teachers were given another problem about maximizing profit from selling T-shirts and sweatshirts. They worked on it for a short time before moving to a computer lab to work with spreadsheet statistical applications and interactive geometry software on an interactive board. The discussion was on the proper use of these technologies to foster inquiry thinking and learning.

Philip stressed that it was important to teach with explorations. Philip demonstrated that a triangle could be made from paper and the angles measured. This method could be used to demonstrate that the angles of a triangle add to 180 degrees. Philip pointed out that teachers who jumped to this conclusion after only two or three examples were modeling inappropriate inductive thinking. With the interactive Geometry

software, he made a triangle, measured each angle and added them with the Calculate

tool. Now, when he moved a vertex of the triangle, he had shown hundreds of examples.

The students could then come to a conclusion inductively with much more confidence.

The teachers seemed comfortable with the program.

The interactions on Wednesday flowed differently than Monday or Tuesday

because of the interactions with the students and the work in the computer lab. The

breakdown of the themes was 18.25 (38.4%) inches of transcript on inquiry, 4.25 inches

(9%) on building community, 2.25 inches (4.7%) on monetary issues, 9.25 inches

(19.5%) on barriers and concerns, 9.5 inches (20%) on the proper use of technology and 4

inches (8.4%) on other issues.

Figure 4.4 Wednesday's Theme Breakdown

Once again, barriers and concerns and technology were heavy themes. The percentage of inquiry was steady at close to 40%. But most notably, the spending of the classroom money and the stipend were being discussed for the first time since Sunday evening.

Thursday flowed much the same as Wednesday. Dray taught the first class of students. She led the students through the problems without much interaction. The teachers were mostly to themselves.

Between the two classes, both Philip and Dray expressed their dissatisfaction with how the class went. They articulated that they didn't like being the leaders of the class

most of the time. When that happened, the teachers were the ones learning, not the students. Dray and Philip wanted the teachers to take an active role in helping guide the students much sooner in the next class.

When the second class arrived a few minutes later, Philip gave a brief guide to what he wanted the students to do that day. The teachers immediately began helping the groups of students work through the problem and use the calculators. The class went smoothly, very differently from the first, with the teachers highly engaged with the students.

While helping a student with the units in the problem, Wendy said that "getting units in problems is something I need to improve in my teaching. It's something I'm bad at." She had just explained to a student why units were important. She used an SAT example where multiple choice answers may differ only in units but have the same numeric value. The context of the problem was seen as very important.

The teachers continued to work their problems after the students left. Then, the conversation switched to the goals of Inquire. Philip explained, "The biggest part of this project is to get you all to talk to each other, to use each other. The second biggest part is to push inquiry in the classroom."

Dray explained that the thing she had hoped for in the past was to have e-mails sent back and forth, but it hadn't happened often. She tried to facilitate that, but has had only about a dozen e-mails in four years. She asked for suggestions on what might work. She said, "I was just kind of hoping that teachers would share the stuff they did and what did and didn't work. Good and Bad."

The teachers continued the day attempting problems and talking about the effective use of inquiry. Inquiry made up about 32.5 inches (46.1%) of the day's transcripts, building community had 9.75 inches (13.8%), monetary issues had five inches (7.1%), barriers and concerns had 7.75 inches (11%), technology had 11 inches (15.6%) and other issues had 4.5 inches (6.4%) of transcripts.

Figure 4.5 Thursday's Theme Breakdown

While inquiry continued to dominate the day, the other themes were becoming more evenly represented. The discussion of the money provided to the teachers began to get more attention, but was still about the same as other non-theme issues combined. The

other three themes, technology use, barriers, and community, were all given about the same amount of attention.

Friday was the last day of Inquire. As had been explained prior to the week, it was a short day. The morning classes with the students continued much as the previous days did with the teachers helping the students through problems and trying their new inquiry skills and questioning techniques.

After the classes, the teachers began to wrap up their week. Philip urged, "There are lots of things we hope you take out of this week. The biggest thing is to use each other. It is so easy to get isolated in the classroom,"

Dray added that teachers should share this with their department, and then start with a problem "the way we did it with you." Then, she suggested having the teachers think about the engagement level. "It's the same way we think about a lot of professional development. You should be able to find context in almost all of what you teach."

Philip said. "Use music, art, physical science to get context. Once you're thinking this way, context just starts appearing."

The teachers discussed the money and a few other issues. They all seemed very enthusiastic about what had occurred. They shared several ideas about how to apply inquiry with each other.

Philip added, "I hope you had fun this week."

Dray thought that the energy level was great. She praised the teachers for their outlook and let them know that their love of teaching showed. Dray told them that some Inquire teachers in the past had not been as willing to accept the inquiry method as a

viable option for their teaching or their students, but this group had been very enthusiastic. "Don't tell the others," she said, "but, you're my favorite."

There were questions about money again. Dray and Philip said that there are a few avenues for the money to be disbursed. There was the expense report, the five-hundred dollars for the first half of the stipend and the orders for the classroom money. Once again, all would be handled through a separate office.

There was chatter among the teachers as Philip continued to download problems for some onto thumb drives from his computer and the logistics of getting everyone back to their cars was discussed. Randolph said his good-byes to get back to his family. A couple of teachers decided to have lunch at the cafe across the street and other teachers decided to make their way back home. As the teachers were leaving, many said they felt like they were leaving camp and seemed sad.

Friday had less interaction because it was shortened. Inquiry made 4.75 inches (22.1%) of the day's transcript, community made 9.25 inches (43%), monetary issues made 3.25 inches (15.1%), barriers and concerns made 3.75 inches (17.5%), no discussion was made about technology and other issues had 0.5 inches (2.3%) of transcripts.

Figure 4.6 Friday's Theme Breakdown

For the first time, other themes began to rival inquiry. A little more time was spent on monetary issues and how money would be disbursed to the teachers for their stipends and their classroom use. No technology discussions took place during this shortened day of wrap-up.

The themes and discussions that emerged from the transcripts of the week of Project Inquire tell how much time and emphasis was spent on the stated goals. It helped paint a picture of each day and how it was spent. The aggregate of themes gave an overall picture of the emphasis of each one.

Over the whole professional development experience, there was a total of 333.5 column inches of transcripts. Of that, inquiry dominated with 159 inches (47.7%), proper technology use was second with 56.25 inches (16.9%), building community was third with 44.75 inches (13.4%), barriers and concerns were fourth with 40.5 inches (12.1%), other non-theme issues were fifth with 20.5 inches (6.2%) and monetary issues were a distant sixth with 12.5 inches (3.7%) of the week's transcripts column length devoted to it.
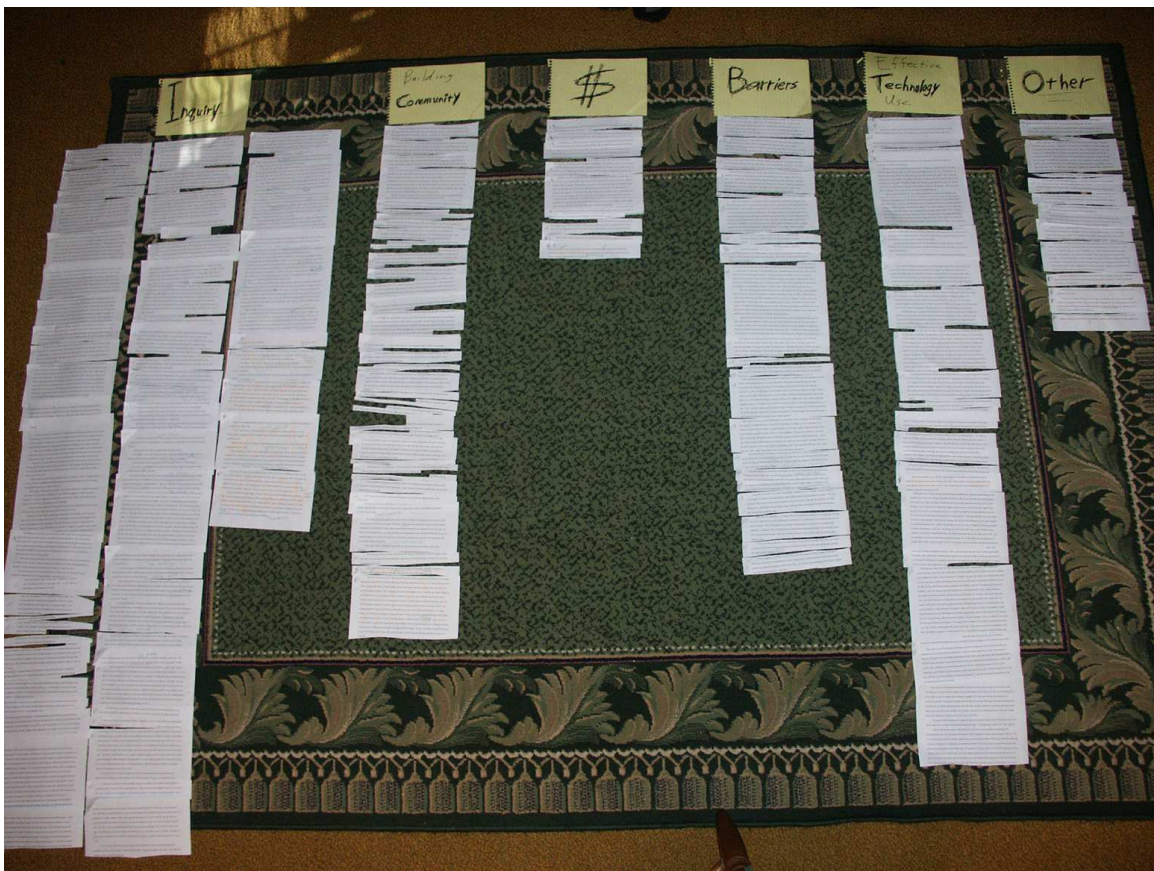
Figure 4.7 Week's Total Theme Breakdown

Clearly, inquiry discussion dominated the week. But, the proper use of technology took second over building community. The barriers and concerns to inquiry that the

teachers brought up in discussion took a close fourth and were a very prominent theme.

The amount of discussion about the money for the teachers' classroom and stipends were

the least discussed themes in the transcriptions of the video and notes taken by the

researcher.

Throughout the week of Project Inquire, themes rose and ebbed from day-to-day.

Inquiry started out the week strong and fell off just a bit by Friday. The building of

community started out strong and ended strong, but decreased a bit in the middle of the

week. Monetary issues started out as a small theme. Then, it disappeared totally.

Reappearing slowly by the end of the week, it had the lowest representation. Barriers and

concerns to implementing inquiry were steady throughout the week. The use of

technology in inquiry grew until it peaked on Wednesday. Non-theme issues remained

steady throughout the week. Table 4.1 displays the relative amount of discussion of each

theme during the week.

Table 4.1

Theme Summary Table

	Inquiry	Building Community	Monetary Issues	Barriers & Concerns	Technology Use	Other	Total
Sunday	16.5" (56.4%)	5.5" (18.8%)	2" (6.8%)	0" (0%)	1.25" (4.3%)	4" (13.7%)	29.25" (100%)
Monday	61.5" (64.7%)	9" (9.5%)	0" (0%)	9.75" (10.3%)	10.5" (11%)	4.25" (4.5%)	95" (100%)
Tuesday	25.5" (36.6%)	7" (10%)	0" (0%)	10" (14.3%)	24" (34.4%)	3.25" (4.7%)	69.75" (100%)
Wednesday	18.25" (38.4%)	4.25" (9%)	2.25" (4.7%)	9.25" (19.5%)	9.5" (20%)	4" (8.4%)	47.5" (100%)
Thursday	32.5" (46.1%)	9.75" (13.8%)	5" (7.1%)	7.75" (11%)	11" (15.6%)	4.5" (6.4%)	70.5" (100%)
Friday	4.75" (22.1%)	9.25" (43%)	3.25" (15.1%)	3.75" (17.5%)	0" (0%)	0.5" (2.3%)	21.5" (100%)
Total	159" (47.7%)	44.75" (13.4%)	12.5" (3.7%)	40.5" (12.1%)	56.25" (16.9%)	20.5" (6.2%)	333.5" (100%)

Each theme had its place in Project Inquire and, in some way, reflected or added to the stated goals. Inquiry and the building of community had been explicitly stated as goals throughout the week. Money for the teachers and their classrooms was a built-in incentive of Inquire that could have a large effect on teachers' motivation and ability to carry out inquiry learning. The use of graphing calculators and other technologies was briefly stated as a goal and made up a large amount of time during the week. Barriers and concerns to inquiry implementation needed to be addressed if the teachers were to employ inquiry in their classrooms.

Present Participant's Data

During the week, all of the participants were given problems to solve in an inquiry setting and were given opportunities to practice inquiry with high school students. But, what was their view on inquiry? What were their concerns? What had they taken from this week? To give insight into these questions, the researcher gathered comments from the teachers during supper on Wednesday evening. The participants completed a graphic organizer, called a Frayer model, on inquiry at the end of the week.

The researcher initiated comments at supper Wednesday night to gauge the teachers' general feelings about Project Inquire. They were to write down their thoughts, questions, concerns and any comments. No name was required. Some responses were complimentary, but generic, such as how nice it was to discuss teaching with enthusiastic colleagues, but some reflected thought about the processes and goals of Inquire. One teacher wrote that she still did not understand the purpose of homework in an inquiry lesson. Another mentioned that more time should be spent on how to ease the students into an inquiry setting. Many of these reflections mentioned that the participants were in agreement with the aims of Project Inquire and that the enthusiasm was refreshing. This reflection exercise revealed that most participants agreed with the Inquire goals, but had concerns about the implementation that needed to be addressed.

In the graphic organizer, the participants put the word "inquiry" in the middle of a piece of paper. They wrote what they thought was the definition of inquiry in the upper left quadrant of the paper, what they thought were attributes in the upper right, examples of inquiry in the lower left quadrant and non-examples in the lower right. On the back of

the paper, they answered three questions. What do you like about inquiry? What do you not like about inquiry? How do you think you will use it? Once again, no names were required and this time the administrators of Project Inquire were not present.

The results of this exercise showed that most of the participants were familiar with the main points of inquiry teaching and learning. When defining inquiry, the participants had common ideas, such as exploration, student centered and real-life situations. The attributes listed most were student engagement, connections and writing to explain a process. Examples given were real-life contextual problems. Non-examples that were listed were lecture, drill and memory-oriented education. This part of the exercise showed that the teachers knew what attributes inquiry models usually took.

When the teachers were asked what they did not like about inquiry, many concerns were still present. The loss of control and disciplinary problems were at the top of the participants' concerns as teachers were worried that students would just give up when stuck on a problem. The amount of time for planning and setting up lessons was another concern. All of them stated that they planned to use inquiry, but in different amounts. Some planned to use inquiry to introduce a topic and some planned to use it more often.

The data gathered during Project Inquire showed that the goals intended by the administrators were addressed in varying amounts during the week. The efforts of the trainers were shown to have had some impact on the participants through the interactions of the participants and the feedback gathered from them.

Past Participant's Data

Data were gathered from two previous participants of Project Inquire. There were an interview, observation and documents gathered from Kristen, who visited this year for a few hours during the week. And, there was an interview from a participant from the previous year, Terry. Terry visited briefly to see the students and have lunch with the teachers. The data gave a perspective on what the beliefs and teaching methods of past participants were.

Kristen was a participant two years before this class of Project Inquire. In her interview, she began by describing a project on polygons that she gave to her students. But, she soon backtracked and said that the students must first learn vocabulary and theorems before they could apply them. She said that she had the students use a flowchart to learn theorems and then she could ask an application question. As we continued to talk about her teaching, she mentioned that she had used problems from Inquire during the year. When asked about the goals of Inquire, she stated that it tried to make math real for the learners. One problem can teach many standards. In her philosophy of education, Kristen believed that if she could show a person how to work a problem, then that person could do it. This belief seemed contradictory to the inquiry method where the students learn by working the problem. The projects Kristen used in her classes were not necessarily inquiry-based. The projects discussed in the interview were of skill-type questions and definitions that were arranged in a PowerPoint. They had no contextual setting and no higher level thinking skills were needed. One project in her Geometry class was a construction where the students built an object and analyzed the size and

surface area of it. This project had elements of inquiry. According to Kristen, good professional development used a variety of methods and gave teachers many ways to reach their students. She ended the interview by saying how much she enjoyed Inquire and she learned much from it.

The class the researcher observed of Kristen's was a 50-minute honors Geometry class. There were 27 students, 10 African American, two Asian, 12 Caucasian and three Indian. The students were in grades 9 through 12. The class was organized in rows and a projector was used for instruction. The topic was rotations of geometric figures.

Kristen used lecture with discussion to work with the students as they filled out a sheet about what was occurring on the projected image. The students had 20% to 80% engagement for most of the class. The class seemed monotonous with no contextual references for the rotation of the figures. The cognitive activity was mostly meant to promote procedural knowledge. Key indicators of the lesson, such as generating conjectures and real-world context, were mostly rated low to medium by the researcher. While there were some elements of effective instruction, the content lacked relevance, and the lesson was quite limited in its likelihood to enhance understanding.

The documents provided by Kristen were a unit plan, a project, tests and exams. In the unit plan, the essential question was, "How do you use solids in real life?" The lesson questions that followed the unit question were not contextual in nature. For example, one asked, "What is the unit of area?" Solving practical problems was listed in the state standards and was addressed in the unit plan. Interestingly, performance was not listed as an assessment strategy in the unit plan even though there was a place to check it

off. The project was a PowerPoint that required mostly lower level thinking. It was basically a list of topics and definitions that had been covered in the unit. In the conclusion of the project, the teacher asked the students how they would apply the things they had learned, but she did not ask them to apply them. The test and exams that were provided were mostly multiple-choice with little application or contextual thinking. There was one out of forty problems on a test, and there were 15 out of 100 problems on a multiple choice exam that were contextual.

The data gathered from Kristen gave evidence of some limited use of contextual problems in her teaching. She included an essential question with a contextual reference in her unit plan. Although she had stated that real-world context was important, her teaching and assessment techniques did not contain much context or inquiry. Also, in her interview, she stated more than once that students could apply knowledge after they learned definitions and theorems.

Despite her extensive 16 years of experience, there seemed to be a disconnection between Kristen's beliefs and her pedagogy. Her experiences in Project Inquire and other professional development appeared in her beliefs as added diversity to her repertoire of teaching methods in her interview. However, the observations and artifacts of her teaching did not reflect use of these methods. Since there were no data collected before she attended Inquire, it was not known if she already had these beliefs. All that could be determined was that her pedagogy and beliefs were not in agreement.

The researcher also conducted an interview with Terry, a Project Inquire alumna who was visiting for a day. In the interview, she described a math lesson she would give

to students as one that had an opening activity, like a practice problem, and extended it to the lesson topic. According to Terry, the Inquire goals were to get new ideas about teaching, get new technology and give more meaning to the problems teachers assigned to students. She believed all students can learn, and her opinions about how to teach had changed. She believed the way to reach more students was to do more discovery for deeper meaning. In her assessments, she often used writing to explain a problem. In other training she had had, Terry referred to getting the students to understand the uses of math, make connections and communicate math. This was similar to the aims of inquiry that were the major focus of Inquire.

The brief interview with Terry gave insight into the way her beliefs had changed. She said that previously she had used direct instruction as her main tool for teaching, but now she varied her methods. Communicating and understanding context was important in her teaching. Interestingly, her background also included training that had had similar goals as Project Inquire. This overlap helped produce a synergistic effect that changed her beliefs. The actual change in her pedagogy was unclear, but the changes in her beliefs were evident.

Subjects of Analysis after Project Inquire

Wendy after Inquire

The data gathered for Wendy, the teacher who just finished her first year of teaching, consisted of an extensive interview, an observation, an inquiry problem that she gave to her students and several e-mail correspondences. The data were arranged in

chronological order to give a linear view of how the year progressed for her. During a conversation as the school year was still young, Wendy said that she was using inquiry almost exclusively with her geometry classes and a good bit with her other classes also. She was enthusiastic and her students were enjoying a different kind of math class.

In an e-mail sent just after Inquire week, Wendy asked for problems dealing with the order of operations. She was still thinking about an upcoming unit in the summer classes she was teaching. She was able to try her new techniques soon after her professional development.

In August, just after the school year had started, Wendy replied to an e-mail from Philip that she was going to attempt a problem that had just been made available on Philip's website. It was a problem about the area of a garden. She said she reworked some of the questions because they "didn't follow for me." Later in the afternoon of that same day, Wendy replied again and said that the problem worked well, but her lower level students had had a difficult time with the algebra. Her college prep class did well with it.

About a week later, Wendy e-mailed the group and asked Dray how to do an activity where geometry students described the making of a peanut butter and jelly sandwich. The activity was supposed to drive home the idea of proof by showing the students that they had to pay attention to detail. If the description was missing any steps, the sandwich would not be made correctly. The students actually used each other's descriptions to make a sandwich, if they could. These e-mail exchanges were the most sent by any of the participants to this point.

The observation of her class was of this peanut butter and jelly problem. It was a 50-minute class made up of college prep Geometry students. There were 25 students in the 10th and 11th grades, 19 African American and six Caucasian. The class was conducted in the cafeteria because of the need to make PBJ sandwiches, and there were school rules that no food was allowed in the classrooms. The students were seated at long tables with the sandwich ingredients on another.

The first ten minutes of the class was a lecture on the set-up of the problem and directions on what the students were to do. For the next twenty minutes, the students worked in small groups to create their instructions. The teacher circulated and gave small hints and instruction. The level of engagement began high, but decreased toward the end of the twenty minutes as the students finished their directions. As the students were finishing, they began to make a PBJ using the directions of other students. Some were successful, but, as expected, most ran into difficulties for various reasons. Most of the students were engaged and amused. The others who were waiting for their turn were not engaged. The cognitive activity was high as they worked through the problem as long as they were engaged. During the last ten minutes of the class, most students had finished the lesson and the engagement was low. Despite this decrease in participation the lesson was rated high on key indicators of instruction, such as connecting mathematics to real-world contexts and encouraging students to seek alternate modes of problem solving. Overall, the lesson was effective and quite likely to enhance understanding.

The lesson document provided by Wendy was a simple one-page sheet which instructed the students to each make directions for a PBJ. Then, they were to vote on the

best directions for the group. The group members that did not get voted best were to make the PBJ according to the winners' directions. A list of materials was given and other responses were open-ended.

During the days that Wendy was working on this with her classes, she e-mailed the Inquire group and said she would post what went well and what didn't and that she would post some pictures as well. At the end of her PBJ lessons, she was excited about how well the activity went. She was pleased that it was easy to incorporate into her lessons on writing geometric proofs. Wendy seemed to be successful at inquiry instruction and she was excited for her students.

About a month and a half after the e-mail on her PBJ problem, the researcher interviewed Wendy about her school year so far. Even though her inquiry problems went well, a typical lesson for her was still to give a review, then go through new material before practice problems were assigned. Frustrated that the students couldn't get beyond the simple investigation to find the underlying patterns and formulas from a problem, she began to revert to her previous routines. She said, "It's annoying. I try to work with other teachers, but they're more book-driven and they don't want my ideas. They are not open to it. I'm by myself. It's hard."

Her students wanted to be taught in the old routine that they were used to as well. One even told her to lecture "so we don't have to do anything." She gave them a college prep level test and they all failed. Wendy believed it's because they didn't have higher level skills. She felt stuck and stated, "I just feel disconnected; I don't think it's flowing."

Asked if she had tried manipulating the problems to fit her students better, she said that she tried, but it always seemed to be over their heads. She felt inadequate and that the students' failure to connect ideas was her fault. She hadn't done an Inquire problem "in a while." But, she did many in the beginning of the year. She felt that as long as she could provide a safe environment for her students, they would learn.

In a professional development workshop after Inquire, Wendy found that the U.S. had a poor ranking in math education in the world. Japan, which has a high ranking, had significantly fewer standards and topics to cover. Japan covers half as many topics as the U.S. and has much smaller math textbooks. She said that they cover topics in more depth. The relationship to similar ideas from Inquire seemed to miss her. She believed good professional development related to the needs of the teachers.

Wendy still had not spent her money for the classroom. She had about $1300 left out of the original $1,600. She just didn't know what to spend it on. She didn't think of spending it on balls, measuring tapes and other manipulatives for her classes. "I didn't know what to do with it, because I didn't have a plan." The monetary difficulties that were expressed by the administrators of Inquire continued even though teachers of Project Inquire were given suggestions of what to buy and where to find products.

Wendy said that communication on her part was good. But, she was frustrated at the lack of communication from the other Inquire participants. "I try to e-mail everybody, but I haven't had any responses other than Sarah." She noted that the administration would e-mail her after she had tried something, but on a scale from one to ten, communication was at a three. "Honestly, we're just not communicating."

Wendy was having issues in continuing with inquiry. She felt that the students were unmotivated and quit too easily. She felt that she needed more training to handle these situations. "Dray said that she doesn't have these problems in her school…Well, I have problems." The other four teachers in her math department who had been through Inquire had not been able to ease her transition to inquiry.

Overall, Wendy believed that inquiry was an effective method. She had seen students work in her class with inquiry who usually didn't. Her frustrations came from her own misgivings about her ability to keep students engaged. She was very excited about the experience of Inquire when she left, but she realized she had some learning to do. She still believed in the goals of Project Inquire.

Sarah after Inquire

After Project Inquire, the researcher conducted an observation and an interview to see how Sarah's year was going. Once again, there seemed to be a disconnection between what she said and what she was doing in her classes. The observation was conducted just days before the interview and both were toward the end of the first semester.

The observation was of a college prep Algebra 1 class that had only 12 students, 9 African American and 3 Caucasian. It was 50 minutes in length, and the desks were arranged in rows with the teacher at an overhead projector in the front of the class.

The class started with a five-minute warm-up where the students found the slope of a line from two points. After this, the teacher demonstrated how to find slope from two points and the students copied a definition from the text. The teacher lectured with some discussion for the next 15 minutes. The classwork assignment was 20 problems from the

text. The problems had no context. The teacher circulated and helped some students with the problems. The students continued to work the problems until the class ended.

The cognitive level of the lesson was generally low with mostly lecture and skill building taking place. The engagement remained high and was most likely due to the small class size. The ratings of key indicators, such as encouraging alternate modes of problem solving and connections to real-world contexts were almost all rated low by the researcher. The only indicator rated high was the teacher's understanding of math concepts. Overall, this lesson had elements of effective instruction, but it was quite limited in its likelihood to enhance students' understanding. The tone of the lesson was monotonous and lacked relevance.

In the interview, Sarah expressed that she would like to give more hands-on activities to her students and attend more professional development that would teach her how to make math more fun. She learned much from Project Inquire and enjoyed the problems. She liked the idea that one problem could hit many standards and concepts. The problems prepared the teachers to be ready for the classroom.

She had not had any professional development experiences since Inquire, but the one aspect of good professional development that came to mind for her was that it should occur during school hours. She had had many boring moments in workshops and did not believe it should infringe on personal time. She thought planners of professional development should relate the topics to the classrooms and to the teachers' needs.

Sarah had tried one problem from Project Inquire so far, and it went well for her. She was afraid that the students would give up, but they were really curious. She said that

they were not getting the "more challenging work." The inquiry problem apparently was not perceived as being as challenging as other assignments.

With her classroom money, Sarah bought a laptop and a camera. She said that she could use the laptop for projects and with a projector; but, she did not elaborate on the camera use in her classes. Sarah had not done any other inquiry problems from Inquire or elsewhere. Sarah stated that she was "just using a lot of bookwork and stuff."

When asked about her philosophy of education, Sarah said that American students didn't value education like they did in her country. She did not speak of her philosophy, only about the state of education in America.

Sarah had sent one e-mail about the problem she did from Inquire. She had read an e-mail from another teacher who had used the same problem and it helped her know some issues to expect when she tried it. The communication, although reported to be scarce, did help with this teacher's problem.

At the time of this interview, Sarah was planning on doing another inquiry problem in the next few days. The researcher was planning to observe this lesson and gather documents, but the lesson was postponed and never rescheduled.

Despite the lack of use of Inquire problems, Sarah did make some use of the classroom money. The use of the technology purchases was not observed, but the teacher seemed pleased.

Sarah claimed that she enjoyed Inquire and had fun sharing with the teachers. She wanted to do more hands-on work with her students, yet she resisted employing more inquiry in her class. The one problem she did went well according to her. The observation

told a different story. Even when Sarah had the luxury of a small class, she still used lecture with no context to teach a topic that could have been rich with application. The energy it would have taken to employ inquiry with 12 students would not have been excessive.

Amy after Inquire

The data gathered on Amy after Inquire consisted of e-mail correspondences with the group and a questionnaire that followed the same protocol as before the summer of Inquire. The veteran teacher was already familiar with many instructional methods, including inquiry.

These beliefs may be the reason why her philosophy of education valued the process of logical reasoning, not just finding an answer. If she could help her students feel like their persistence and problem-solving skills would yield results, then she had accomplished her goal of helping students become life-long learners. She felt that inquiry was a way to reach this goal and was vital to math education. She said, "A nation of good problem solvers, I believe, is the foundation of a strong society."

Amy self-reported using about 20% of her class time in group activities, projects and inquiry-based investigations. She had engaged her students in about seven inquiry problems during the first semester; but, none of them had been from Project Inquire, though she planned on using several of these as well. According to Amy, all of the inquiry problems had gone well. None had been too difficult. She used them, mostly, to pique the interest of the students at the beginning of a topic. She said her students were overly cautious not to volunteer a wrong answer, and the reluctance to engage in problem

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solving and independent thinking was an overall weakness. Implementing inquiry-based activities had been a slow process with this group of students.

The questioning techniques she refined at Project Inquire had helped her get more out of her students. When she did not give them the answer too quickly, it helped foster some risk taking; but, for reasons mentioned earlier, waiting had been a struggle.

Amy had contacted the Inquire group only once, so far, by e-mail about a particularly interesting problem. The rest of the time she read the e-mails with interest, but did not respond. She had an illness in her family and regretted not being able to commit fully to the conversations.

The money she received from Inquire was helping her buy an interactive whiteboard for her classroom. She was waiting for her district to order and install it. "I had already wanted one, but my experience this summer… made me even more eager to have one in my classroom."

Amy was a teacher who came to Inquire with experience and confidence in many types of teaching methods. Her experience in Inquire was very good, and the resources and support she received had a positive effect on her instruction. "By far, my experience at Project Inquire was the best professional development I have had in years."

In an e-mail communication from Amy sent to the Inquire group the following week, she reflected on an activity where her Algebra 1 students compared their height and shoe size. Her rich description told of her success:

> I did this activity with my Algebra 1 classes this week and
>
> they gained so much from it. It was exciting to hear their

comments and the observations they made. As we collected the data from each class, I made a transparency of each scatterplot. I then showed it on the overhead for the class to determine their regression line. I did each class (4 in all) in a different color. Once the class had decided on the line of regression, I placed the scatterplots of earlier classes over their data. As the day progressed the data's linear relationship became even more apparent. I showed the earlier periods all the data the next day.

I had the students answer the questions independently before the class discussed them. Even some of my weaker students had accurate responses. My last period is the most competitive and asked me to use the other classes' regression line with their data. When my fifth period's line seemed to match their data more closely than theirs, they didn't seem to like that too much.

Other observations students made were that some students from different classes were the same height and had the same shoe size. They also noticed that about three points seemed to be outliers. A couple made comments that someone must have not known what size shoe they wore or they measured their height incorrectly.

Needless to say, my students enjoyed this thoroughly and

they connected so many mathematical ideas.

I plan to do Raising Money one day next week. As I move

into quadratics, I plan to use several other inquiry-based

activities throughout the quarter to keep the concepts of

linear functions fresh in their mind. This will relieve the

boredom often accompanying more traditional review

activities. (p. 1)

Amy's commitment to inquiry and her masterful teaching techniques were evident in the way she ran her classroom and reflected on her teaching. She had used the experience of Project Inquire and found more tools with which to work. Her beliefs and pedagogy were parallel.

Administrators after Project Inquire

After the week of Project Inquire, Philip and Dray attempted to keep interest up and the teachers thinking about inquiry as the year progressed. One of the difficulties the administrators had had was keeping the conversations going throughout the year. They each attempted to keep momentum in discussion going through e-mail and a talk at a state math conference.

Philip sent e-mails to the present and past participants of Project Inquire about the appearance at the state math conference. It was titled Project Inquire: Building A

Network of Teachers. The talk at the conference was attended by a few of the Inquire participants.

In mid-August, Philip sent e-mails with the link to his website for many inquiry problems just as he said he would at the end of Inquire week. And, in late September, he sent another e-mail with the contact list for the teachers and asked to get some discussions going about the inquiry they were attempting in their classrooms.

Dray sent an e-mail in October discussing which problems she had done with her students and said, "I would love to hear about the real-world constructive mathematics that you are doing." She sent a few of these each year in hopes of generating some discussions.

In response to a request from the researcher to answer a few quick questions about how the year was going, Dray said that the discussions had been just a little better than in years past, but thought it was only because half of the stipend was tied to communication this year. She had seen just a few responses about the inquiry attempted. And, only one question about method and classroom management had been posed. Dray thought that they were not building community very well. There was no discussion about how to spend their classroom money. Dray stated, "I still firmly believe that this does help the teacher see the possibility of inquiry." She thought that face-to-face contact is essential in really making change.

Influence on Subjects of Analysis

Inquire's Influence on Wendy

Before Project Inquire, Wendy ran a traditional skills-based classroom. She would review homework, give new material, give new work, and then assess at a later date. She would give "a lot" of problems and avoid word problems. Her classes were uninspiring with little contextual reference of problems. Most students in her classes were not engaged in the material. Many students were hindered by low reading skills that made word problems almost impossible to comprehend. During observations of two of her classes, the researcher rated her likelihood to enhance student understanding low. The researcher observed both small and large classes and the results were similar. Assessment and lesson documents verified these findings.

Wendy had no preconceptions or knowledge of the content of Project Inquire. Interestingly, during the interview with Wendy before Inquire, she expressed the need and desire to change in ways that could have been taken from the goals of Project Inquire. She expressed a desire to lecture less and have the students engaged in more hands-on activities. She wanted a way to gradually get away from the lecture format.

Her philosophy also reflected her desire to engage her students in more interesting, meaningful problems. She wanted to give them tools they could use in the real world. She didn't like to lecture, but she did not know how to change. Her previous professional development experience had been quite limited. This was her first year out of college and her first year as a teacher. She had not had the opportunity to find her teaching style, though she explicitly expressed a need for more pedagogical knowledge.

The data gathered from Wendy after Project Inquire tells a very different story. Wendy was excited about the new techniques she had learned at Inquire and was ready to employ them. She communicated by e-mail before and after the school year started several times. She began her year with inquiry problems from Inquire and all of her classes. Her Geometry classes used inquiry almost exclusively at the beginning of the year.

In an observation of Wendy's Geometry class, the students were engaged and interested for most of the day. Wendy was the facilitator just as she had expressed a desire to be. She was moving away from lecture. It seemed to be a smooth transition. She set up the problem and the students worked hands-on. The document that accompanied the lesson was simple and allowed for independent, open-ended thinking and student problem solving. The class was rated high in key indicators and was likely to enhance student understanding. Wendy seemed to have the tools and skills that she desired.

However, later in an interview, she expressed more frustration. She had reverted back to her previous teaching methods. She was frustrated that students couldn't get past simple connections and would not progress into more advanced problem solving. She was not getting interactions from other teachers and she felt alone and isolated. Even her students wanted the old routines so they wouldn't be expected to perform. She had tried to adjust the problems to their level, but to no avail.

The money provided to Wendy was still largely unspent. She was unsure of her needs and didn't think there were any tools she was missing. With no plan to spend the money, she was stagnant.

Wendy said she still believed in the goals of Inquire. She planned to try more inquiry problems with her students. She had had some problems in support from the professional community, inquiry methodology and spending the money. There were barriers and concerns that still needed to be addressed.

Inquire's Influence on Sarah

Before Project Inquire, Sarah's teaching was monotonous and uninspiring. During the observation, she had trouble with students' behavior and her classes were skill and practice events. Even though there were some mathematical discussions, the students were largely unengaged and uninterested. The ratings for her classes were low and not likely to enhance students' understanding. The general lack of interesting structure of the class seemed to add to its difficulties.

However, during the interview that followed, Sarah said that her students thought that math was boring and teachers should do hands-on activities with them. But, she went on to say that memory aides and calculator use were hands-on examples. She thought that hands-on meant anything other than lecture. Real-world problems for Sarah had little to do with algebraic problems, solving equations and graphing. She did not assign projects.

At this point, she only knew that Project Inquire was a workshop that had teachers interacting with students. She liked the fact that it would not be an event that employed only lecture. She hoped that teaching students effectively was the goal of Inquire. She was happy about the monetary aspect of Inquire as well.

Sarah's belief that education was the path to the future was grand, but her teaching techniques were traditional. In documents from her teaching, there was very little contextual relevancy and her methods were lecture and note-taking.

After Inquire, Sarah seemed to have changed little. She had attempted one inquiry problem and responded to the e-mail communications only a minimum of times. She continued to use the same techniques. Even though the experience of Inquire went well, her routines did not change.

When she was observed, she had the luxury of a small class of 12 students and still gave non-contextual problems with her lecture. Once again the class was uninspiring, with the desks arranged in rows and the teacher up front working on the overhead. The cognitive level was low, and the lesson was unlikely to enhance understanding.

But, as before, in the interview, Sarah continued to say that she would like to give more hands-on problems. She said that she learned much from Project Inquire and enjoyed the problems. The one problem that she had tried went well for her. She said that the students were more engaged.

Sarah's purchases for her classrooms were a laptop and a camera. Her claim was that the laptop was convenient for her and would help with projects. Interestingly, she did not mention the assignment of any projects. She did not speak of the camera use either.

Even though there appeared to be parallel beliefs between Sarah and the goals of Project Inquire, there was still a disconnection between her beliefs and her practice. She had difficulties in building community, in using the monetary incentives and in

employing inquiry. Project Inquire had made a small difference with Sarah, but there were still issues with the barriers and concerns.

Inquire's Influence on Amy

Before Project Inquire, Amy was an accomplished teacher with many years of experience. She had earned many certifications and accolades. The questionnaires and documents she provided gave insight into her varied teaching methods.

She believed that teachers should start with students' pre-existing knowledge and work forward from there. She listed many teaching methods that she employed, such as collaborative learning, modeling and projects.

She was familiar with Inquire before she arrived because of conversations with colleagues. She knew it involved teacher collaboration and working with students to improve teaching techniques. She hoped it would give her insight into new ways to reach students and connect her with other teachers.

Amy believed that learning was a continual process that helped children reach their full potential and become problem solvers. She started a unit by assessing prior knowledge through a pretest or observation and introduced new concepts through real world connections. Collaborative learning, good questioning techniques and assessments with real-world connections were cited as common in her teaching. It seemed that Amy could take the place of the Inquire administrators if needed and the documents from her teaching attested to this.

After Inquire, Amy sent only a couple of e-mails to the other participants. She had had an illness in her family and time for responses was an issue. But, she indicated that she read the correspondences of others with interest.

She had led several inquiry problems with her classes over the semester, but none was from Inquire. She had these already in her arsenal. This was evidence of her experience as an inquiry based teacher before she attended Inquire. She believed that inquiry was vital to students becoming good problem solvers.

She mentioned the questioning techniques that she learned at Inquire. She had used them in her classroom and had been pleased with the results. The students had to think a little longer and deeper. She believed this fostered her goals.

The money provided by Project Inquire was being used to help Amy buy an interactive whiteboard like the one seen at Inquire. She was excited about the new technology and said she can't wait to use it with her students.

She had great praise for Inquire. It corresponded with her teaching beliefs and style. It enhanced her knowledge of inquiry and problem solving. She claimed that it was the best professional development that she had had in years.

Amy's beliefs and pedagogy were already in line with the goals of Project Inquire before she attended. Her experience was one of enhancement and expansion of her skills in inquiry. The money provided by Inquire was well spent on technology that would be front and center for her students. The only theme that was problematic was building community, and that was because of issues out of Amy's hands. The barriers and concerns for Amy were largely non-existent at the beginning of Project Inquire.

Rival Conjectures on How Teachers are Influenced by the Factors of Professional

Development

As evident from the analysis, all three subjects of analysis were affected by Project Inquire in different ways. How do these changes happen? What are the underlying factors that explain how three teachers can go through the same professional development experience and have three different influences in their beliefs and their pedagogy?

The differentially influential factors that emerged from the data and literature are on a personal and on a program level. The personal factors that differentially influenced the subjects were their experience, beliefs, perceived needs and skills, both pedagogical and content. The program factors that differentially influenced the subjects were the amount of discussion spent on themes, the ability to attempt inquiry during Inquire week and the building of community. These factors lead to rival conjectures where each partially explains the influence of Project Inquire on the subjects.

The data show that Wendy was transformed and used inquiry in a greater amount than Sarah. Amy, who already used inquiry in her teaching, was less transformed by the inquiry discussion, but had an affirming experience throughout the week. The amount of discussion on inquiry could most likely have been less with Amy and could have still achieved similar results. The amount of inquiry discussion influenced Sarah some, as is evident from the fact that she attempted inquiry once and found it helpful. The data suggest that perhaps the amount of discussion spent on the themes during Inquire is a factor of influence for the participants.

The first conjecture considers the time, energy and effort that are spent on each of the major themes during the week of professional development. It asserts that the more time spent on a theme the greater the learning and comfort level of the teachers will be. For example, if a great deal of time is spent on inquiry methods, then transformations will occur in inquiry. If a theme has less time and discussion associated with it, then there will be less transformation in the teachers. This conjecture asserts that a theme needs a critical mass of discussion during a professional development experience in order to transform teachers of mathematics and this transformation can occur at different levels.

Conjecture 1: How teachers of mathematics are influenced by professional development depends on the amount of discussion spent on themes during the professional development experience.

The subjects of analysis were chosen through purposeful sampling to observe how teachers with a wide range of experience would progress through a professional development experience. Indeed, there was evidence that the more experienced teacher, Amy, had a different influence than the other subjects who had less experience. Wendy, with little experience, was a "clean slate" who was open to new methods before the week of Inquire. Sarah was a teacher with several years of teaching who had experienced professional development of different types and had views about what she wanted and needed in professional development.

The literature also suggests that experience may be a factor of influence in professional development. Bell and Gilbert (1996) found that if previous experiences were inconsistent with the intent of the experience, then the influence of the experience might not be realized. These beliefs and experiences can determine to what degree a teacher will transform after training. The accumulation of experiences can affect the beliefs and practices of teachers. Consequently experience is a key factor.

The second conjecture considers the experience level of the teacher participants in professional development. It asserts that a more experienced teacher has a greater range of pedagogical skills that she has built and practiced over a long career and that a less experienced teacher does not yet know of many types of teaching skills. So, if a teacher is less experienced, the more potential she has of adopting new practices. There is less interference from previous professional development and other habits of instruction.

Conjecture 2: How teachers of mathematics are influenced by professional development depends on the previous experience of the teacher.

Bell and Gilbert (1996) also found that if beliefs were inconsistent with a professional development experience then the intended influence may be affected. Chval et al (2008) found that if a teacher's needs and concerns are not addressed, or mismatched in a program, the change that was intended by training may be small, or non-existent. Some teachers may come away from a course or seminar with useful information depending on the needs and previous experiences of the individual (Hammel, 2007).

The data of this study showed that the belief structures of the three subjects of analysis were different. Amy already had beliefs consistent with the themes of Inquire. Wendy wanted to have professional development to help her pedagogy, but was unaware of what methods were available. Sarah had a belief that her teaching methods were sufficient for her students and that it was her students that were lacking in their educational commitment.

The third conjecture considers what teachers think they need in order to improve their teaching. It asserts that a teacher knows what she needs and wants out of a professional development experience. A teacher will "buy-in" to ideas and new skills that are congruent to her pre-existing beliefs. The closer a professional development experience is to what teacher's think they need, the more likely it is that the learning will be used in the classroom.

Conjecture 3: How teachers of mathematics are influenced by professional development depends on the perceived professional needs and beliefs of the teacher.

Another main challenge to inquiry is the demand on teacher content knowledge (Jarrett, 1997). When investigating a topic using inquiry, it is often the case that the line of discussion and discovery diverges from an expected path. Loucks-Horsley et al found that the content of the mathematics is mastered through the teachers' experience and the methods of inquiry need to be experienced by a teacher in order to become a competent inquirer (Loucks-Horsley, Hewson, Love, and Stiles, 1998). As teachers work through

problems together they realize how students might perceive or misperceive some details in the problems.

The fourth conjecture considers the content knowledge and teaching skills of the teacher as a factor. It asserts that the more comfortable a teacher is with the content of the courses they teach and teaching skills, the more comfortable she will be trying new pedagogical skills. If she does not have to think as hard on the math or classroom atmosphere, then she can concentrate more on the new classroom procedures and instructional methods being employed.

Conjecture 4: How teachers of mathematics are influenced by professional development depends on the comfort level of the teacher with content knowledge and pedagogical skills.

In the following chapter, these conjectures are discussed and given different amounts of credence. Each conjecture is compared across the data from the subjects of analysis, the current literature and input from Inquire administrators. Triangulation of findings from all of these sources is used to sift through the conjectures to give insight into how much validity each conjecture has.

CHAPTER FIVE

CONCLUSIONS AND CLOSING VIGNETTE

This chapter begins with a discussion of the rival conjectures that emerged from the data and are supported by the literature. The researcher analyzes how pedagogy and beliefs are influenced by these conjectures, and draws conclusions from the data about how much significance each of the conjectures has in answering the research questions. These conclusions can affect the design of professional development and future research. After a discussion on case study validity, a brief closing vignette is included that leads into the next year of Project Inquire and reveals the beginnings of many of the same themes found in this study.

Sifting Through the Rival Conjectures

Several design aspects are prevalent in effective professional development. Loucks-Horsley et al. (Loucks-Horsley, Hewson, Love & Stiles, 1998) identified several elements that are essential for effective professional development. These include experiences that foster collegiality and collaboration; promote experimentation and risk taking; provide time to participate, reflect and practice; supply rewards and incentives; have designs that incorporate knowledge bases; and integrate goals of districts and schools. All of these aspects are found in the design of Project Inquire throughout the week and may have implications for the rival conjectures presented.

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Each of the subjects reacted differently to the same experience. They have individual differences that illustrate how one size does not fit all in professional development. When designers of professional development begin to put together an experience for teachers, they should take into account the different aspects of their target audience as much as possible and should expect different results from individuals.

Conjecture 1: How teachers of mathematics are influenced by professional development depends on the amount of discussion spent on themes during the professional development experience.

Professional development experiences are limited by time. In this limited amount of time, planners of professional development must make choices about what to have a discussion about and how much to discuss it. The designers may also choose to include different activities to immerse the learner in the themes of the experience. The discussions and activities are the experience. It is logical that the themes of the experience that the designers wish to have influence on the learners are given discussion time and activity time. If the designers spend more of the discussion and activities on one theme and less on others, there would be more influence on the one theme than the others. If a theme is not discussed at all, then there would be no influence on the learners. For example, if a professional development experience does not mention using a certain type of discipline strategy, then the use of that strategy would not be influenced by the

experience. The amount of discussion of the themes is a part of the influence on the teacher learners.

It is not assumed that each teacher will be influenced in the same way or in similar amounts by the amount of discussion. Each teacher during Project Inquire experienced roughly the same amount of discussion on each of the themes. This first conjecture asserts only that the amount of the discussion of the themes of the week of Inquire directly influenced each teacher.

In Inquire, as the teachers worked through the problems, they experienced firsthand the questions that they would give their students. They worked together in groups that were changed from time to time by the administrators of Project Inquire. This added to the collegiality and collaboration between the teachers. With the building of collegiality, risk taking was an acceptable part of the week. The problems themselves, being inquiry based, promoted experimentation and risk taking. Time was also given to the teachers to try inquiry and to practice teaching with the inquiry method with the Academic Camp students. They reflected about their experience after the students had left each day (Jarrett, 1997).

Immersion into the strategies or topics that are meant to transform a teacher has been shown to be an effective strategy (Loucks-Horsley, Hewson, Love, and Stiles, 1998; Office of Educational Research and Improvement, 1998). Project Inquire employed this strategy vigorously. The teachers discussed problems and strategies in questioning techniques. They discussed how to answer questions and when to give a hint to an answer to elicit more thinking from a student. Then, the teachers were able to see these strategies

in use with the Academic Camp and attempted them to see how effective the strategies could be. Wednesday, Thursday and Friday mornings of the week were spent with the students so that the teachers could immerse themselves into real teaching scenarios with real students. Practice and reflection have long been touted as an effective strategy for teacher learning (Alderton, 2008; Dewey, 1933; Schon, 1983).

The amount of discussion spent on the themes can be related to the second of the three frameworks used by Fraser et al. (2007). This framework identified the type of professional development as transmissive, transitional or transformative (Bell & Gilbert, 1997). The aim of Project Inquire was to be transformative in nature. The goals of transforming teachers and their classrooms were stated in the documents provided by the administrators, the correspondences from the administrators and their interviews. The administrators attempted to reach these goals by community collaboration, time to practice by immersion, program administrator support and a clear vision.

Inquiry was the most discussed theme of the week. It comprised almost half of the discussions (159 inches of the 333.5 inches of total transcripts). Interviews, observations and documents showed that Wendy implemented inquiry into her classroom with enthusiasm and vigor at the beginning of the school year, though she backed off from inquiry as the year progressed. She was, at least initially, influenced by the time spent on inquiry in a greater amount than the other two subjects of analysis. Even after Wendy scaled back her use of inquiry, she referenced inquiry for future use in her interview at the end of the first semester after Inquire. Sarah used an inquiry problem only once, and Amy used her own inquiry problems, but made use of the new questioning techniques she

learned. All of the subjects of analysis and the other participants showed a clear understanding of inquiry through the documents and observations during the week.

Though each teacher was influenced by the emphasis on inquiry, the time spent on inquiry problems in the subjects' classes varied widely. Each teacher started the professional development experience with a unique background and was influenced in a different way. Amy had a confirmatory experience, as opposed to a transformational one, as she had already embraced an inquiry-based approach. Wendy had her teaching transformed by the experience by adding inquiry to her methods. She had concerns about inquiry; however, she began to use the method. Sarah had attempted inquiry, albeit only once. There was still a large gap between the use of inquiry by Sarah, Wendy and Amy, but the method had been added to their teaching and supported in their beliefs. The experience of Inquire had influenced all of the subjects of analysis in some meaningful way.

The proper use of technology in an inquiry classroom was the second most discussed theme of the week (56.25 of the 333.5 inches of transcript). The discussion on technology had differing amounts of influence on the subjects. The proper use of technology was not a major topic of discussion after Inquire week in the online correspondence or in the interviews and observations. Technology was purchased with the money that was made available to the teachers. Wendy bought a graphing calculator utility for use on computers and interactive whiteboards. Sarah purchased a laptop computer and digital camera. Amy merged her money with her district money to buy an interactive whiteboard. The availability of technology in the classroom was affected in

varying degrees by the Inquire experience. However, the way the technology was used was not immediately evident.

The monetary rewards were manifest in the stipends and classroom money made available to the teachers. Interestingly, none of the subjects purchased more hands-on materials, such as stop watches and tape measures, which were a staple of instruction during the week of Inquire. Also, out of the three subjects of analysis, two had spent all or almost all of their money, making large, technology purchases. The third, Wendy, still had spent only a small portion of her money. She claimed that she didn't really know what to buy. The large technology purchases by two of the three subjects of analysis indicated that either they already had hands-on materials necessary for inquiry-based teaching or they were not clear on what they needed for implementing inquiry in their classroom. From the data gathered from the three subjects of analysis, it was clear that Wendy was not sure what other hands-on equipment was needed for inquiry lessons, Sarah was not implementing hands-on or inquiry lessons and Amy already had a great deal of experience in inquiry. Technology was a means to spend the money quickly. No hands-on activities were observed in the post-Inquire visits to Sarah. Only 3.7% of the discussion during Inquire, 12.5 out of 333.5 inches of transcript, concentrated on the money theme. The money was spent, but the results were varied. It is evident that the critical amount of discussion for influence varies from participant to participant. These data are in agreement with the first rival conjecture because the influence of the themes was observed in the three subjects of analysis.

The building of community theme made up 13.4% of the discussions during the week. This part of Inquire was described as largely ineffective by both participants and administrators. Wendy said that she still felt alone in her quest to implement inquiry in her classroom and that the lack of support was one of the reasons she had reduced the amount of inquiry in her classes. She received feedback from administrators when she asked for it, but other participants shared their experiences only occasionally. Sarah and Amy made only token contributions to the online discourse that occurred. This theme could have benefited from more discussion during the week of what was expected. Also, the discussion during the week was mostly about the discourse that was expected to occur online, not about what other communities to build within their schools or districts.

It was also possible that the teachers did not have the critical support from colleagues in the same building. If teachers had more of their close colleagues trained in the same methods, then the possibility of help from a community of teachers would be enhanced. Some schools had more teachers trained than others. For example, in Wendy and Sarah's school, there were two other teachers that had training from Inquire, but the results were still mixed. In another school, there were many teachers, like Terry, who had great support for Inquire from their department head. The influences had been observed in Terry's and Amy's interviews, questionnaires and observations. The influence of the close proximity of other Inquire teachers may have been beneficial in some cases, but it was still a factor that has great endemic variability.

At one school included in the project, the math department head was an Inquire alumnus. In his leadership position, he was able to influence other teachers. Amy was

from this school, which may be a reason for her expertise in inquiry and knowledge of the program. Almost all of the math teachers in that school were past participants in Inquire. In another school, half of the math teachers were past participants. However, the community was not strong enough to alleviate the barriers and concerns that teachers had about using inquiry in their classrooms. The roles of proximity of leadership in community building and in communication between teachers in the same school were factors of the way that community takes shape. It was not evident that the amount of discussion spent on community building was sufficient to overcome the variations in the support the teachers received from their departments once they were back in the classroom.

The theme raised by the participants on the barriers and concerns about implementing inquiry was given 12.1% of the discussion during the week. That was 40.5 out of 333.5 inches of transcript. During the post-interviews with Wendy and Sarah, they both continued to have concerns about this theme. Their main concern was how to deal with the lower level students that had major disciplinary problems. Both of these subjects felt that they were still unprepared to deal with these types of students in an inquiry atmosphere that required some student autonomy. These feelings were main reasons that they were having difficulties with their own comfort levels in inquiry. Amy, an experienced teacher already comfortable with inquiry, was using her new skills to add to her classroom repertoire. Time spent on how to deal with these issues during the inquiry theme and a clearer set of parameters for discourse in the online community could have yielded more results in transforming the participants.

So, how does the time spent on the different themes during Project Inquire influence teachers? The themes needed a critical amount of time devoted to them in order for them to be transformative. It was evident that this critical amount varies from participant to participant. The building community theme, the money theme and the barriers and concerns theme could have used more time during the week for certain teachers, but not all of the subjects needed the same amount of support. These themes were described as being areas of potential improvement by both administrators and participants. The amount of discussion spent on inquiry, while dominating the theme discussion, seemed to be sufficient in influencing the teachers' willingness to attempt inquiry and seemed to be sufficient on influencing teacher beliefs. The understanding of inquiry was strong in all participants throughout and after the week. Technology was an influential theme, in some degree, in all of the subjects of analysis and was proven to be sufficient in both quantity and quality at least to motivate the subjects to use their classroom money for technology purchases.

The different themes were all transformative or confirmatory in some amount. From the data, the subjects expressed the need for different levels of support for various themes. Wendy needed more support for her inquiry lessons and discipline issues. Sarah expressed a need for strategies to support discipline and student motivation. Amy expressed no needs for more support and was using her new techniques to fit her needs. If the amount of discussion were to increase or decrease, then it is likely that some of the needs would have been addressed.

The amount of discussion spent on themes was a factor on the way that teachers were influenced by the professional development experience, but the amount of variability in the subjects' reactions to the themes indicates that this conjecture is insufficient to explain the influence of the professional development experience on the subjects. The themes worked together to affect the participants in different ways. The critical amount of discussion to spend on a conjecture for each teacher varied as would be expected. In order for the conjecture to be transformative, the critical amount of discussion depended on the comfort level of the teacher with the conjecture. For example, the online discussions would have been more useful for Wendy and Sarah, but not for Amy since she already had experience in inquiry teaching. This experience level leads to the next conjecture.

Conjecture 2: How teachers of mathematics are influenced by professional development depends on the previous experience of the teacher.

Some teachers may come away from a professional development course or seminar with varying amounts of useful information depending on the needs and previous experiences of the individual. In Project Inquire, professional development on inquiry teaching used many examples to reach and teach the participant's in the method. Amy, with a greater amount of experience, gained little new knowledge from the experience because inquiry was a part of her teaching already. The experienced teacher may be able to connect on levels that the novice teacher cannot. During the same seminar, Wendy

gained a whole new avenue to reach students. The difference in previous experience can influence the effectiveness of the seminar for a certain type of teacher (Good & Weaver, 2003; Hammel, 2007; Jehlen, 2007). The subjects of analysis in this study illustrated this difference in experience and showed how this variation can affect the transformation of the teachers.

The overall experience level of a high school mathematics department can be negatively affected when teacher turnover is an issue. According to one of the administrators of Project Inquire, Philip, one of the most frustrating aspects of recruiting teachers to attend was the turnover that some of the schools experience year to year. The teachers that were hired for these schools tend to stay in their schools for three years or less for various reasons. They were often either new to the profession or had been recruited from other countries and had trouble acclimating to a rural community. The impact of Project Inquire could have been great in these teachers since they were likely in need of new teaching methods and experiences. On the other hand, when the school lost them to other opportunities, that advantage was erased. The best scenario for leveraging the long-term impact of Inquire was to find teachers open to new ideas and who would be around to use them for years to come.

Wendy was a novice teacher who wanted a better way to teach. In her preliminary interview, she had commented on her desire for training in different teaching methods and even expressed a desire to be able to practice her training before she started her classes the next year. She had very little experience in any method other than lecture and conducted her classes in a traditional manner. When she was trained in inquiry, it became

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the only hands-on method with which she was comfortable. It is no surprise that she embraced inquiry almost exclusively at the beginning of the next school year. She did have her difficulties, but the seeds of inquiry teaching were planted in her psyche and have an excellent chance to be used in the future.

Sarah was a veteran teacher of several years and was resistant to employing inquiry in her classes. She expressed many concerns about classroom management and felt that it will not work with her problem students, despite the fact that she had success with inquiry the one time she tried it. Through the observations and documents gathered, she seemed to be tied to the traditional methods of teaching with the text and did not lead real explorations or deep mathematical discussions. Her comfort with habituated teaching methods was a barrier to change that was more difficult to transform than in the novice teacher with little experience.

Amy was a veteran of 13 years and already used inquiry in her classroom on a regular basis. She had many inquiry lessons in her teaching toolbox already and Inquire added to her already vast knowledge and resources. In her questionnaires, she was grounded in her philosophy and knew what worked in her classroom. She had taken some questioning techniques from Inquire and would add some of the problems to her lessons. Amy had used the experience of Project Inquire as an enhancement to what she already did. Her practice did not require a transformation to inquiry, since it was already a major instructional strategy for her.

One of the reasons the three subjects of analysis were chosen for this study was because of their experience level. The researcher wanted to study how teachers with

marked differences in experience might react and learn from Inquire. The interviews and questionnaires before and after Inquire showed how the teachers' varying levels of experience did shape their transformations. However, experience is more than just time spent in the classroom. The longer a teacher is in the profession the longer a teacher has to form opinions and receive training in many methods of instruction. Wendy wanted to know more about different teaching methods and embraced the lessons from Inquire. Sarah was comfortable with her methods and did not want to try inquiry more than the required amount. Amy was using inquiry and other methods already and took confirmatory reassurance and a few more techniques from her experience. The experience factor of influence evidently had some effect on how teachers were influenced by the professional development experience. It seemed the old adage of "you can't teach an old dog new tricks" is not absolute. However, it was partially true in this case. The intended changes in the subject with a relatively clean professional development slate were more influential and less likely to be hindered by blockage from other experiences. Nonetheless, the new method evidently needed continuous support, at least in the early stages of implementation, to take root.

How the subjects reacted to the requirement of the online community reflected this need for support. Wendy was a regular contributor to the online discussions while Sarah and Amy were not. Wendy became frustrated with the lack of response from other Inquire participants and her attempts at inquiry faded. Amy cited time and personal reasons for her inability to join in regular conversations in the online community, and

Sarah did not indicate a need for the interaction. Sarah and Amy, the two experienced subjects, did not feel the same need for the community that Wendy did.

The concerns and barriers to transformation in Wendy were not adequately addressed largely due to the lack of the support community. The fading of her inquiry attempts and her frustrations with being able to continue inquiry fueled the barriers to her continued use of high amounts of inquiry in her teaching. She did acknowledge that her teaching was transformed and she would use inquiry in the future. The concerns and barriers for Amy were largely non-existent. She was comfortable with the method before Inquire and did not require continued support. Sarah needed no help with her concerns because she attempted inquiry only one time, and that time was rated a success. The more experienced subjects had little use to address concerns and barriers.

The monies made available to the participants were spent on technology purchases by the subjects. However, after one small technology purchase, Wendy said she felt frustrated because she did not know where to spend her classroom money. Once again, the more experienced subjects spent their money more quickly because they knew what purchases they required for their particular pedagogical plans while the novice was left to ponder what her needs were.

The experience level of Amy helped her in her teaching methods and in her ability to spend the classroom money quickly on products she was sure would help her teaching. However, she was not inclined to participate often in the online discussions because there was no need for her to seek help. Wendy, being the novice teacher, needed extra support from experienced teachers like Amy, but she was not able to find help in sufficient

amounts. She was also unable to focus her spending as a result of feeling "by myself." Sarah had pre-existing ideas of what worked in her classroom. And, as a result, she did not seek out extra help in inquiry or spending. However, she was able to find items to buy with her classroom money.

The experience level of the three subjects of analysis affected the transformation of the teachers in different ways depending on the theme. The inquiry theme transformed Wendy in a significant way. Sarah was transformed slightly, and Amy had a confirmatory experience. The money theme and the technology theme transformed Sarah in a significant way with the purchase of a central piece of technology for her classroom. Wendy was slightly transformed by the money, and the transformation of Sarah was not evident through her purchase of her laptop and camera.

Each teacher forms her own ideas about what works for her and what her professional needs are, leading to the next conjecture of how professional development transforms teachers of mathematics.

Conjecture 3: How teachers of mathematics are influenced by professional development depends on the perceived professional needs and beliefs of the teacher.

In the first framework that Fraser et al. (2007) employed to understand the complexities of professional development, the personal and social aspects of teacher learning were addressed (Bell & Gilbert, 1996). In this framework, the previous learning experiences and teacher beliefs were considered the aspects that ultimately decide what

transformations in the teacher took place. The teacher must have buy-in to the ideas that were proposed and must perceive that the ideas were important. If not, the professional development experience may not change the teacher in a significant way. The framework sees learning in isolation as problematic and calls for communities to be formed to aid teachers in new techniques. Inquire attempted to address these issues by fostering teacher learning and forming the online community for support as a group by allowing teachers to practice their new skills with the students of the Academic Camp.

Congruent to this line of logic in professional development design is the notion of pre-existing ideas that are shaped by teachers' previous experiences. Teachers' beliefs and the way they teach are often set and may not be easily changed by the time they enter a particular learning experience. If the ideas and methods are inconsistent with teachers' beliefs, then the goals of the professional development may not be reached. Or else, they may be implemented only partially. A well designed and implemented experience should take into account these contrasts and make efforts to address them (Good & Weaver, 2003; Tillema, 1995; Hammel, 2007; Moeini, 2008).

So, why does the professional development experience of Project Inquire influence the subjects of analysis differently? Certain aspects of effective professional development were found in other studies that correlate with these design aspects. Collaboration with colleagues is an effective means of gaining participant buy-in to a program. Time to plan and implement change could mean the difference between connecting a teacher's belief transformations into a transformation of her classroom practice. Providing support and having a clear vision are also means to create buy-in to

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change. Community collaboration, allowing time to plan and implement change, program administrator support and articulating a clear vision are recurring themes in good professional development design (Chval et al, 2008; Knapp-Philo et al., 2006; Welch, 2007). These parts of designing professional development work together to ensure that efforts in teacher training are not wasted. For example, if a teacher's needs and concerns are not addressed, or mismatched in a program, the intended change may be small, or non-existent.

Wendy had a perceived professional need for new, better teaching techniques before Inquire began. As she gained knowledge in inquiry, her buy-in to the ideas was strong. She believed that this new teaching method would benefit her students and create a more effective atmosphere for learning. As a result, she implemented many inquiry lessons in the beginning of the following school year. However, as the year progressed, she had some difficulties in inquiry and needed some assistance. The help she received from the administrators and other Inquire participants did not supply her with all of the help she needed. She felt alone and employed inquiry in smaller amounts as the year progressed. The seeds of inquiry grew quickly in this novice teacher at first while she was a part of a community, but then waned as she realized the community was not strong enough for continued support. Her beliefs needed to be reinforced as the year progressed.

Sarah had no pre-existing perceptions that she needed another method of teaching. Her mindset was that she knew what worked for her and the students would not be mature enough for an inquiry environment. She employed inquiry in only one lesson the following semester and, even though she says it went well in the follow-up interview, she

did not attempt to do any more with inquiry. The buy-in to inquiry and the need for it was weak in the beginning with Sarah. Also, since she did not employ inquiry in any significant manner, she had no need for the online community of support. Lack of perceived need was one reason for her token contributions to the discussions via e-mail. Also, her purchases with her classroom money indicated a need to spend without taking into account exactly how she would employ her new laptop and camera. She was interviewed after the first semester and had not used either of the purchases to employ an inquiry-based lesson or project.

Amy was already very familiar with inquiry and incorporated many inquiry lessons in her classes. She had the buy-in before she attended Inquire and used Inquire as an enhancement in her teaching. The lessons of the week of Inquire and the money provided to her classroom were not put to the side. Her purchase of an interactive whiteboard provided a tool that could be employed on a daily basis in her classroom. She knew what she wanted to employ from Inquire and had little need for the professional network for herself. She did have personal issues that pulled from her time to respond to some discussions. This removed a veteran's perspective that would have aided the other teachers, particularly Wendy, who needed feedback from other participants, not just from the administrators.

A primary purpose for building professional networks is to build knowledge (Good & Weaver, 2003; Loucks-Horsley, Hewson, Love, and Stiles, 1998). In this experience, administrators expected that the teachers would attempt inquiry in their classrooms and discuss their successes and failures via e-mail or some other means in

order to become better at their craft. In discussing the successes and failures of teaching, the communications between the teachers need to be sufficient in both quantity and quality. The discussions might be prompted by the administration on several occasions throughout the year, but responses from the teachers have to be regular. Professional networks can be fragile. If a teacher is separated from the community by her own fault or by the fault of network breakdown, then the desired effects can evaporate before they have a chance to become part of her repertoire. Inquire attempted to create such a professional network, but both participants and administrators see room for improvement.

As teachers gain experience and confidence in their craft, they build a perception of what works for them in the classroom. This perception leads them to have more specific views of what needs they have in professional development. Also, as they gain experience, teachers are exposed to professional development and content that expands their knowledge of content and pedagogy. Knowledge and skills lead to the next conjecture of how professional development influences teachers of mathematics.

Conjecture 4: How teachers of mathematics are influenced by professional development depends on the level of the teachers' content knowledge and pedagogical skills.

Inquire attempted to engage the participants in mathematics through inquiry from the very first meeting. The administrators presented many problems during the week and they provided different perspectives on mathematics that many of the participants had not considered. This type of learning was meant to increase the teachers' content knowledge

while modeling the inquiry technique at the same time. Numerous problems presented in different ways increase the depth of understanding that math teachers need in their day-to-day teaching. They provide opportunities for practice and reflection as a community that are essential in a transformative professional development experience (Zaslavsky & Leikin, 2004).

When investigating a topic using inquiry, it is often the case that the line of discussion and discovery diverged from an expected path. For example, a discussion on linear relationships may end up becoming a discussion on arithmetic sequences. While both are closely related, these topics have their own nuances and learners may not have the knowledge to link the two effectively. The teacher must have as broad a content base as possible in order to prepare for such diversions. Indeed, a teacher needs content knowledge that can give students multiple representations of a topic on different levels of sophistication. Only then can inquiry be truly effective in helping students construct their own knowledge (Jarrett, 1997).

The purposeful sampling of the subjects of analysis targeted the experience level of the teachers to provide a wide perspective of the range that teachers have in a typical professional development experience. Their experience levels ranged from novice to well-seasoned. The more experienced a teacher is in the classroom, the longer she has been exposed to the math content in the standards she is to teach. The more experienced teachers in this study had also been exposed to more professional development than the novice teacher, Wendy. This difference could be seen in the reactions and transformations that occurred as a result of Project Inquire.

Wendy, being the novice subject, was fresh out of college and had a sound understanding of the content of her courses as was evident from observations and interviews. This content knowledge allowed her to concentrate on the new technique of inquiry Inquire had taught her. During the observations before Inquire, Wendy was comfortable and knowledgeable about the mathematics content, but had little knowledge in methods other than the standard lecture or drill classroom. From observations and documents, she used almost no application problems in her classes before Inquire. After Inquire, her interviews, observations and documents showed a more sophisticated approach to teaching in which she employed different methods, including inquiry. She still had some difficulties, but she was attempting inquiry in many of her lessons. The new method of inquiry found fertile ground to take root.

The observations and documents gathered from Sarah showed that there was very little change in her teaching methods. She continued to use the traditional lecture from the overhead method. In many interactions with Sarah throughout the year, it was observed that her pedagogical knowledge had gaps and she was dependent on the generic lesson plans provided by the textbook publisher. Sarah expressed difficulties with the content of a course she was teaching several times during the year. She was unsure about what the text was trying to convey on topics such as the unit circle and trigonometric relationships. Sarah seemed to gravitate towards the skill and drill lessons that had no inquiry or application part to them. Although the lessons were from the textbook material, her content knowledge on the topics observed was accurate. Still, the lessons were of simple skills and did not delve into more robust mathematics. This adherence to

the text materials and classic style indicated a lack of sophistication in content and pedagogical skills one would expect to find in a teacher with several years of experience. Sarah struggled with both pedagogical skills and deep content knowledge, creating an even more difficult hurdle for her to overcome in implementing inquiry in her classroom.

Amy, in contrast, showed a vast knowledge of different teaching methods and knowledge of content that allowed her to experiment and use different parts of learning from the professional development week. She had already been familiar with inquiry and was able to use her own lessons as well as what she took from Inquire. Her responses to the questionnaires showed that she was in touch with her students' understanding of math and that she could monitor and adjust her lessons as needed. Her content knowledge was sound from her interactions with others during Inquire week and the documents she provided from her instruction.

So, how do the content knowledge and pedagogical skills of the subjects of analysis influence the transformation of teachers of mathematics? The two teachers who showed a thorough understanding of their subjects' content attempted inquiry in many lessons through the first semester after Inquire. Amy had already used inquiry and was comfortable with it. Both Amy and Wendy were using the method and were employing some form of pedagogical skills that they gained from the professional development week. Sarah, who showed little pedagogical influence and had content issues from the beginning, did not seem confident enough to use inquiry more than once. It seemed that content knowledge and pedagogical skills did influence a teacher's propensity to try new, and sometimes unsure, teaching methods.

Each conjecture partially explains the influence of the professional development on the three subjects of analysis. To some extent, the second conjecture, which proposes that the experience level of the teacher is influential in the transformation of teachers, includes effects that the third and fourth conjectures have. The perceived professional needs, beliefs and knowledge in content and pedagogy are all factors that can be influenced by the experience of the teacher. As a teacher continues through her career, it is expected that her needs change, her content level improves and her skills in teaching are modified and enhanced. This melding of conjectures leads to the consideration of the effect of belief transformation through experience.

Teachers' beliefs about math and teaching are significant in shaping teachers' instructional behavior (Chval et al, 2008; Thompson, 1992). Beliefs should be considered when a professional development program attempts to influence teachers' classroom practice. Beliefs can be affected by the experience level of a teacher, but there can be other factors, such as prior experience as a student and prior professional development.

The conjectures discussed here represent what the researcher has identified as the most likely factors that determine how professional development influences teachers of mathematics. They are triangulated in varying degrees by the current literature, observations, interviews, documents and questionnaires from participants and program administrators. Which ones have more influence in how a professional development experience, like Project Inquire, influences teachers of mathematics?

Influence on Pedagogy and Belief

The main research questions of this case study were as follows:

RQ1: What personal and program factors influence teachers as they progress through a professional development experience?

RQ2: How do these personal and program factors influence teachers as they progress through a professional development experience?

The sub-questions of this case study are:

RQ2a: How are teachers' beliefs influenced by the factors of professional development?

And

RQ2b: How are teachers' pedagogies influenced by the factors of professional development?

In the sections that follow, the two sub-questions are discussed in relation to the rival conjectures and together will form an answer to the main research question, RQ2.

Pedagogical Transformation

In the first rival conjecture, the amount of discussion on the themes must reach a critical level in order to influence teachers of mathematics. The inquiry theme was the most discussed and practiced part of Inquire week. The administrators hoped that the participants would change their teaching to incorporate more inquiry so that they might better reach their students. This critical level was dependent on the teacher. Different teachers have different critical levels of influence.

Designers of professional development should take into account the level of discussion of themes. However, the critical level needed to be transformative or supportive in nature is a difficult target to estimate. If the goal of professional development is to begin or sustain change in a teacher's pedagogy, then any movement in the positive direction is a success. It would be unrealistic to expect that all teachers would attain mastery from just one experience.

Wendy was already searching for different teaching methods and was receptive to the new ideas presented to her. The amount of discussion was sufficient to transform her teaching and influence her pedagogy toward inquiry. Sarah still had concerns when Inquire ended and was unsure that this method was right for her and her students. Her teaching was influenced little. Amy already had inquiry as a tool for her classes and her pedagogy was not transformed beyond picking up some new questioning techniques. But, she did gain affirmation of her practices. The large amount of discussion and practice on inquiry was sufficient to influence Wendy. Sarah was not influenced to a significant degree, and Amy had her methods reinforced.

The amount of discussion on money and technology influenced all of the subjects to purchase some form of technology for their use. However, the researcher did not observe the pedagogical influences of technology purchases. Also, Wendy's purchase of a graphing calculator emulator was not widely observed in her classes. The purchase of an interactive whiteboard by Amy was likely to be used since it would be the center piece of her classroom. However, it was not clear in what way she would use this board. The

amount of discussion on technology clearly influenced the subjects, but the data revealed no influence in their practice.

The discussion of the theme on barriers and concerns reached the critical amount for Wendy and Amy, but not for Sarah. The amount of concerns for Amy was minimal since she was already a user of inquiry. Wendy had barriers and concerns during and after the week, but they were not enough to prevent her from attempting inquiry on multiple occasions. In her interviews and observations, it was evident that she was using inquiry and becoming more comfortable with it. Sarah had attempted inquiry only once. In her interviews and observations, she still did not feel comfortable enough to try inquiry on a regular basis. As data indicate from her interview, she did not believe she could overcome her classroom management barriers. Sarah's barriers and concerns prevented her from leaving her comfort zone to attempt an inquiry lesson more than once.

Sarah and Wendy needed more discussion from the community about their barriers and concerns. The expectations of the community of professionals did not reach a critical level as was evident from the different participant and administrator responses to interviews and e-mails. The inquiry attempts by Wendy dwindled as a result of frustrations that she was unable to reconcile. In her interview, she stated that she needed responses from more than the Inquire administrators. The experience that could have been shared by the other participants, especially Amy, could have provided the critical discussion she needed to overcome her frustrations and continue inquiry lessons.

In the second conjecture, the experience levels of the teachers were factors in the influence of the subjects' pedagogy. The two teachers with some amount of experience

changed their teaching in small amounts due to Project Inquire. Amy incorporated only the new questioning techniques she learned. She stated that she was going to incorporate some new inquiry problems, but she had not needed them during the first semester of the next school year. Sarah attempted inquiry only once during the year and did not follow through with her plans to attempt more. Wendy, on the other hand, attempted inquiry several times at the beginning of the year and continued to use the method, albeit in much smaller amounts, throughout the semester. More change in teaching methods occurred in her than the other, more seasoned teachers. The novice teacher had more room in her teaching toolbox for inquiry because she had yet to become familiar with other pedagogical strategies. The other two subjects had already had training in other methods and continued to use methods with which they were comfortable. As teachers become more seasoned, their beliefs become set, and they form solid ideas about their professional needs.

The comfort level with content and pedagogical skills evidently influenced the teaching of the subjects of analysis. The two subjects that showed more skill, Wendy and Amy, were more receptive to attempting inquiry than Sarah. This difference could be attributed to the difficulty Sarah had in being effective in her day-to-day planning and management and in her difficulties making connections between the math topics and application problems. With little confidence in her ability to be able to handle a student's tangential mathematical thought or a student's behavior, she reverted to the same lecture and skill practice. The influence of content knowledge and pedagogical planning was strong in achieving transformations in the subjects.

Belief Transformation

The inquiry theme was the most prevalent one discussed of all of the five themes. It was heavily influential in the transformation of Wendy's and Sarah's beliefs. Both of them provided evidence in their interviews that they believed inquiry was an effective form of teaching. Amy, on the other hand, already believed in the inquiry method of teaching and this was more confirmatory for her.

Wendy and Sarah also expressed concerns over discipline and keeping students on task. The barriers and concerns over implementing inquiry caused them to have little belief that this method would work in their classrooms. Wendy attempted inquiry in large amounts to begin the year, but reduced the use of it as the year progressed and her concerns grew. Sarah attempted inquiry only once and did not return to it. The time spent on the barriers and concerns did not receive a critical amount of attention for these two subjects of analysis to believe that inquiry could be a sustainable alternative to the more traditional instructional strategies with which they were comfortable. Both subjects believed that inquiry was effective, but could not be implemented for their problem students.

One way that Inquire attempted to deal with teacher concerns during the year was to form a community of professionals that could support each other. The subjects of analysis and the administrators rated the building of community low. This theme did not achieve a critical amount of time to change teachers' beliefs that inquiry could be a part of their practice. Wendy made more contributions to the discussions than the others, but

soon became disenfranchised when her concerns were not addressed in sufficient amounts by other teachers.

The theme of proper technology use did reach a critical amount to change the beliefs of the teachers. All three teachers believed that spending at least some, if not all, of the money provided by Inquire on technology for their classrooms was worthwhile. Sarah believed that the technology purchases for her classroom could help her create more projects for her classes. In her initial interview, she stated that she did not assign many projects. From her questionnaire, Amy believed that an interactive whiteboard could contribute to her already inquiry-rich classroom. And Wendy believed her purchase of computer software could influence her effectiveness in her classroom. How she could use her purchases in an inquiry-based classroom was unclear. However, from the interviews, observations and questionnaires, they all believed that technology could improve their classes in some way.

The subjects had different beliefs about how the money could be used to support their teaching. Two of the three teachers did spend all, or almost all, of their money. But, their purchases were large ticket technology items whose use was not evident. Wendy had spent only a few hundred dollars of the $1,600 she had available to her. She said that she did not really know what she needed in her classroom and she would have liked more guidance in her purchases. She, and other participants, could have benefited from more discussion on this theme. For example, Wendy did not believe that other items, such as bouncy balls and measuring tapes, were necessary items for an inquiry classroom. Discussion about how manipulatives such as these could be useful in many inquiry

applications may have been well received. Discussion about what items could help her transform her teaching was not of critical amounts to change her beliefs and motivate her to shop and spend.

The amount of discussion spent on themes during the week of Inquire was a variable that had different effects on the beliefs of the subjects of analysis. While it is obvious that if no discussion is spent on a theme, then there would be no effect on subjects, it is not clear how much discussion it would take to change an individual. For example, the discussion on barriers and concerns during the week of Inquire was of the same amount for all three subjects of analysis. They all shared in the same professional experience. But, the needs of the subjects were very different in this area. The teacher that already had inquiry as a method that she was comfortable employing did not have many concerns about inquiry implementation. The experienced teacher with no background in inquiry teaching changed her methods very little even though her beliefs in inquiry teaching were positive. The novice teacher changed her teaching a great deal at first, and then used inquiry less frequently as the year progressed. Her beliefs remained positive, though her pedagogy shifted back. The individual variables that teachers bring with them to a professional development experience interact to form how they employ, or do not employ, the intended influence of the training.

The conjecture that the previous experience of the teacher influenced how teachers of mathematics are transformed by professional development also had mixed results from the three subjects. Wendy, being new to the profession, believed that inquiry was a method that would transform her teaching. During her initial interview, she

commented that she needed more diverse ways to reach her students. During the week of Inquire, she had a few issues about barriers and concerns, but she planned on bringing inquiry to her classrooms. Sarah said that she thought that inquiry was a useful teaching method, but she never believed that it could work with her diverse students. Amy, already a user of many inquiry lessons, had much experience in the teaching method. Her beliefs were confirmed through the experience. The differences in the belief transformations of the subjects indicate that the experience level of the teachers is a significant factor in the influence that a professional development experience can have.

Summary

The difference between the two experienced teachers and the novice teacher is that the novice, Wendy, did not have training in the methods introduced by Inquire that she could use as a viable alternative to the lecture method. She was using the method with which she was familiar. As teachers remain in the profession and take classes or attend seminars, they acquire a repertoire of methods that work for them. These experiences all work together to create a personal belief cannon. A cannon that is resistant to change. The most significant transformation in the beliefs of the subjects occurred in the novice teacher.

Teachers find which teaching methods work for them and what methods fit into their own teaching style. They perceive that they have particular professional development needs. All three subjects had some belief of what good professional development was. In Sarah's interview, she alluded to the seminars that occurred on a school-wide basis. She perceived them to be a waste of time and wished that building

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administrators would offer more that would help her in her day-to-day classroom situations. The beliefs of the teacher were forged by the experiences she had and blended with the experience level to shape the teacher's perceptions of what worked for her.

The comfort level of the content and pedagogical skills was a factor that influences beliefs. With a deeper knowledge of math content, the two teachers that employed inquiry on a broad basis were more confident to do so. They were able to take risks in the classroom and broaden their teaching methods and increase their classroom skills. A greater comfort level can be attributed to the connections in math that they could see that other, less knowledgeable teachers cannot. More knowledgeable teachers were more apt to follow divergent thinking. When a teacher could see many connections that a topic had to real-world applications, it made sense to exploit these connections to aid instruction through a variety of methods. This knowledge fueled beliefs that inquiry and application are worthwhile.

Both Wendy's beliefs and her pedagogy were influenced by Project Inquire. Her classes were rated higher in likeliness to be effective for her students and her post-Inquire interview showed more knowledge of inquiry. Her experience was transformative on several levels.

After Inquire, Sarah stated that she believed inquiry was an effective method to employ, but her practice remained stagnant. She showed no signs of changing her pedagogy even though she believed in the new method. Her barriers and concerns to change were not overcome. Her teaching may be influenced in the future either by

improved content or pedagogical knowledge. Her experience was transformative on her beliefs, but not her present practice.

Amy had small changes in her practice as a result of Inquire, but the professional development experience had more of a confirmatory quality for her. She was already using inquiry and believed in its use as an effective teaching method. Her technology purchase and new questioning techniques were most likely to influence her pedagogy.

Impact on Professional Development Design

The influences of this professional development experience on the three subjects of analysis vary greatly. Designers of professional development should be familiar with their audience. They should take into account the experience level of the teacher learners with which they will interact as well as what their audience perceives as important in professional development. Designers should consider any prerequisite factors that their intended transformation may require, such as deep content knowledge to handle an inquiry environment. Designers of professional development might include prerequisites, such as having participants complete an introductory module on a technique before attending an intermediate module.

Also, when designers get to know their audience, they will be more likely to plan discussion on the major themes of their message in a sufficient amount to reach all participants in some way. Barriers and concerns to change should be anticipated when possible. Plans should be made to deal with them. Without addressing the barriers to change in a sufficient manner, participants will be less likely to embrace and use new

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knowledge. What is sufficient may be difficult to determine and dependent on the complexity of the intended transformation. The professional development experience will not achieve all of its goals if these barriers and concerns are not addressed.

In becoming familiar with the teacher participants, a designer of professional development should gain insight into their beliefs, experience and concerns. Greater insight could indicate how much discussion to plan for each theme. As the experience progresses, the designer should allow time for discussion to address barriers and concerns and allow more discussion where needed. For example, if a teacher still does not feel comfortable enough in inquiry to let go of some control to her students, then some role play and analysis could be warranted in order to overcome her concerns. This monitoring and adjusting of the amount of discussion on themes as the professional experience unfolds is analogous to how a teacher would proceed in a classroom.

This study suggests that in order for a professional development experience to be influential, the design should incorporate important aspects. They are as follows:

1. A critical amount of discussion needs to be identified and dedicated to the major goals and themes of the professional development experience, especially barriers and concerns that the participants have about the intended transformations. As the professional development experience progresses, monitoring and adjusting may need to take place and should be anticipated.

2. The designers should take into account the previous experience of the participants, especially their perceived professional needs and beliefs. Designing specific professional development for levels of experience or by polling

prospective participants to gauge perceived needs could lead to a more focused professional development experience.

3. Designers of professional development need to be aware of and address the aspects of the participants that may affect the intended influences and transformations, such as their content knowledge and pedagogical skills.

4. Designers should plan for ongoing support and collaboration between colleagues. When the teachers return to their classrooms, the influences and transformations that are targeted may need continued reinforcement by way of a structure for teachers to meet and/or discuss concerns and successes. These can and should occur at as many different levels as possible.

These four aspects of the design of professional development require knowledge of the participants that may be difficult to gain without a major investment of time and energy. With many participants and few administrators, the one-on-one attention coupled with a community of support may be impossible to achieve. However, with some initial planning and anticipation, a designer of professional development can have some intimate knowledge of the participants that is needed for a more focused experience. Some knowledge of the participants in any professional development experience can be assessed through quick questionnaires, observations or interviews. For example, if a principal wants to train her staff in differentiating instruction, then a quick survey of what methods are familiar to teachers may be of great value during planning. It would save both time and energy for teachers to target their particular needs and have a menu of methods from which to choose.

Many teachers dread the seminars that are required during a typical school year. Many school administrations could save time and money by surveying their teachers before they require their whole faculty to sit through a seminar that may become a waste of time for most participants. Professional development experiences could anticipate needs and gain knowledge of participants in order to provide more meaningful content.

All participants and administrators acknowledged that Inquire was a very worthwhile program. It met the criteria for effective professional development described in the literature. This study is an exploration into how different teachers respond to a PD experience. Also, no one should expect any professional development to take all participants to the same place. It might be considered successful if it helps participants establish a vision of where they want to go and provides the first steps in moving them toward that vision. All of the three subjects were influenced in different amounts, in different areas and according to their own comfort level with the teachings of Project Inquire. By this measure, Inquire should be considered successful.

The research on effective professional development is often generic in its conclusions with little insight into how personal and program factors work together to influence teachers. This study followed three individuals through a professional development experience and illuminated how each one was differentially influenced. Wendy, Sarah and Amy all had different pedagogical techniques and beliefs heading into Project Inquire. Wendy's teaching and beliefs were influenced towards inquiry more than Sarah's. Amy's teaching and beliefs were largely reinforced. However, all three reacted to the program factors through their personal factors in some way. This study reveals how

these factors work together on an individual basis. Future research should be completed to gage the influential effects of each factor individually over subjects with varying levels of experience and varying belief structures.

Case Study Validity

The validity of this case study is addressed on several levels. In case study methods, different types of data gathered from various sources add to the internal validity of the study (Stake, 1995; Yin, 2003). There were 29 points of data from seven different sources and six different types. Some of these points of data had more than one collection associated with it. Internal validity was also enhanced by the administrators of Project Inquire. They suggested corrections and had an opportunity to contribute to the overall conclusions. The naturalistic generalizations that appeared throughout the data were the main drivers for the themes and conjectures about the influence this experience had on the subjects of analysis.

External validity is addressed through the review of the literature on professional development and the major themes of discussion throughout the week of Inquire. The literature addressed the themes and conjectures in this study and provided frameworks that supported results.

The findings of the case study may not be unique. The widespread difference in influence of the individual teachers is illustrated by the wide level of experience and expertise of the subjects. This case study is a picture of what happened to these teachers and may not translate to other types of professional development with other individuals.

However, the broader lessons of this study could be of interest to designers of professional development in planning for the nuances, such as barriers and concerns to change, that they should not ignore if they wish to implement a quality experience. Small details about individual learners could aid administrators and designers in helping individuals to change. More research should be conducted in these nuances to add to the knowledge of what works best under different circumstances.

Closing Vignette

There are new faces in the crowd at Project Inquire. It is a new summer and new teachers are happy to be the students instead of the teachers for once. Philip looks at the crowd and smiles. It is the fifth and final year of Project Inquire. He starts modeling inquiry right away with a seemingly simple problem. He holds a piece of paper up toward the light and folds it. He makes a point that it is now two layers thick instead of one. He folds it again. After commenting on the growth of the thickness of the stack, he asks the teachers to estimate how high the stack will be after 50 folds. The teachers think and a few begin some quick calculations. He stops them and makes them guess. Most guess in the few inches to the few feet range. A guess of a half-mile leaves most of the teachers snickering. They see no way it could possibly grow that much.

Philip lets them contemplate their answers while they begin introductions. There are many different levels of experience in this class of Inquire participants. There are two pairs of teachers where one was a former teacher of the other. The dichotomies of

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experience are stark. It seems that the more experienced teachers know math well, but the younger teachers are more receptive to new methods of instruction.

There is some discussion about the money that the teachers will have available, about the communication that is expected to take place and about the schedule for the week. The themes begin to emerge again as Philip takes the new participants back toward the paper problem solution.

How high will the height of the paper grow after 50 folds? Philip points out that a ream of 500 sheets is usually about two to three inches thick. There is more discussion as they approach the solution. The answer surprises all.

APPENDICES

Texas Collaborative Observation Protocol

Texas Collaborative for
Excellence in Teacher Preparation

TxCETP

CLASSROOM OBSERVATION PROTOCOL

I. Background Information

A. Observer
1. Name: _____

2. Institution Name: _____

3. Date of Observation: _____

4. Length of observation: _____

5. Was the teacher informed about this observation prior to the visit?   O Yes   O No

B. Teacher/Faculty
1. Name: _____

2. CETP Teacher?   O Yes   O No

3. Gender: O Male   O Female

4. K-12: Licensure/certification_____

OR College Rank: (*Check one.*)

O Instructor/Adjunct Faculty   O Full Professor
O Assistant Professor   O TA: primary responsibility?_____
O Associate Professor   O Other:

II. Classroom Demographics

A. What is the total number of students in the class at the time of the observation?
O 15 or fewer   O 26–30   O 61–100
O 16–20   O 31–40   O 101 or more
O 21–25   O 41–60

B. Was a paraprofessional or teaching assistant in the class?
O Yes   O No

C. 1. Grade Level (K-12)_____
OR
2. Student Audience (majority of students. *Check all that apply*):
(a) O Prospective teachers: (1) O Elementary (2) O M.S. (3) O H.S.
(b) O Liberal Arts Majors
(c) O Mathematics/Science Majors

D. Subject Observed/Descriptive Course Title: _____

E. Scheduled length of class:_____(minutes)

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III. Classroom Context

Rate the adequacy of the physical environment for facilitating student learning.

	1	2	3
1. Classroom resources: (from "sparsely equipped" to "rich in resources")	O	O	O
2. Room arrangement: (from "inhibited interactions among students" to "facilitated interactions among students")	O	O	O

IV. Class Description and Purpose

A. Classroom Checklist:

Please fill in the instructional strategies (*not* the instructor's actual activities, in case they are correcting papers or something non instructional), student engagement, and cognitive activity used in each five-minute portion of this class in the boxes below. There may be one or more strategies used in each category during each interval. For example, SGD, HOA, and TIS often occur together in a five-minute period, but SGD and L do not.

Type of Instruction:

L	lecture/presentation	CL	coop learning (roles)
PM	problem modeling	LC	learning center/station
SP	student presentation (formal)	TIS	teacher/faculty member interacting w/ student
LWD	lecture with discussion	UT	utilizing digital educational media and/or technology
D	demonstration	A	assessment: Please describe.
CD	class discussion	AD	administrative tasks
WW	writing work (if in groups, add SGD)	OOC	out-of-class experience
RSW	reading seat work (if in groups, add SGD)	I	interruption
HOA	hands-on activity/materials	OTH	Other: Please describe.
SGD	small group discussion (pairs count)		

Student Engagement:

HE   high engagement, 80% or more of the students engaged.
ME   mixed engagement
LE   low engagement, 80% or more of the students off-task.

Cognitive Activity:

1   **Receipt of Knowledge** (lectures, worksheets, questions, observing, homework).
2   **Application of Procedural Knowledge** (skill building, performance).
3   **Knowledge Representation** (organizing, describing, categorizing).
4   **Knowledge Construction** (higher order thinking, generating, inventing, solving problems, revising, etc.).
0   **Other**: e.g., classroom disruption, please describe.

Time in minutes:

	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60
Instruction												
Student												
Cognitive												

	60-65	65-70	70-75	75-80	80-85	85-90	90-95	95-100	100-105	105-110	110-115	115-120
I												
S												
C												

B. In a few sentences, describe the lesson you observed and its purpose. Include where this lesson fits in the overall unit of study, syllabus, or instructional cycle. Note: This information needs to be obtained from the teacher/faculty member.

V. Ratings of Key Indicators

In this section, you are asked to rate each of a number of key indicators as descriptive of the lesson in five different categories, from 1 (not at all) to 5 (to a great extent). Note that any one lesson may not provide evidence for every single indicator; use DK, "Don't Know," when there is not enough evidence for you to make a judgment. Use N/A, " Not Applicable," when you consider the indicator inappropriate given the purpose and context of the lesson.

1. This lesson encouraged students to seek and value alternative modes of investigation or of problem solving..	1	2	3	4	5	DK	N/A
2. Elements of abstraction (i.e., symbolic representations, theory building) were encouraged when it was important to do so...............................	1	2	3	4	5	DK	N/A
3. Students were reflective about their learning......................................	1	2	3	4	5	DK	N/A
4. The instructional strategies and activities respected students' prior knowledge and the preconceptions inherent therein...........................	1	2	3	4	5	DK	N/A
5. Interactions reflected collaborative working relationships among students (e.g., students worked together, talked with each other about the lesson), and between teacher/faculty member and students...........	1	2	3	4	5	DK	N/A
6. The lesson promoted strongly coherent conceptual understanding........	1	2	3	4	5	DK	N/A
7. Students were encouraged to generate conjectures, alternative solution strategies, and ways of interpreting evidence..................................	1	2	3	4	5	DK	N/A
8. The teacher/faculty member displayed an understanding of mathematics/science concepts (e.g., in his/her dialogue with students)...	1	2	3	4	5	DK	N/A
9. Appropriate connections were made to other areas of mathematics/ science, to other disciplines, and/or to real-world contexts, social issues, and global concerns...	1	2	3	4	5	DK	N/A

For the following questions, select the response that best describes your overall assessment of the *likely effect* of this lesson in each of the following areas.

10. Students' understanding of mathematics/science as a dynamic body of knowledge generated and enriched by investigation.........................	1	2	3	4	5	DK	N/A
11. Students' understanding of important mathematics/science concepts.....	1	2	3	4	5	DK	N/A
12. Students' capacity to carry out their own inquiries...........................	1	2	3	4	5	DK	N/A

VI. Capsule Description of the Quality of the Lesson

In this final rating of the lesson, consider all available information about the lesson, its context and purpose, the complete instructional cycle, and your own judgment of the relative importance of the ratings you have made. Select the capsule description that best characterizes the lesson you observed. Keep in mind that this rating is *not* intended to be an average of all the previous ratings, but should encapsulate your overall assessment of the quality and likely impact of the lesson. Please provide a brief rationale for your final capsule description of the lesson in the space provided.

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○ **Level 1: Ineffective Instruction**

There is little or no evidence of student thinking or engagement with important ideas of mathematics/science. Instruction is *unlikely* to enhance students' understanding of the discipline or to develop their capacity to successfully "do" mathematics/science. Lesson was characterized by either (select one below):

    ○   **Passive "Learning"**

         Instruction is pedantic and uninspiring. Students are passive recipients of information from the teacher/faculty member or textbook; material is presented in a way that is inaccessible to many of the students.

    ○   **Activity for Activity's Sake**

         Students are involved in hands-on activities or other individual or group work, but it appears to be activity for activity's sake. Lesson lacks a clear sense of purpose and/or a clear link to conceptual development.

○ **Level 2: Elements of Effective Instruction**

Instruction contains some elements of effective practice, but there are *substantial problems* in the design, implementation, content, and/or appropriateness for many students in the class. For example, the content may lack importance and/or appropriateness; instruction may not successfully address the difficulties that many students are experiencing, etc. Overall, the lesson is *quite limited* in its likelihood to enhance students' understanding of the discipline or to develop their capacity to successfully do mathematics/science.

○ **Level 3: Beginning Stages of Effective Instruction** (Select one below.)
    ○ Low 3   ○ Solid 3   ○ High 3

Instruction is purposeful and characterized by quite a few elements of effective practice. Students are, at times, engaged in meaningful work, but there are *some weaknesses* in the design, implementation, or content of instruction. For example, the teacher/faculty member may short-circuit a planned exploration by telling students what they "should have found"; instruction may not adequately address the needs of a number of students; or the classroom culture may limit the accessibility or effectiveness of the lesson. Overall, the lesson is *somewhat limited* in its likelihood to enhance students' understanding of the discipline or to develop their capacity to successfully do mathematics/science.

○ **Level 4: Accomplished, Effective Instruction**

Instruction is purposeful and engaging for most students. Students actively participate in meaningful work (e.g., investigations, teacher/faculty member presentations, discussions with each other or the teacher/faculty member, reading). The lesson is well designed and the teacher/faculty member implements it well, but adaptation of content or pedagogy in response to student needs and interests is limited. Instruction is *quite likely* to enhance most students' understanding of the discipline and to develop their capacity to successfully do mathematics/science.

○ **Level 5: Exemplary Instruction**

Instruction is purposeful and all students are highly engaged most or all of the time in meaningful work (e.g., investigation, teacher/faculty member presentations, discussions with each other or the teacher/faculty member, reading). The lesson is well-designed and artfully implemented, with flexibility and responsiveness to students' needs and interests. Instruction is *highly likely* to enhance most students' understanding of the discipline and to develop their capacity to successfully do mathematics/science.

Please provide your rationale for the capsule rating:

Committee Member Observation Protocol

Classroom Observation Protocol

Date:_____   Grade: _____

Demographic Information on the class:

Number of students:_____   Female:_____ Male:_____

Ethnicity:

African American: _____   Asian:_____

Caucasian:_____Hispanic:_____

Native American:_____

Length of class period:_____

1. Method of co-teaching / team-teaching:

2. Classroom arrangement (Sketch):

3. Lesson being taught

4. 4. Instructional strategies used:

Instructional Strategy	Approximate Time Allotted
Lecture	
Interactive Lecture	
Demonstration	
Directed Practice (Drill and Practice): Worksheet: Textbook:	
Question / Answer	
Writing	
Homework	
Problem Solving:	
• Open inquiry	
• Guided Inquiry: Inductive Model: Deductive Model: Concept Attainment Model: Integrative Model:	
• Performance Task	
• Project (Multiple Class Periods)	
Games – Concept Attainment	
Games: Concept Reinforcement	
Games: Skill Attainment	
Games: Skill Reinforcement	

5. Organization for instruction:

   Whole Class _____   Small Group_____   Pairs _____

   Individual _____   Other:_____

6. Accommodations for students with special needs:

7. Organization of lesson:

8. Content:

   Accuracy of materials presented:

   Connections to other mathematical concepts:

   Connections to real world (purpose for studying concept):

   Examples used:

Response to student questions:

Accuracy of response

Adequacy of response

9. Materials:

Type	Purpose

10. Questioning techniques:

Assessment techniques:

Formal:

Informal:

11. Teacher conception of Mathematics:

Instrumentalist: _____

Evidence:

Platonist: _____

Evidence:

Problem Solving: _____

Evidence:

12. Classroom management plan

Appendix C

Project Inquire Teacher Semi-Structured Interview Protocol

Question 1: Please state your name and relationship to Project Inquire.

Question2: What would (or does) a math lesson be like that you would give to students or would like to receive from a math teacher? Give an example if you wish.

Question 3: What do you know about Project Inquire?

Question 4: Describe what you think or hope the main goals of Project Inquire are.

Question 5: What is your philosophy of education?

Question 6: What does a typical lesson or unit you teach look like?

Question 7: How do you assess your students? What does a typical assessment task in your class look like?

Question 8: Describe other professional development you have had.

Question 9: What kinds of professional development programs are effective?

Question 10: May I have access (or copies) of lesson plans, units and assessments that you have used this year?

Appendix D

Project Inquire Administrator Semi-Structured Interview Protocol

Question 1: Please state your name and relationship to Project Inquire.

Question2: What would (or does) a math lesson be like that you would give to students or would like to receive from a math teacher?

Question 3: Describe what you see as the main goals of Project Inquire?

Question 4: What is your philosophy of education?

Question 5: Describe what you like for Project Inquire to accomplish.

Question 6: Describe any areas that may be improved upon in Project Inquire.

Question 7: Is there anything else that you would like to tell me about Project Inquire or teaching?

Question 8: May I have access to any artifacts (or copies of artifacts) about Project Inquire to which you have access?

Project Inquire Teacher Highly-Structured Questionnaire

Name_____   School_____

Attach more pages if necessary.

Question 1: Describe a math lesson that you would give to students or would like to

receive from a math teacher?

Question 2: What do you know about Project Inquire?

Question 3: Describe what you think or hope the main goals of Project Inquire are?

Question 4: What is your philosophy of Education?

Question 5: What does a typical lesson or unit you teach look like?

Question 6: How do you assess your students? What does a typical assessment task look

like in your class? You may attach blank assessment instruments if you wish.

Question 7: Describe other professional development you have had.

Question 8: What kinds of professional development programs are effective? What are

their attributes?

Question 9: Are there any other issues you think are important to know about or tell to

producers of professional development programs?

Question 10: May I have access (or copies) of lesson plans, units and assessments that

you have used this year? Please attach.

Appendix F

Questionnaire Protocol for Dray after Inquire

1. How has the communication been between the Inquire teachers during this first

semester? Approximately how many have you seen and what has been the

content/subject? Etc.

2. Have you seen much inquiry attempted?

3. Have they asked questions about methodology, classroom management, etc.?

4. What are your general feelings on the success of building community?

5. Is there anything you wish to add about project Inquire?

6. Have you heard of how they are spending/using the money?

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