FOSTERING MATHEMATICAL THOUGHT IN OUT OF FIELD MATH TEACHERS

A Capstone Project Submitted in Partial
Fulfillment of the Requirement for the Degree of
Master of Education
Notre Dame de Namur University

André J. Mathurin
Spring 2002

I certify that I have supervised and read this Capstone Project and that, in my opinion it meets the requirements for the M.Ed. degree.

Dr. Kim Tolley
Lecturer, Notre Dame de Namur University

I certify that this Capstone Project meets the requirements for the M.Ed. degree.

Dr. Kristin Geiser
Director, M.Ed/MAT Programs
Notre Dame de Namur University

Approved for submission to the Graduate School at Notre Dame de Namur University.

Dr. Diane Guay
Dean, School of Education and Leadership
Notre Dame de Namur University

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Abstract

With increasing debate over the declining state of mathematics education in the United States, parents, teachers, administrators, and policy makers each have their view on the causes as well as the solution to improving mathematics education. Often the analysis of the quality of mathematics education begins with a discussion of the effectiveness and preparation of mathematics teachers.

This paper presents a study of the increase in the number of math teachers who do not hold extensive academic background in mathematics itself. This paper explores methods for improving the ability of these teachers to communicate fundamental mathematics concepts to students as well as how to help these teachers move towards more conceptual teaching.

Introduction

What are the goals of teaching mathematics? What teaching methods that are effective in helping students reach these goals? The answers to these questions have changed significantly over the last thirty years. What once was an almost exclusive focus on abstract reasoning skills has been transformed into a practical, real-world endeavor of utility as evidenced in the standards published by the National Council of Mathematics Teachers (NCTM). Technological advances such as graphing calculators are partly responsible for instigating this shift by necessitating a change in the curriculum. For example, lessons teaching how to compute the inverse of a 3x3 matrix have lost their value now that calculators can perform this operation. As a result, most mathematics textbooks have replaced rote drill exercises with real-world application problems.

Underlying this change has been a hope that mathematics would no longer be perceived as a subject that either you were able to understand well or not at all. The shift in mathematics education was to hopefully erase stereotypes: boys understand it better than girls, success requires memorizing a bunch of processes, and mathematics is a boring, uncreative endeavor. Slogans such as “algebra for all” have captured this crusade for transforming mathematics into a valued and enjoyable part of education. Teachers have been challenged to make classes more exciting by moving away from lectures that involve detailed explanations of procedures to managing planned investigations that would allow students to be able to uncover mathematics for themselves.

While the mathematics curriculum has changed, so has the profile of mathematics teachers. Mathematics courses continue to be taught despite the reported shortage of “qualified” mathematics teachers (DOE, 2000). This explains the increase in the number of non-mathematics degreed teachers teaching mathematics. At the same time math teachers are being expected to teach in a much different manner than the mathematics teachers of thirty years ago. But what happens when math teachers themselves do not understand what is happening? The fact that many current mathematics teachers do not hold a college math degree would seem to limit their ability to implement a curriculum that seeks to engage students in meaningful, realistic mathematics projects that have at their root fundamental mathematical concepts.

This research paper focused on finding activities for teachers with limited mathematics expertise that can improve his or her ability to communicate fundamental mathematics concepts. While no research has directly linked the depth of a mathematics teachers' knowledge of math to student achievement, there has been research which has examined the effectiveness of certain teaching techniques on improving student achievement and understanding. Developing a teacher's ability to recognize valid alternative solutions to problems and to adequately critique them could make a difference in affecting student perceptions of mathematics.

As industry lures math majors away from teaching and the need to staff math departments becomes more and more an issue, identifying actions that can assist mathematics teachers in the classroom has become more important. It might happen that the best candidate for a mathematics teaching position will not have much teaching experience or math experience. Perhaps mathematics department chairs as well as school administrators would want to then try and make up the difference by offering practical assistance for this teacher. Perhaps credentialing programs can use this information in establishing standards for preparing mathematics educators.

In this study the term *fundamental mathematical concept* refers to an abstract idea that can be applied across several different areas of mathematics. For example, the concept of symmetry would be a fundamental mathematical concept since it has applications in geometry, algebra, and other areas. Practical activities refer to activities that have been shown to correlate with increased student comprehension or achievement.

Review of Current Literature

The results of the recent Third International Mathematics and Science Study (TIMSS) and National Assessment of Educational Progress (NAEP) have led many people to believe that graduates from American high schools are less prepared mathematically than students from other countries. Could it be that American students are not as bright as students in other countries? Perhaps American students are just not good test takers? In this current era of accountability neither of these possibilities is politically acceptable. Rather, politicians and the media have been focused on determining who is responsible for American students ranking below so many other countries. Some policymakers have identified teachers as an important source of the problem. For example, the report *Before It's Too Late,* written by a national committee chaired by John Glenn, raised concern as to the quality of classroom teachers with regards to mathematics ability (DOE, 2000).

The problem is that there is no precise method for measuring a teacher's mathematics ability. Imagine two high school teachers, one who holds a degree in English and the other holds a degree in chemistry. Who would be a better mathematics teacher? Since chemistry requires the use of mathematics a reasonable conclusion would be that the person with the degree in chemistry is more knowledgeable in mathematics. However, suppose the person with the English degree worked for three years as a land surveyor. Given this new information, it becomes more difficult to judge who would be a better mathematics teacher.

While no formal methodology for ranking people on their knowledge of mathematics exists, education research has identified factors that influence mathematics instruction. As a result, the issue of improving a teacher's mathematics instruction ability must include a discussion of three major areas. The first is the identification of factors that influence mathematics instruction. Second is finding out what the mathematics curriculum expects of teachers. Third, it is necessary to identify the subject-area abilities that are necessary for a teacher to implement the curriculum. It is important to point out that differences exist when dealing mathematics education on the high, middle, and elementary school levels. While this particular literature review will attempt to focus on the teaching of mathematics in secondary schools since the results of one study suggest that one way to improve mathematics education on the middle school level is to concentrate on developing a math teacher's classroom management abilities (Tooke, 1997).

What are the qualifications for becoming a mathematics teacher? The answer seems to depend on who and when you ask. Consider the perspective of a high school administrator who is desperately seeking an Algebra 1 teacher but can not find a candidate with a degree in mathematics. As a result of the reported teacher shortage, high school principals are faced with making this kind staffing decision each year. Of all the courses of action, using substitute teachers, hiring underqualified teachers, and reassigning other teachers are the most often utilized practices (Ingersoll, 1999). This has led to the rise of a phenomenon referred to as *out of field teaching.*

Out of field teaching occurs when teachers are assigned to courses that might not fall within their area of training and expertise. This phenomenon has become more and more common over the last decade. A 1996 study concluded that one quarter of all high school students taking a math course were being taught by a teacher who did not hold at least a college minor in mathematics (Ingersoll, 1996). Baker and Smith (1 997) noticed that out of field teaching was more prevalent in mathematics and science courses. This helps explain why there are people who do not hold a degree in mathematics hired to teach high school mathematics. In addition Ingersoll believes that out of field teaching contribute to lowering of teacher morale and commitment.

Nw consider what a department chair of a math department seeking a teacher for Calculus BC. The department chair may use whether a candidate holds a mathematics degree as a significant factor in evaluating a candidate's ability. While research supports the view that student learning is increased when teachers have more background preparation in the subject matter they are teaching (Monk & Rice, 1997), degree attainment alone cannot accurately measure how well a teacher is able to teach (DOE, 2000). In fact, completing college coursework in mathematics alone may not be enough to guarantee a certain depth of teacher knowledge (Jones, 1995). Even with two candidates who possess identical academic mathematics backgrounds, taking into consideration their degrees, math courses, and grade point averages, it would not be possible to infer that they teach math the same way.

At the same time, it would be impudent to completely discount the value of college-level mathematics courses in teacher preparation. Successful completion of college-level mathematics courses requires these future math teachers to explore mathematical concepts in more depth. This is significant since teachers whose knowledge of mathematics has greater depth tend to focus instruction on more conceptual aspects, while teachers with limited expertise in mathematics favor instruction characterized by rote practice and examples (Jones, 1995). For example, a teacher familiar with complex analysis is able to integrate the structure of the number system into a discussion about how many solutions exist for a fourth degree polynomial equation. The ability to address both concept and procedure simultaneously provides students more substance from which they can construct their understanding.

Research that indicates a correlation between the college mathematics training of high school math teachers and their students' level of attainment (Tooke, 1997) suggests that there are certain mathematical concepts that are important for math teachers to have been exposed to. For example, the Missouri Middle Mathematics Program identified that the study of modern algebra is a "foundational imperative for mathematics teachers" (Papick, Beem, B. Reys & R. Reys, 1999, p. 306). Resek's (2000) suggestion of courses includes probability, statistics, and discrete mathematics. While there is no consensus on the entire list of required mathematical concepts or courses for teachers, indications are that the list should not be excessive. Monk & Rice (1997) noted that there appears to be a limit to the positive effect of the number of math courses completed by a teacher and the improvement of student success.

While many people in the world possess a rich academic background in mathematics not all of them have chosen teaching careers in math. This brings up another consideration: the motivation to teach mathematics. What causes a person to become a math teacher? Some math teachers say their like of mathematics can be traced to their success at solving textbook problems or to their view of math as a clearly mandated series of steps and decisions (Jones, 1995). However, successful teaching involves more than just presenting curriculum material. Those teachers who excel have a passion for the subject. Is it possible that people who disliked mathematics in high school could go on to become highly effective, even great math teachers? Reports and studies on math anxiety make clear that teaching and learning mathematics involves a human dimension that must be considered.

Regardless of background, a teacher's confidence level in his or her mathematical ability is a crucial factor for instruction. This is especially true for elementary teachers who are more generalists in the sense they are responsible for instruction across many subject areas. For example, some educators believe that elementary math teachers avoid formally teaching a number of fundamental mathematics concepts such as logic, probability, and statistics because they feel uncomfortable with those concepts (Eckmier & Bunyan, 1995). While this does not mean that elementary students are not being taught mathematics, it does suggest missed opportunities for facilitating a student's future learning. A similar situation occurs on the secondary level when you consider the preparation of elementary teachers and out of field high school teachers to teach math. For example, an out of field teacher who is unsure about the validity of a student's alternate method for solving a particular problem may simply tell the student "you shouldn't do the problem that way." Like the elementary teacher, the out of field secondary teacher is placing limits on student engagement in mathematics reasoning, negatively affecting student potential (Mapolelo, 1999).

In addition to teacher confidence, substantial research has led many to conclude that a teacher's view of mathematics plays a significant role in the way he or she teaches math (Jones, 1995). While sources of teacher beliefs can include personal experience or reasoned insight, it must be recognized that feelings can also determine beliefs. While it may not seem that emotions would be a concern for teaching mathematics, a case can be made for regarding feelings in mathematics instruction. In teaching problem solving skills, there are times when it is useful for teachers to know what their students are feeling. Teaching requires an ability to understand what students are feeling as well as what they know and do not know. Having a sense of one's feelings towards problem solving can help a teacher become more aware of a student's progress in solving a problem (Eclunier & Bunyan, 1995).

A director for a state's department of education credentialing program or the director of a university mathematics education program might focus on additional factors in constructing a list of qualifications for teaching mathematics. While subject matter concerns would be part of the list, a portion of the qualifications would also involve fundamental teaching methodology. In fact, being able to teach mathematics is not synonymous with possessing mathematical knowledge (Masingila, 1998). There are some people who believe that degree or extensive background in a subject area should not be a major concern. Kennedy (2000) believes that a knowledge of mathematics and genuine desire are the only real necessary qualifications for allowing someone to teach math. Others believe that preparation in teaching methodology is more crucial to being a good teacher (Ingersoll, 1999) which is echoed by Papick et a1.(1999) who note that both student understanding and ability to apply mathematics is strongly dependent on how it is taught.

Over the past decade, the National Council of Teachers of Mathematics (NCTM) has set forth sweeping curriculum changes (NCTM, 2000). What used to be a curriculum stemmed in teaching rote fundamentals and detailed mathematical procedures has been replaced with the recent NCTM Standards call for teaching students broad concepts. A key factor of the proposed curriculum is changing the role of the teacher from that of disseminator of knowledge to the expert challenger who encourages students to think critically, explore, and take and active role in the learning process (NCTM, 2000). Teachers are encouraged to allow students to explore and discover mathematical concepts through real-world situations (Eckmier & Bunyan, 1995). For example, when investigating probability students should be asked to make a conjecture, perform a simulation, analyze the data, and make inferences. While teachers face the challenge to find ways to teach students of different abilities that are not procedural, great care must be taken that teaching flexible methods is not done in a procedural way (Gray, Pinto, Pitta & Tall, 1999).

How can these new curriculum goals be accomplished by teachers who themselves are unsure of their own mathematical ability? Imagine the predicament of a chemistry teacher asked to teach a course in calculus. A natural response might be a feeling of apprehension stemming from the fact that the teacher may not have used calculus in several years. This apprehension is pretty understandable: it is difficult to explain material that is unfamiliar. Yet this is the anxiety that elementary school teachers and out of field secondary math teachers face all too often.

Results of research conducted by the FATHOM program identify teacher anxiety and mathematical expertise as areas that need to be addressed in effecting the NCTM Standards at the elementary level (Eckmier & Bunyan, 1995). For instance, a teacher's lack of understanding, whether it involves in educational practices or in conceptual knowledge of mathematics, can be masked by the use of a teacher-centered delivery instructional style (Artzt & Armour-Thomas, 1999), opposite from the NCTM Standard's call for teachers to move away from strict lecture format. Another study of pre-service elementary teachers concluded that the ability to bring students to develop critical thinking skills and promote discovery will depend on the ability of teachers to expand their instructional strategies from procedural to conceptual (Reinke, 1997).

While the ability to address these concerns can be built into a credentialing program for pre-service teachers, what can be done to help current classroom teachers? A study of 45 elementary teachers that focused on their perception of their mathematics background revealed that workshops and inservice programs helped improve their confidence in their ability to teach math (Van Voorhis & Anglin, 1994). But for many current classroom teachers, confidence may not be the real issue when discussing the NCTM Standards reform of mathematics curriculum. Instead, the issue involves a more philosophic notion: how to reconcile NCTM curriculum goals and instructional practices with their own personal beliefs about the nature of mathematics.

Expecting math teachers to embrace the notion of how to teach mathematics is as proclaimed in the NCTM Standards is unrealistic, since many teachers have their math experience rooted in the traditional curriculum (Jones, 1995). Evidence of this tension can be seen in a study by Camacho, Socas, and Hernandez (1998) which indicates that while teachers highly value deduction and formal thinking, they did not believe that mathematics should be taught in a way that was formal and deductive. Thus, a focus for professional development for mathematics teachers should involve having teachers reflect and think about what it means to teach mathematics.

Another important aspect of professional development would consist in asking teachers to evaluate their own fundamental beliefs about what constitutes mathematics (Masingila, 1998). This is important in light of evidence that suggest that teacher beliefs about the nature of mathematics and what methodologies to employ in teaching mathematics can have an impact on their student's views of learning mathematics (Carter & Norwood, 1997). The research of Camacho, Socas, and Hernandez (1998) further highlights this connection between beliefs and instruction when they conclude:

> There is an apparent contradiction between the ideas the student teachers have about mathematics teaching and their conceptions of mathematics. This can be seen as a cognitive obstacle, and it implies the need to implement teacher training programmes for secondary school mathematics teachers that facilitate changes in conception and attitudes towards mathematics, so that new teachers handle these curricular innovations successfully (p. 323-324).

This demonstrates that professional development of mathematics attention should not focus only on instructional methodologies, but should also include a component that brings to discussion fundamental mathematical concepts.

In addition to instructional concerns, the NCTM Standards require that teachers have the ability to assess students in ways that allows students to express their constructed knowledge (NCTM, 2000). Again, current classroom teachers are more familiar and comfortable with traditional assessment tools such as quizzes and tests, In 1984 Thompson assessed preservice teachers utilizing oral interview in an attempt to give preservice teachers firsthand knowledge of the effectiveness of performance assessments.

Research Methods and Data Sources

The research examined how engaging teachers with limited math expertise in conversation and reflection on fundamental mathematical concepts affects their teaching of mathematics. Particular attention centered on detecting whether a shift from procedural to conceptual teaching occurred and whether teacher confidence in mathematics changed. The research method took the form of a case study of a female teacher at Bellarmine College Preparatory who is teaching a math course for the first time in her teaching career. She agreed to participate and her principal gave his consent for her participation.

The study occurred over a span of two instructional weeks. Data for the case study was collected using four components: interviews, assessment skill evaluations, classroom observations, and a questionnaire. At the beginning of the two-week period, the subject completed a two-part questionnaire. The first part consisted of a Likert Scale frequency survey to assess her confidence level in teaching math.

After completing the questionnaire, the subject took part in an interview aimed to discover her perceptions of mathematics and how her perceptions relate to the methodologies she employs in teaching mathematics. After the initial interview, a classroom observation occurred that focused on characterizing her instructional techniques by identifying the percentage of procedural versus conceptual instruction. Subsequently, the subject participated in two separate conversation sessions that centered on elementary number theory topics. These conversations included an explanation of some fundamental concepts by sharing examples, discussing the historical development of the ideas, and reflecting on what relationship the concepts share with the current topic of instruction in her classes.

After these conversation sessions, another classroom observation occurred with the same focus as the previous observation. A few days after the second observation, the subject completed a questionnaire identical to the previously administered questionnaire. Finally, a follow up interview took place to see if there has been any change in her perceptions of mathematics and to investigate her perception of the conversation sessions.

The data from both questionnaires was analyzed for general shifts in confidence from the beginning to the end of the study. Additionally the questionnaires were be analyzed for changes in conceptual and procedural abilities. Data obtained from the classroom observations were summarized in tables and then analyzed for any shifts in the subject's instructional methods. The portions of the interview relating to the research topic were summarized and compared to existing research that was discussed in the literature review.

The validity of this study was enhanced by the use of multiple data points and careful design. A tape recorder was utilized when feasible to ensure the accuracy of interview responses. The reliability of this study was limited by its focus on a single case study and the short time span of the study. However, the detailed portrait that was constructed of this first-time math teacher identified issues that are worthy of further examination.

Data Analysis

The initial interview began with questions on the subject's philosophy of mathematics. She thought that mathematics was important for three reasons: a) mathematics is a good "brain exercise" b) mastering mathematics helps build confidence and c) mathematics is a stepping-stone for many other endeavors and courses. Her high school experience with mathematics was generally negative with the exception of her Algebra 1 class which she remembered as a very positive experience. She attributed this positive experience to the fact that "the teacher went really slow" which she believed was a good thing because it allowed her the ability to do well in the course. She described her Algebra 2 class as moving too fast and as soon as the class reached the topic of cosines, she knew "it was all over" and it proved to her once again that she could not do math. After dropping Algebra 2 in high school, she avoided math courses the rest of her academic career, even through college. It was not until 2001 that she decided to see if she could successfully pass an Algebra 1 course at a local community college.

Evidence suggests that over the course of the two week her definition of mathematics evolved. When asked to define mathematics, her response during the initial interview was that mathematics was like a process where one thing leads to another. She also added that she liked mathematics because it has right and wrong answers so in a sense is free from ambiguity. Her response at the post interview was two-fold. First she said that at a deep level mathematics is a way of interpreting the world around us that is so subtle that most people miss it. Afterwards she said that at an obvious level mathematics "massages your brain" and provides a mental workout. The fact that during the post interview she identified different levels of depth to her responses indicated a greater level of thought about mathematics as a whole. The use of "deep level" as one of the categories for her post interview suggests a shift from solely procedural thinking to more conceptual thinking.

Evidence supports the conclusion that her understanding of the difference between procedural and conceptual teaching increased over the course of the study. For example, at the initial interview she was not sure about the meaning of conceptual versus procedural teaching. She believed that conceptual teaching had to do with "teaching why it is the way it is" whereas procedural teaching was more about "plugging in numbers." She also pointed out that a majority of the students prefer the teaching of procedures so that they can "just get it over with" and move on to the next topic. During the post interview, she declared that conceptual teaching of mathematics was more purposeful than procedural teaching. She also said that it was too bad that more teachers did not make more connections between the material they are teaching and previous or future topics because it would help students understand and make it more interesting.

These previous statements also suggest that in addition to understanding the difference between conceptual and procedural, she also gained an appreciation of conceptual teaching that she had not previously held. During the post interview, she stated that she believed that a combination of both methods was necessary for it to make total sense to the students. When asked at the post interview how she would characterize her teaching of mathematics, she said that unfortunately the bulk of her teaching was procedural. She indicated that she knew that there needs to be a combination of both procedural and conceptual, but that until she learns more about mathematics that her ability to teach on a conceptual level is limited. Furthermore, that she used the word unfortunate in describing her teaching as mostly procedural indicated that she had attached positive value to conceptual teaching.

Data from the classroom observations showed that in terms of teacher response to student-initiated questions (Table A) a shift occurred away from procedural teaching and towards conceptual. While the percentage of student questions categorized as procedural remained the same during both observations, during the second observation she responded to procedure specific questions with more procedure general answers. This data indicates her increased awareness of conceptual teaching as well as her desire to embrace conceptual teaching.

Table A
Results of Classroom Observation Comparing Student-Initiated Questions and Teacher Response

	Procedural				**Conceptual**			
	Specific		**General**		**Surface**		**Deep**	
	Student Question	Teacher Response	Student Question	Teacher Response	Student Question	Teacher Response	Student Question	Teacher Response
Initial Visit	38%	23%	54%	69%	8%	8%	0%	0%
Post Visit	50%	0%	38%	88%	0%	13%	13%	0%

The shift towards more conceptual instruction appears in the data from the comparison of teacher-initiated instruction (Table B). The shift from procedural to conceptual indicates her attempt to move towards more conceptual teaching. The reason why the shift falls short of being more significant probably lies in the level of expertise needed to secure the ability to make meaningful connections for students.

Table B
Classroom Observation of Teacher-Initiated Instruction

	Procedural	**Conceptual**
Initial Visit	100%	0%
Post Visit	81%	19%

The data from the first part of the questionnaire detected a slight increase in her mathematical confidence (Table C). Comparing the 10 identical statements from the initial survey to the post survey, there are 5 where confidence increased, 3 with no change in confidence, and 2 where confidence decreased. One potential reason the two statements that showed a decline in confidence may stem from increased self-awareness of the subject matter or that the material that she was teaching during the post survey was less familiar than the material she was teaching during the initial survey.

Table C
Results of Mathematics Confidence Survey

Survey Question 1 Never 2 3 4 5 Always	**Initial Survey**	**Post Survey**	**Net Result**
I am able to understand the math explanations that are presented in the textbook	3.5	4	-
I encounter instances when I am familiar with the math procedure but am unable to successfully complete the procedure	3	2	-
I encounter difficulty explaining math procedures that I am familiar with	3	3	«
I encounter textbook problems where I am unsure of what procedure to use in order to arrive at the correct solution	1	2	—
I am able to explain math concepts with which I am familiar	4	4	«
I encounter math problems that I can solve without difficulty but experience difficulty explaining to others how to solve.	3	2	-
I am able to identify the math concept(s) that are necessary for solving textbook problems	4	3	—
I encounter math procedures that I am able to perform but am unsure why the procedures work	3	2	-
I have difficulty judging the validity of a student’s alternative procedure for completing a mathematical process that I am familiar with	3	2	-
Students ask questions about math concepts that I am not familiar with	2	2	«

Conclusions

An outside observer can detect the impact of engaging a novice math teacher in discussion of fundamental mathematical concepts, but the novice math teacher struggles to see a real or significant impact. When asked to comment on the usefulness of engaging in a discussion of number theory during the post interview, the subject said that the sessions were interesting but also said that some portions of the conversation sessions were over her head. The subject also said that she did not perceive any change in her perception of mathematics because she is already enamored with mathematics. However, she did say that she had never thought of math as part of the world but rather that she used to think of mathematics as more of an academic subject. As for the effect the conversations had on her teaching of mathematics, she said that she saw no connection. In her mind the conversations did not change the way she teaches mathematics other than reinforce the idea that a little explanation behind the concept will help student better understand the why.

A possible reason that the novice math teacher cannot detect any impact from the conversations on their teaching involves field of vision. For example, suppose you are looking at a map of California tracking a car's progress along a particular path. If all of a sudden the map you were looking at changed to a map of the United States the scale of the new map would affect your perception of the progress of the car. It may appear that the car is going slower because the tracking does not move as much as it did on the previous map. This is similar to what the novice math teacher may experience when broadening his or her conceptual view of mathematics. The broadening of the view makes it more difficult to perceive an increase in progress.

This research seems to confirm the fact that a prerequisite for the ability to teach mathematics conceptually is for the teacher to have expertise in mathematics. In the case of this first time mathematics teacher, informal conversation on deep mathematical concepts will not provide expertise, but it does seem to spur increased reflection on mathematics. In this particular case study, the increased reflection did seem to have the effect of shifting her instruction away from strictly procedural to include more conceptual elements.

Further research, especially in the arena of private schools where teachers often are not required to hold credentials, should focus on professional development models that effectively promote novice math teachers to begin moving away from strictly procedural teaching. If research focuses on those teachers who do not hold credentials, then perhaps the results can be extended to middle and grade school teachers whose math experience is often comparable to out of field secondary math teachers.

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Mathematical Confidence Survey

For each of the statements below please circle the value between 1 and 5 that corresponds to the frequency with which the statement occurs.

1	2	3	4	5
Never				**Always**

Statement					
I am able to understand the math explanations that are presented in the textbook	1	2	3	4	5
I encounter instances when I am familiar with the math procedure but am unable to successfully complete the procedure	1	2	3	4	5
I encounter difficulty explaining math procedures that I am familiar with	1	2	3	4	5
I encounter textbook problems where I am unsure of what procedure to use in order to arrive at the correct solution	1	2	3	4	5
I am able to explain math concepts with which I am familiar	1	2	3	4	5
I encounter math problems that I can solve without difficulty but experience difficulty explaining to others how to solve.	1	2	3	4	5
I am able to identify the math concept(s) that are necessary for solving textbook problems	1	2	3	4	5
I encounter math procedures that I am able to perform but am unsure why the procedures work	1	2	3	4	5
I have difficulty judging the validity of a student's alternative procedure for completing a mathematical process that I am familiar with	1	2	3	4	5
Students ask questions about math concepts that I am not familiar with	1	2	3	4	5

Teacher Instruction – Student Initiated

Type of Student Question	Teacher Response	Comments

CODE KEY					
First Letter			Second Letter		
P	=	Procedural	**S**	=	Specific
			G	=	General
C	=	Conceptual	**D**	=	Deep
			S	=	Surface

Teacher Instruction – Teacher Initiated

Type of Instruction	Teacher Instruction	Comments

Type of Instruction Code Key		
E	=	Example problems
L	=	Lecture/Note Presentation
G	=	Group Activities
R	=	Review

Teacher Instruction Code Key					
First Letter			Second Letter		
P	=	Procedural	**S**	=	Specific
			G	=	General
C	=	Conceptual	**D**	=	Deep
			S	=	Surface

Initial Interview Question Guide

I. Personal Philosophy of Mathematics

How would you define mathematics?
What is your experience with math?
Background and formal vs informal training, why/what credentials do you possess to teach the subject?
Why do you think math is important?
Why are you teaching math?
— Motivation, Goals, Hopes

II. The New Experience of Teaching Mathematics

Now that you are actually teaching a math class, how does it compare with what you perceived it would be like?
How does it compare to other teaching experiences you have had?
— Challenges, Differences, Similarities, Change of view, Concerns/fears

III. Views on conceptual versus procedural

What would you consider to be conceptual teaching?
What would you consider to be procedural teaching?
How are they related? How are they different?
How comfortable are you with each?

Post Interview Question Guide

I. Conversation Sessions

What are your impressions on what was discussed?
— significance for you as a teacher?
— awareness of conceptual versus procedural