2010

A survey of college math professors' reported instructional strategies in courses in which prospective teachers enroll

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A SURVEY OF COLLEGE MATHEMATICS PROFESSORS' REPORTED INSTRUCTIONAL STRATEGIES IN COURSES IN WHICH PROSPECTIVE TEACHERS ENROLL

by

Kelly Frances Finn

<u>An Abstract</u>

Of a thesis submitted in partial fulfillment
of the requirements for the Doctor of
Philosophy degree in Teaching and Learning (Mathematics Education)
in the Graduate College of
The University of Iowa

May 2010

Thesis Supervisor: Associate Professor Carolyn Colvin
Associate Professor Joyce Moore

ABSTRACT

The focus of this survey research is on the self-reported instructional strategies of college mathematics professors. Using a modified *Approaches to Teaching Inventory* (ATI-R), the survey employed demographic, Likert scale, rank order, and open-ended items to characterize the instructional strategies of a national sample of college mathematics professors. Using factor analysis, three factors (scales) were found to describe college math professors' approach to teaching: conceptual change with a focus on teachers or students, and information transmission focused on teachers. Participants were categorized as high or low on each of the three scales. Findings suggest that well defined lectures, practice problems and tests are common instructional features. More research, including observational studies of teaching will shed light on math professors' rationale for their teaching practices.

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CERTIFICATE OF APPROVAL

PH.D. THESIS

This is to certify that the Ph.D. thesis of

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To (My children Emily and Thomas I love you.)

ACKNOWLEDGMENTS

I want to thank my children Emily and Thomas for the time they gave up with me in order that I could complete this degree. I want to thank my ex-husband Andy Hasley for his help on this project. I want to thank the co-chairs of my committee Professors Carolyn Colvin and Joyce Moore for their time and consideration. Finally, I want to thank my Dad who had a seventh grade education and never stopped believing in me. Thank you for your love and support Dad and Mom.

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ABSTRACT

The focus of this survey research is on the self-reported instructional strategies of college mathematics professors. Using a modified *Approaches to Teaching Inventory* (ATI-R), the survey employed demographic, Likert scale, rank order, and open-ended items to characterize the instructional strategies of a national sample of college mathematics professors. Using factor analysis, three factors (scales) were found to describe college math professors' approach to teaching: conceptual change with a focus on teachers or students, and information transmission focused on teachers. Participants were categorized as high or low on each of the three scales. Findings suggest that well defined lectures, practice problems and tests are common instructional features. More research, including observational studies of teaching will shed light on math professors' rationale for their teaching practices.

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CHAPTER 1 INTRODUCTION

Background

The goal of this study is to describe how college mathematics professors teach undergraduate mathematics courses based on their self reports of instruction in a national survey of college and university math professors. Little research exists at this time to document the teaching practices of professors in higher education. This is a worthy area of study because there is some research (Marshall & Smith, 1997) to suggest that students learn to define good teaching based on the models they observe in college and university classrooms. My interest in this area specifically applies to the teaching models that future teachers may observe in college and university undergraduate math classrooms. A secondary goal of this research is to illuminate how college mathematics professors evaluate their instruction in terms of what they do well and where they might improve their instruction.

Mathematics education has been under scrutiny in recent years, with inputs from various national and professional groups to address the quality of instruction. Most notable is the Federal Government's enactment of the *No Child Left Behind* Act (U.S. Department of Education, 2002). A key requirement of this act is that schools hire "highly qualified" teachers, once again making research on teacher education in mathematics an important topic.

In *Before It's Too Late* (Glenn Commission report, 2000), the commission found that American schools are not educating our students in a manner that will allow them to be productive later in life The report concluded that to improve K-12 education, teacher educators must better prepare future teachers. The report states that one of the most important goals for teacher educators is to, "Increase significantly the number of mathematics and science teachers and improve the quality of their preparation" (p. 9).

This goal underscores the need to understand more about our teachers' mathematics preparation.

Recent policy has underscored the need to focus on the undergraduate mathematics preparation of K-12 teachers. Two professional organizations concerned with the preparation of mathematics teachers are the Mathematical Association of America (MAA) and the National Council of Teachers of Mathematics (NCTM). Both organizations have recommended frameworks for change in college level mathematics education (Leitzel, 1991). Underpinning these frameworks is the philosophy that students are learners who construct knowledge through their interpretations of the world around them (Roth-McDuffie, McGinnis, & Watanbe, 1996).

Two other organizations involved in mathematics education are the Conference Board of the Mathematical Sciences (CBMS) and the American Mathematical Society (AMS). CBMS is an umbrella organization whose members are the presidents of sixteen professional associations in the mathematical and statistical sciences including the AMS and the Mathematical Association of America (MAA). Every five years since 1965, the Conference Board of the Mathematical Sciences (CBMS) has sponsored a national survey of undergraduate mathematical and statistical sciences in two and four-year U.S. universities and colleges. The CBMS 2000 survey indicated that the "the predominant instructional modality continued to be the standard lecture model" in undergraduate mathematics classrooms (CBMS, 2000, p. 126).

In 2001, CBMS sponsored a report titled, *The mathematical education of teachers,* which called for rethinking the mathematical education of teachers at U.S. colleges and universities. All prospective secondary mathematics teachers enroll in methods courses where they learn how to teach mathematics. During their field experiences they typically observe two main models of teaching: one in college mathematics courses and one in K-12 mathematics courses (Calderhead, 2006) The CBMS authors concluded that "often, neither of these models suffice for the demands of current high school curricula" (p.142, CBMS, 2001). Wu (2005), a mathematician and critic of many practices in the mathematics education community stated that "teaching prospective teachers make heavy demands on the instructor's pedagogical competence in addition to mathematical competence. This is because the teaching style of prospective teachers is more likely to be influenced by what they observe in their instructor's teaching than by what they are told" (Wu, 2005, p. 41). In the study reported here, the teaching strategies of college mathematics professors are surveyed and described in order to learn more about the mathematic models of teaching prospective teachers observe.

Renewed interest in mathematics preparation of teachers is not only noted in reform policy initiatives, but also in recent research studies (e.g., Wilson, Floden & Ferrini-Mundy, 2002; Putnam & Borko, 2000). According to these studies, two key sources of mathematical knowledge for pre-service teachers are high school and college courses. High school math classes tend to be teacher-centered, with students expected to receive information, memorize facts, and become proficient at using mathematical procedures (Ball, 1990; Grossman, 1991; Schifter, 1993).

Pre-service teachers' mathematical education may send the message that rote learning is sufficient (Borko, Eisenhart, Brown, Underhill, Jones, and Agard, 1992). Though this message is not supported by existing research, preservice teachers are still likely to absorb it and to reify it in their own teaching. Further, Cooney (1999) and Knuth (2002) both conclude that pre-service teachers do not experience mathematic instruction as undergraduates that enables them to build deep mathematical understanding when they go on to teach their own students. Rote learning does not substitute for understanding mathematical concepts (Borko et al., 1992). College mathematics professors tend to teach mathematics in a procedural manner, where rote learning is emphasized and learners are considered to be more passive than active (Von Minden, Walls, and Nardi, 1998). Students are active only in terms of being receptors of information given to them by the teacher.

One important aspect of teacher education in mathematics involves increasing teacher knowledge. Shulman (1987) identified a minimum of seven knowledge bases for teaching: (1) content knowledge, (2) pedagogical knowledge, (3) curricular knowledge, (4) pedagogical, content knowledge, (5) knowledge of students, (6) knowledge of context, and (7) knowledge of educational goals. Of particular interest to this study are two areas: content knowledge and pedagogical content knowledge. Content knowledge is the understanding of a discipline's key facts, concepts and principles. Pedagogical content knowledge enables an instructor to present a discipline's topic in a way that students can understand.

Shulman (1986) explains the importance of these domains of teacher knowledge by stating, "the key to distinguishing the knowledge base for teaching lies at the intersection of content and pedagogy, in the capacity of the teacher to transform the content knowledge he or she possesses into forms that are pedagogically powerful and yet adaptive to the variation in ability and background presented by the students" (p. 15). The current study describes the instructional strategies of college mathematics professors as an exploratory step toward addressing the implications for how pre-service teachers may learn pedagogical content knowledge.

More recently, educational researchers have characterized the state of U.S. teachers' pedagogical content knowledge: "American teachers aren't incompetent, but the methods they use are severely limited, and American teaching has no system in place to get better. It is teaching, not teachers, that must be changed. (Stigler & Hiebert, 1999, book jacket). There is a need to move beyond placing the blame on teaching and attempt to understand who legislates, influences or mandates systems of teaching and defines what should be changed. How can teacher educators learn more about why teachers' methods are limited?

Lortie (1975) suggests that the time spent as a student is an "apprenticeship of observation" and "these images of teaching are difficult to overcome" (p. 65). Further,

> Experiences as students provide prospective teachers with memories of strategies for teaching specific content. Teachers' knowledge of content becomes confounded with their knowledge of instructional strategies, since what prospective teachers learned is tied to how they were taught. (Lortie, 1975, p. 61)

The impact from the college classroom experience may be particularly strong for secondary education preservice teachers because they complete an academic major in a subject that they will later teach themselves (Grossman, 1990). Because prospective secondary mathematics teachers spend more time in college mathematics classes than elementary teachers, they may be more influenced typically by the instructional strategies particular to those classes.

The preparation of secondary mathematics teachers is an important issue and the college mathematics classroom is a place to begin this research. Academic and professional groups, such as the CBMS and the AMS have recommended that college mathematics professors include a variety of teaching strategies in their instruction (CBMS survey, 2000) and this research project is a first step toward the documentation of the teaching strategies of college math professors.

The process of learning to teach and learning to teach effectively is complex. Research has explored how primary and secondary teachers learn to teach mathematics. For example, researchers have examined the role of subject matter knowledge in teaching place value (Ball, 1991). Teachers' subject matter knowledge "interacts with their assumptions and explicit beliefs about teaching and learning, about students, and about context to shape the ways in which they teach mathematics to students" (Ball, 1991, p. 1).

In the United States, research on learning to teach at the college level has not been investigated as thoroughly as teaching in primary and secondary classrooms. In Australia, on the other hand, researchers have begun to focus on the teaching strategies and teaching philosophies of college professors. For example, Willcoxson (1998) focused on the relationship between academics' personal learning strategies and their preferred teaching modes. Interviews were conducted with 15 professors from four different disciplines (engineering, mathematics, nursing, and psychology) and with 23 of their students in a large Australian University. Students evaluated the teaching effectiveness of lectures by rating the lectures on comprehensibility, structure, and enthusiasm. Willcoxson's results indicate that five out of six professors who prefer to teach by lecture indicate a personal preference for learning through independent rather than group-based activities. Although the lecturers who enjoy group-based learning do not generally introduce small group work into the lecture time, "they do seem to pay more attention to the interpersonal or emotional dimensions of teaching and learning than do the lecturers who prefer to learn through reading or other essentially solitary activities" (Willcoxson, 1998, p.6).

In the United States, we need more research on the way mathematics is taught in courses taken by pre-service teachers. Studies have typically not focused on the instructional models observed by pre-service teachers. Instead, research in mathematics education has traditionally focused on elementary or secondary classrooms. More research is needed to understand pre-service teachers' content knowledge (Stigler & Hiebert, 1999). Indeed, many studies have "portrayed the beginning teacher as the central problem in teacher education" (Wideen, Mayer-Smith & Moon, 1998, p. 168).

In 2001, the members of the CBMS organization called for rethinking the mathematical education of teachers at U.S. colleges and universities. One of the report's key recommendations for mathematics departments is to develop courses that confer on future teachers an in-depth understanding of the mathematics that they will be later be teaching. Studies such as the one described here are important because preservice teachers may learn approaches to teach mathematics by what they observe in their undergraduate mathematics classes.

Research Questions

In order to better understand the teaching models observed by pre-service mathematics teachers in college mathematics classrooms, this study characterizes the instructional strategies of college mathematics professors. The following questions guided this research:

1. What are the instructional methods that college mathematics professors use?
2. How do college mathematics professors evaluate the effectiveness of their instructional practices?

Significance of the study

Since 2002, with the enactment of the federal *No Child Left Behind* Act, the need to improve the quality of teaching in our schools has been seen as an important part of the national agenda. One way to improve the quality of teaching in U.S. schools is to improve the preparation of K-12 teachers. With respect to mathematics, "Teachers draw largely on their experiences in learning mathematics and are predisposed to teach mathematics by telling. Teaching by telling means to state facts and demonstrate procedures to their students." (Smith, 1996, p. 387). The interdependent nature of teaching and learning processes should be studied if teacher educators are to understand more about how to improve the mathematics preparation of K-12 teachers.

Pre-service teachers take courses both in education and mathematics that emphasize content knowledge and pedagogy. In many math education methods courses, students may explicitly learn about effective teaching. However, research suggests that students learn about teaching through all their classroom experiences (Marshall & Smith, 1997). This suggests that students may learn about mathematics pedagogy in their college mathematics courses. Knowing the instructional environments of pre-service teachers is an important step to understand more about the opportunities they have to learn.

Educational reform efforts have focused on describing the difficulty of learning to teach math. For example, Graves, Suurtamm, and Benton (2005) study explored the professional development experiences that help beginning teachers develop a deeper understanding of mathematics and mathematics teaching so that they will facilitate effective mathematics inquiry in their classrooms. Grave et al.'s findings suggest that even when beginning teachers have experienced learning about mathematics in a reform-oriented learning environment and acknowledge this approach as supporting mathematical learning, when they are presented with an opportunity to teach using an inquiry approach there often remains a tension between the reform-oriented and traditional approaches which interferes with implementing an inquiry approach. This means that often once a traditional approach to teaching is learned it may hinder the implementation of a reform-oriented inquiry approach; even when they know that this approach supports mathematical learning and have had professional development experiences in this area.

If pre-service teachers learn mathematics and mathematics pedagogy in their college mathematics classes, then teacher educators must turn their attention to these classroom opportunities. The opportunity to learn (OTL) concepts provide an avenue for this concept to be examined. The OTL concepts were first studied in the 1960s (cf. Grouws & Cebulla, 2000). They were implemented when teachers were asked to rate the extent of student exposure to particular mathematical concepts and skills (Husen, 1967). Strong positive correlations were found between OTL scores and mean student achievement scores.(Grouws & Cebulla, 2000). The study reported in this document is unique because it characterizes college mathematics professors' instructional strategies and may have implications for increasing our understanding of the opportunities future teachers have to learn mathematics pedagogy. These opportunities to learn mathematics pedagogy may impact how these students teach future students.

Overview of study methodology

The survey population for my study consisted of members from two professional organizations: The Mathematical Association of America (MAA) and the American Mathematical Society (AMS) who teach college mathematics courses taken by secondary preservice teachers. These instructors were asked to participate in an electronic inventory of teaching approaches. The electronic inventory contained ten demographic items, twenty-two survey items, and two open-ended questions. (See appendix A for The revised *Approaches to Teaching Inventory-R* (ATI-R) (Trigwell and Prosser, 2004), and seven additional items were used to characterize the instructional strategies reported by college mathematics professors.

Organization of the dissertation

Chapter two provides a review of the literature associated with the reform of school mathematics and continues with a review of related literature on models for teaching, research on instructional strategies, and closes with a review of undergraduate mathematics teaching. Chapter three explains the methods used in this study. Chapter four presents the data and analyses from the study. Chapter five discusses the conclusions, limitations, and implications of this study.

CHAPTER 2 REVIEW OF THE LITERATURE

This chapter examines literature on the reform of school mathematics and its relationship to the teaching of mathematics at the K-12 and college level. The chapter provides a context for the calls for reform in the teaching of mathematics. I explore the research on Models of Teaching and Instructional Strategies as a way to represent the models of teaching available to teachers of mathematics. I then discuss the research on how individuals learn to teach, which is followed by information on the preparation of math teachers. I conclude Chapter Two by describing the connections between teaching and learning in mathematics.

Reform of school mathematics

National commissions and professional societies such as the National Research Council, the Fordham Foundation, and the American Federation of Teachers are concerned with the future of teacher preparation programs. (Wilson, Floden & Ferrini-Mundy, 2002). The debate is both about how much we know and what we should do (Darling-Hammond, 2000). One way to understand teacher preparation is to investigate the opportunities pre-service teachers have to learn pedagogical content knowledge in the college mathematics classroom.

Reform of K-12 Mathematics Education

For the last twenty years, research at the primary and secondary level has described what it means to teach for conceptual understanding in math (Hiebert & Carpenter, 1992). More specifically, “there are direct parallels between the way a teacher is taught and the instruction they implement in their classroom as a result” (Hiebert & Carpenter, 1992, p. 90). One implication to follow from this study is to continue to expand research on the relationship between the instruction that preservice teachers experience and the kind of instruction they later implement.

The NCTM *Standards* (1989, 1991, and 2000) documents describe an ambitious vision for school mathematics. Part of this ambitious vision is the principles for school mathematics that provide guidance in making decisions. A major point in the report is that "Effective mathematics teaching requires understanding what students know and need to learn and then challenging and supporting them to learn it well" (NCTM, 2000, p. 16).

Further, pedagogical knowledge is described as "knowledge that helps teachers understand how students learn mathematics, to be able to use a range of different teaching techniques and instructional materials, and organize and manage the classroom" (NCTM, 2000, p. 17) which is consistent with Shulman's definition of pedagogical content knowledge. The NCTM authors conclude that this kind of knowledge is beyond what most U.S. teachers experience in their preservice mathematics courses.

Models of teaching

During the past 40 years, theoretical models for teaching have undergone change. Early approaches to teaching and learning were based on a transmission model (Blumenfeld, Marx, Krajcik & Soloway, 1997). In this model the main focus is on the teacher's organization of material and clear explanations. Most of a lesson plan is based on "telling" the students what they need to learn (Smith, 1996). Information or content passes directly from the teacher to the students.

Direct instruction

An approach to teaching based on the transmission model of teaching and learning is direct instruction. The term direct instruction has been commonly used to refer to behaviorally based instructional strategies that are directly related to increasing achievement in basic academic skills. Specifically,

> Instructional practices are considered to be *direct* if the explicit purpose of instructional activities is to increase student achievement in basic education and if instruction emphasizes teacher behaviors and variables related to classroom structure, such as small-group instruction, teacher

> direction of learning, academic focus, high rates of accurate responding, controlled practice, use of higher cognitive-level questions, group responding, independent practice, and feedback to student responses, (Rosenshine, 1978, 1979).

There are a number of different approaches to direct instruction, varying in specificity (e.g., Good, Grouws & Ebemeier 1979). For example, the University of Oregon Model of direct instruction puts considerable emphasis on task demands and their presentation in the instructional sequence. This approach to direct instruction developed out of the work of Englemann, Bereiter, and Becker with disadvantaged children (Becker & Carnine, 1981; Bereiter & Engelmann, 1966). The main features of this specific type of direct instruction approach are: scripted instructional strategies, highly prescribed curricula and classroom procedures, frequent interaction between teacher and students, grouping of students by performance level, and tracking. In this approach, learning is accelerated when: (1) instructional presentations are clear, (2) the teacher rules out likely misinterpretations, (3) the teacher facilitates generalizations, (4) lessons are fast-paced, carefully scripted, and tightly sequenced.

A direct instruction lesson plan is appropriate when the teacher wants to communicate specific knowledge, to introduce new vocabulary, or to teach certain procedures. In a direct instruction lesson, the teacher has more control than in an investigative/problem-based lesson, and the lesson generally has a tighter focus (Reys & Lindquist, 2004).

A form of direct instruction widely used at the college level is the lecture method of teaching. The lecture method of teaching is defined as: an exposition of a given subject delivered before an audience or a class, as for the purpose of instruction (Pickett, et al., 2000). There are many formulations of the lecture method of teaching; however, ultimately the basic idea in lecturing is to teach by telling. Wu (1998) refers to lecturing as the “sage-on-the-stage” method:

> The professor gives an outline of what and how much students should learn, and students do the work on their own outside of the 45 hours of class meetings. Lecturing is one way to implement this contract. It is an

> efficient way for the professor to dictate the pace and convey his vision to the students, on the condition that students would do their share of groping and staggering towards the goal on their own. It should be clear that without this understanding, lectures would be of no value whatsoever to the students (p. 5).

In Wu's "sage-on-the-stage" method it is imperative that students understand their responsibilities and do the work of learning outside of class. Wu's rationale for using this method is that it is the most time-efficient method of teaching mathematics in that the struggle to learn new concepts is done outside of class. Wu goes on to say that "lecturing is an effective way of teaching in a university—and for that matter in grades 7-12 so long as our education system stays the way it is" (p. 3). According the Wu, the lecture method maybe an appropriate way to teach prospective secondary teachers because he believes the lecture method is an effective way to teach secondary school students. However, Wu (2002) later wrote that teaching preservice teachers "makes heavy demands on the instructor's pedagogical competence in addition to mathematical competence. This is because the teaching style of preservice teachers is more likely to be influenced by what they observe in their instructor's teaching than by what they are told" (p.41). Today, many transmission approaches to teaching such as "direct instruction increasingly include a cognitive element" (McInerney, 2005, p.589). Thus the actual implementation of these transmission models may include aspects from other models of teaching.

<u>Transformation models of teaching</u>

"In contrast to transmission models which focus on the teacher, the focus of transformation models is on "the cognitive processes that are engaged by students as they learn" (Blumenfeld, et al., 1997, p. 824). Inherent limitations of the transmission model brought about new thoughts on how learning occurs. The focus on what the teacher in transmission models may have limited our knowledge of how instructional practices actually shape learning. Consequently, theorists began to focus on the student's cognitive processes.

Turning attention to the student's cognitive processes led to the development of the transformation model of teaching (Blumenfeld, et al., 1997). Like the transmission model of teaching, there are many formulations of the transformation model, e.g., the information processing approach, individual construction, and social constructivism (Blumenfeld, et al., 1997).

Instructional strategies

Models of teaching refer to sets of instructional strategies designed to help students attain certain types of learning outcomes (Joyce, Weil, & Calhoun, 2003). Thus, instructional strategies and lesson plans are parts of these larger models of teaching. In a model of teaching, "alternative instructional strategies are associated with different instructional goals which are all geared toward increasing students' capabilities for future learning" (Morine-Dershimer & Kent, 1999, p.27). Thus, particular instructional strategies are connected to particular types of student learning. All teaching models and instructional strategies are part of general pedagogical knowledge.

College mathematics teaching

Every five years since 1965, the Conference Board of the Mathematical Sciences (CBMS) has sponsored a national survey of undergraduate mathematical and statistical sciences in two-year and four-year U.S. universities and colleges. CBMS is an umbrella organization whose members are the presidents of sixteen professional associations in the mathematical and statistical sciences, including the American Mathematical Society and the Mathematical Association of America.

The 2001 CBMS report is geared toward Mathematics departments and one of its general themes is the special nature of the mathematical knowledge needed for teaching. This report was written to improve mathematics department programs for prospective math teachers.

Among the core recommendations are:

(1) Prospective teachers need mathematics courses that develop deep understanding of the mathematics they will teach.

(2) Courses on fundamental ideas of school mathematics should focus on a thorough development of basic mathematical ideas. All courses designed for prospective teachers should develop careful reasoning and mathematical "common sense" in analyzing conceptual relationships and in solving problems.

(3) Along with building mathematical knowledge, mathematics courses for prospective teachers should develop the habits of mind of a mathematical thinker and demonstrate flexible, interactive styles of teaching. (CBMS, 2001, p. 8).

Little is known about the extent to which interactive teaching methods are used in college mathematics courses for prospective teachers. The fourth and final recommendation states that "teachers need to learn to ask good questions, as well as find solutions, and to look at problems from multiple points of view. Most of all, prospective teachers need to learn how to learn mathematics" (p. 8, CBMS, 2001).

This last recommendation points to the connection between teaching mathematics and learning mathematics. How can we expect teachers to teach mathematics, when many may have not learned how to learn mathematics? How can we expect new teachers to teach using a variety of instructional strategies when they may have not seen this in their college math classes?

The Mathematical Education of Teachers (CBMS, 2001) uses research on learning and teaching to make recommendations to mathematics departments about the education of mathematics teachers, The goal of the report is "to stimulate efforts on individual campuses to improve programs for prospective teachers" (CBMS, 2001,p. xi). Along with these calls for change, the report suggests that one of the important factors in student achievement is the teacher. For example, Rowan, Correnti and Miller (2002) found that in well-specified models of academic growth, teacher effects on elementary school students' growth in mathematics achievement are substantial, with effect sizes ranging from .72 to .85. Thus, the preparation of K-12 teachers should be a focus of the reform of mathematics education in the United States.

Research on Learning To Teach

The research literature on the process of learning to teach at the primary and secondary levels includes studies that examine the beliefs and instructional practice of classroom teachers (Stipek, Givvin, Salmon & MacGyvers, 2001). This large literature base on teaching has begun to be used in parallel studies done at the college level. For example, Willcoxson (1998) examined the factors underlying the approaches to teaching and the teaching strategies adopted by instructors in four different academic disciplines.

Willcoxson investigated the impact of academics' learning and teaching preferences on their teaching practice. Interviews were conducted with 15 college professors and 23 of their students in a large Australian University. Results indicate that five out of six professors who like to teach by lecture expressed that it comes from their personal preference for learning through independent rather than group-based activities. Although the lecturers who enjoy group-based learning do not generally introduce small group work into the lecture time, "they do seem to pay more attention to the interpersonal or emotional dimensions of teaching and learning than do the lecturers who prefer to learn through reading or other essentially solitary activities" (Willcoxson, 1998, p.6).

The results of this study (Willcoxson, 1998) suggest that some professors may not sufficiently reflect upon or question students about whether learning is actually occurring as a result of their teaching. Results of the study showed wide discrepancies between teachers' perceptions of what students do in lectures and students' reports of what they do in lectures.

Willcoxson concludes,

> Perhaps due to a lack of systematic training for teaching or reflective practice, these academics seem mostly either not to interrogate the educational efficacy of their teaching practices beyond questions of what worked well for them or to be unaware of alternative strategies they might use to better facilitate student learning in lectures (p.4).

Further, Raman (1998) states that when college math teachers teach first year courses, which need special sensitivity, they are teaching mathematics at a level of sophistication far below their full competence (as far as mathematical material goes). Someone teaching material far below their potential, much like elementary teachers do, may require help in learning how to teach this content at the students' level.

Finally, extrapolating from the research on the process of learning to teach at the primary and secondary level, college mathematics teachers' beliefs and perceptions about the nature of mathematics teaching must influence their instructional decisions. Many college math professors belong to the Mathematical Association of America (MAA) or the American Mathematical Society (AMS). These groups are among those to suggest changes in the way undergraduate mathematics is taught. For example, the MAA's Preparing Mathematicians to Educate Teachers (PMET) project is funded to provide assistance to college and university mathematicians in finding appropriate instructional strategies for helping future teachers connect their college mathematics to the mathematics they will teach (Katz & Tucker, 2003).

A concept paper titled "Finding Common Ground in K-12 Mathematics Education" published by the American Mathematical Society (2005) has been influential in identifying some common areas of agreement about mathematics education. The authors include two research mathematicians, three mathematics educators, a senior vice-president and math and science policy advisor for a major American technology corporation. Areas of agreement on instructional methods in the document are:

- Students can learn effectively via a mixture of direct instruction, structured investigation, and open exploration.

- Decisions about what is better taught through direct instruction and what might be better taught by structuring explorations for students should be made on the basis of the particular mathematics, the goals for learning, and the students' present skills and knowledge.

In summary, the Common Ground authors agree that "making good decisions about the appropriate pedagogy to use depends on teachers having a solid knowledge of the subject" (p.1058). Thus, some mathematicians and math educators agree that mathematics content knowledge and pedagogy are inter-connected and need to be studied together.

Mathematics teacher preparation

Mathematics content knowledge has been an important part of the preparation of K-12 teachers for many decades. Krauss, Baumert, and Blum (2008) state there is wide consensus that teacher's domain-specific knowledge is an essential ingredient of high-quality instruction, especially in the mathematics classroom (e.g., Ball, Lubienski, and Mewborn, 2001). The research on the link between teacher knowledge and instructional outcomes has been either theoretical (e.g., Shulman, 1986; 1987) or based on indicators such as university grades, number of subject matter courses, or questionnaire data on beliefs.

Ma's book (1999), *Knowing and Teaching Elementary Mathematics* documented some of the issues involved in having a surface understanding of mathematics topics. Ma used a comparative method of analysis of elementary mathematics teaching in the U.S. and China, detailing what teachers know and can do mathematically. This book is particularly relevant to this study because many college mathematics professors have read it and acknowledge the importance of developing a profound understanding of fundamental mathematics.

Ma's study described the subject matter knowledge needed for teaching as a profound understanding of fundamental mathematics (PUFM). By profound understanding, she means "an understanding of the terrain of fundamental mathematics that is deep, broad, and thorough" (Ma, 1999, p. 120). This in-depth comparative study of 23 U.S. and 72 Chinese elementary school teachers reported that while both could do and explain procedures, the vast majority of Chinese teachers had a thorough conceptual understanding of such topics as place value, whereas many U.S. teachers did not.

What inferences might we draw from Ma's study? One possibility is that undergraduate mathematics courses are not addressing the kinds of mathematical understanding prospective teachers need. More specifically, Schoenfeld (2002) explains that

> Teaching for mathematics understanding is hard. It requires a deep understanding of the mathematics involved and of how to create instructional contexts that lead students to engage with mathematics in meaningful ways. The vast majority of today's American mathematics teachers learned the traditional curriculum in the traditional way. Hence they neither have models nor experience teaching in the ways that would best facilitate their student's development of mathematical understanding (p. 20).

In the current study, the instructional strategies reported by college mathematics professors are characterized as a way to begin to better understand the learning opportunities pre-service teachers have in their undergraduate mathematics courses.

Connections of teaching to learning mathematics

One tenet of reform teaching stresses the importance of teachers as learners. The connections of teaching to learning used in the current study are based on research done on student learning.

Connections of Learning Approach to Learning Outcome

A number of researchers have identified three qualitatively different approaches to learning (e.g., Biggs, 1978; Entwistle and Ramsden 1983; Marton, Hounsell &

Entwistle, 1997). The three qualitatively different approaches by students to learning are labeled deep, surface, and achieving or strategic (Trigwell & Prosser, 2004). Deep and surface approaches to learning have been identified in a variety of student learning activities from specific reading tasks (Marton and Saljo, 1997) to approaches to study in general (Biggs, 1987) and in all disciplines typically found at a university (Prosser & Trigwell, 1999).

There is substantial qualitative evidence that reports on the differences between deep and surface approaches to learning (e.g., Biggs, 1978; Entwistle & Ransden, 1983). The phrase “deep processing” was first used in mathematics education by Marton and Saljo (1976) to describe qualitative distinctions in how students respond to a learning task. Deep learning (Biggs 1987, 2003; Tagg, 2003) is described as an approach to the learning process which focuses on meaning making. This is in contrast to a surface approach which relies on rote memorization to earn a grade or pass a test in order to avoid failure. Deep learning can occur when students make connections and formulate personal meaning. Evidence of deep learning approaches can be seen in student’s use of strategies such as discussing ideas with others, asking questions for deeper understanding, applying information to real-world situations, and integrating concepts to prior learning (Schreiner & Louis, 2005). Research on the connection of a particular approach to learning and the quality of the learning outcome produced has been studied.

Recent studies have documented the connections of approaches to learning and the quality of learning outcomes. Marton and Saljo’s (1997) study documented that qualitatively deeper approaches to learning are related to higher quality learning outcomes. Finally, Ramsden’s (1992) study suggests that students’ awareness of their learning environment is related to the approaches of learning they adopt. Thus, the link from learning approach to learning outcome to learning environment is documented and this work provided the necessary ground to begin to examine the connections of learning to teaching.

Connections of Students' and Teachers' Approach to Learning

The connection of learning to teaching have begun to be examined in college classrooms because learning is a shared responsibility between students and instructors and it is important to determine whether instructors emphasize deep approaches to learning (Nelson, Shoup, Kuh & Schwarz, 2007). In their 1999 study, Trigwell, Prosser, & Waterhouse examine teaching in college classrooms by investigating the relations between the teaching approach and the students' learning approach. Figure 1 displays the aspects of teaching and learning included in Trigwell et al.'s 1999 study. Trigwell et al. investigated the missing link between the teacher's approach to teaching and the student's approach to learning. A teaching approach inventory was derived from interviews with 48 university chemistry and physics professors and a modified approach to learning questionnaire was administered to 3956 of their students at Australian universities (Trigwell, Prosser & Waterhouse, 1999). The Approaches to Teaching Inventory is one of several that derive from the work in student learning of Marton & Saljo (1976).

Trigwell et al. (1994) identified for instructors of first-year physics and chemistry courses five different approaches to teaching, consisting of four intentions and three strategies. The four instructional intentions are to: transmit information, acquire the concepts of the discipline, develop their conceptions, and change their conceptions. The three strategies are: teacher-focused, teacher/student interaction, and student-focused. The teacher/student interaction strategy is seen as a link between the teacher-focused and student-focused strategies. The five different approaches identified are:

4.1 a teacher-focused strategy with the intention of transmitting information
4.2 a teacher-focused strategy with the intention that students acquire the concepts of the discipline
4.3 a teacher/student interaction strategy with the intention that students acquire the concepts of the discipline

4.4 a student-focused strategy aimed at students developing their conceptions
4.5 a student-focused strategy aimed at students changing their conceptions

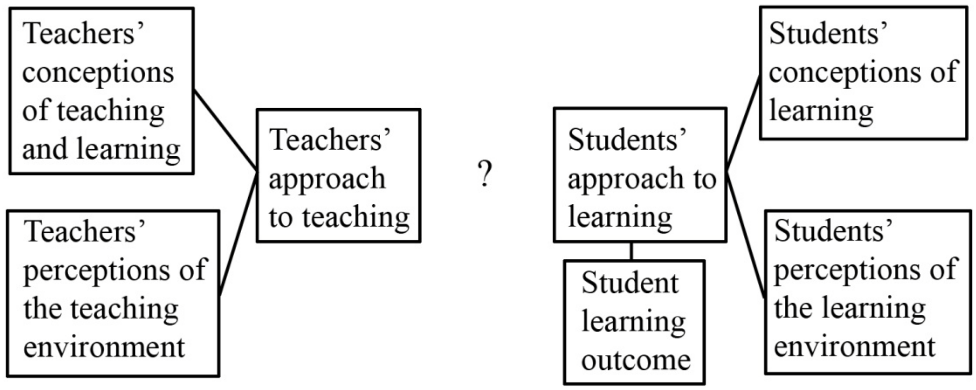

Figure 1. Link between teacher-focused and student-focused strategies (Trigwell, Prossser, and Waterhouse, 1999).

Trigwell et al.'s major finding is that teachers who reported adopting more of a teacher -focused approach to teaching have students who themselves report adopting a more surface approach to learning. Students who adopt a more surface approach to learning do "surface-level processing" which means to focus on the information and rote memorization techniques (Tagg, 2003; Biggs, 1989). With surface approaches, the goal of studying for a test or exam is to avoid failure, instead of grasping key concepts and understanding their relation to other information and how that information applies to other circumstances. This result is significant because studies of student learning have consistently shown that surface approaches to learning are related to lower quality learning outcomes (Marton and Saljo, 1976; Trigwell and Prosser, 1994; Ramsden, 1992).

Trigwell and Prosser (1996) showed that the strategy adopted by these teachers often matches the intention they have for their teaching. From this study came the two teaching approach scales in the *Approaches to Teaching Inventory-Revised* (ATI-R, 2004) (Appendix A).

Other researchers report similar findings. For example, Kember (1997) reviewed 13 studies of professors' conceptions, orientations, and beliefs about teaching. This review organizes the conceptions identified in the individual studies under two orientations that can be viewed as two poles of a continuum: teacher-centered/content oriented and student-centered/learning oriented. Each orientation is divided into two subordinate conceptions which are: a) imparting information and transmitting structured knowledge, and b) facilitating understanding and conceptual change/intellectual development. A transitional or intermediate conception between the two orientations is student-teacher interaction/apprenticeship.

More recently, researchers have used the ATI as a pre and post measure to assess the impact of a professional development program on faculty approaches to teaching (Light, Calkins, Luna & Drane, 2009). Using the ATI, these researchers "have distinguished between faculty who are concerned with teaching as essentially an organization of the content of the teacher's knowledge for transmission to the students and those who regard teaching as facilitating their student's personal construction of knowledge" (Light, Calkins, Luna & Drane, 2009, p. 168).

Findings from this study emphasize the importance of documenting the instructional strategies of college mathematics professors as a way to determine the adoption of a variety of teaching approaches. The current study characterizes the reported instructional strategies of college math professors using the ATI because of the extensive body of research on student learning on which it is based. Existing research has not documented the extent to which college mathematics professors are adopting a variety of instructional strategies.

CHAPTER 3 RESEARCH METHODOLOGY

General research perspective

Using an electronic survey, I examined the self-reported instructional strategies of college mathematics professors in order to better understand the kind and quality of instruction in college mathematics classrooms. A survey is an appropriate method to describe the characteristics of a large group at a particular point in time (Dillman, 2000). A pilot study was conducted to refine the research measures.

Participants

The participants in this study were college and university mathematics professors who teach undergraduate math courses taken by preservice secondary math teachers. The combined membership list of the American Mathematical Society (AMS) and the Mathematical Association of America (MAA) was used to create a database of email addresses.

Representativeness of the sample

The combined membership list of the AMS and MAA is representative of college mathematics professors working in the United States because according to Carol Hill, Director of membership at the AMS, 50 to 80% of U.S. college mathematics professors belong to one or both of these organizations (personal communication, November 12, 2005).

The AMS members tend to emphasize research, whereas MAA members emphasize undergraduate instruction. Collectively, the demographics of these organizations make them an ideal source from which to draw a representative sample of U.S. college mathematics professors. Instructors with titles of instructor, lecturer, adjunct, and assistant, associate, or full professor were included in the sample.

Materials

ATI-R instrument

The primary research instrument used in this study was the *Approaches to Teaching Inventory-Revised* (ATI-R, 2004) devised by Trigwell & Prosser. As mentioned in Chapter Two, Trigwell and colleagues were interested in examining the relations between approaches to teaching and student's approaches to learning. They devised an inventory based on interviews with professors and then they created a leaning questionnaire for students that drew from modifications made from the teaching inventory. For a completed copy of the original inventory see Appendix A. The ATI provides a means to collect data to analyze the relationships between approaches to teaching math and other elements of the teaching-learning environment as perceived by professors in mathematics classrooms. For purposes of this study, I modified the ATI-R survey (not the learning inventory) for use with college mathematics instructors.

The survey used in this study contains four types of items: Likert scale items, rank order questions, open-ended questions, and demographic questions. The likert scale items are a modified version of the ATI-R, other additions included newly created rank order, open-ended, and demographic questions (See Appendix B for the revised survey used in this study). What follows is a description of the original ATI-R research instrument, modifications to that instrument, and a pilot study to refine the instrument.

Likert scale items

The ATI-R contains two 11-item scales, each of which represents a different approach to teaching (Trigwell, Prosser & Taylor, 1994). The first scale is the Information Transmission/Teacher-Focused Approach. This scale has been devised to identify teachers who adopt a teacher-focused approach with the intention of transmitting information about a discipline to students. Teachers who score high on this scale report that they emphasize facts and skills, but not necessarily the relationship between facts, skills and conceptual understanding.

The second scale is the Conceptual Change/Student-Focused Approach. In this approach, the teacher is likely to embrace a student-focused emphasis intended to help students change their world-views, as well as their conceptions of the phenomena they are studying. Because these teachers believe students construct their own knowledge, they believe it is the role of teachers to focus on what students do in the classroom. A student-focused strategy is assumed to be necessary if the students are to reconstruct their current knowledge into a new world-view or conception. Within the Conceptual Change/Student-Focused approach, the teacher may understand that s/he cannot transmit a new world-view or conception to the students. Instead, the teacher’s role is to set up effective learning situations through which the students can develop new understandings and conceptions related to learning (Trigwell & Prosser, 1996).

Each scale is further divided into two subscales, one of intention items and the other of strategy items. Intention items refer to the motive behind the approach, and strategy items refer to the strategy or means used to achieve that intention. For example, the scale labeled information transmission/teacher-focused approach has four items that refer to the intention to transmit information and four items that refer to the use of a teacher-focused strategy to achieve that intention.

For those teachers who employ information transmission/teacher-focused strategies, the students’ prior knowledge may be less important than it is for those teachers who employ conceptual-change/student-focused strategies. The information transmission/teacher-focused teacher may place less emphasis on the relationship between their teaching and the students’ learning. One important feature of the ATI is that it measures the response of an instructor within a particular context. In this study, the context was described as the most recent mathematics course taught by the math professor whose enrollment included preservice secondary math teachers.

Modifications to ATI-R instrument

A number of modifications were made to the ATI-R to reflect a focus on the preparation of secondary mathematics teachers. First, three initial questions were added to the survey to gather information concerning the context of the course about which instructors were reporting. Specifically, questions about the course title and topics, number of students in the course, and the estimated number of preservice secondary math teachers enrolled in the course were added to the survey.

Changes and additions to Likert items

A number of changes and additions were made to the ATI-R Likert items. The first change was to delete one item (#12) from the Information Transmission/Teacher Focused scale. Item #12, "I should know the answers to any questions that students may put to me during this subject" was deleted. This item was deleted after the pilot study because focus group participants stated that they should always know the answer to any questions that students ask them. Second, all Likert scale items were revised to include the phrase "in this mathematics course how often did you …" This change was made to emphasize the particular context of the mathematics courses respondents had chosen as their focus. Finally, ten Likert scale items were added to the ATI-R in order to question respondents about specific instructional strategies thought to improve the preparation of math teachers specifically (items 14, 20, 22, 24, 25, 26, 27, 28, 29, 30). [Refer to Appendix B for the modified ATI-R instrument.] The National Council of Teachers of Mathematics (NCTM) process standards addressing problem-solving, reasoning and proof, communication, connections, and representations were used as a conceptual framework for the design of the ten additional items (NCTM, 2000).

Rank order question

A rank order item was added to measure the importance of specific instructional activities that might be associated with the teaching approaches captured by each scale. Respondents were asked to rank order activities such as well-organized lectures, practice problems, and student to student discussions. The rationale for including these items was to determine what was most important to them in terms of instruction. In addition, the Likert scale data would not indicate professor's preferences and report general approaches. This item can be found in Appendix B, item #32.

Open-ended questions

Two open-ended questions were added:

1. What do you think you do well in terms of your teaching?
2. What do you need to improve upon in terms of your own teaching?

Answers to question (1) provided richer detail about what it is that gives a college mathematics professor a feeling of professional fulfillment regarding teaching. Answers to questions (1) and (2) added to my understanding of how the teacher views the teaching approaches represented in the Likert scale items and provided richer detail about what the college mathematics professors understand as areas where they want to improve their teaching.

Demographic questions

Because participants are more likely to answer simple personal questions when they do not appear to be survey questions, (Sudman and Bradburn, 1982) demographic questions were placed at the end of survey. To this end, the survey began with the modified ATI-R items, followed by two open-ended questions, and ended with nine demographic questions (Appendix B). The demographic section includes questions about types of professional development activities and the institutional and personal factors that influence the respondents' teaching practices.

Pilot Study

A pilot study was conducted at a 4-year liberal arts college in the Midwestern United States with three college mathematics professors participating in order to refine the modified ATI-R instrument. Survey researchers have agreed that pilot testing of surveys helps to ensure valid and reliable results (Dillman, 2000). The pilot test of the modified ATI-R instrument was done as a focus group discussion. Research suggests that the key to conducting a successful focus group is to have very limited and focused objectives (Morgan, 1997). My objectives for the focus group were to see if respondents were able to understand the questions being asked, that questions were understood in the same way by all respondents, and that respondents were willing and able to answer the questions.

A four stage model of the survey response process (Willis, 2005) was used to design the focus group questions.

1. Question Intent: What does the respondent believe the item is asking?
   Question: What do you believe is the intent of this item?

2. Question Intent: Which items disturb respondents and why?
   Question: What, if anything, makes this item difficult to answer?

3. Question Intent: What ways could I use to increase the number of returned surveys?
   Question: What suggestions do you have to improve the survey response rate?

Participants were asked to complete the modified ATI-R instrument prior to attending the focus group meeting. In addition, they were asked to respond to the following questions:

1. What do you believe this item is asking?
   Item # 8, 22, 24, 28

2. What about this item makes it difficult to answer?
   Item # 3, 6, 9, 12, 13, 14, 16, 18 , 30, 32

3. Is your response one of the available choices?
   Item # 32, 38, 39

4. What suggestions do you have to improve the survey response rate?
   Be as specific as possible and bring any notes or comments to the focus group meeting.

I facilitated the focus group meeting which was audio-taped. I transcribed the tapes, then made notes and documented themes which emerged from the transcription. These themes were categorized and discussed in consultation with my dissertation committee co-chairs. Changes were made to four of the Likert scale items based on this discussion. In addition, general changes to the survey administration were made to clarify the questions about the type of institution and level of the mathematics course. Members of the focus group suggested a raffle as an incentive to participants to complete the survey, which I implemented.

Procedures and data collection

The online combined membership list of the (AMS & MAA) was used to construct a database. The online list was searched by the following search terms: Position, state, member organization, and institution country. A database of email addresses, last names and institution names was created. Because some instructors belong to both organizations, the database was sorted and repeated addresses were deleted form the list.

The email address database (N= 4600) contained 960 different institution names. The list of institution names (N=960) were associated with their Carnegie code (The

Carnegie Foundation, 2000) so that analyses could be done based on groups of Carnegie codes. Carnegie codes were assigned to the N= 960 institutions based on the type of institution. The 2000 Carnegie Classification includes all colleges and universities in the United States that are degree-granting. The 2000 edition classifies institutions based on their degree-granting activities from 1995-96 through 1997-98. The National Center for Educational Statistics' Integrated Postsecondary Education Data System (IPEDS) dataset cutting tool provided a list of institution names and Carnegie codes for the database. The 2000 Carnegie Classification description is as follows:

> Doctoral/Research Universities-Extensive: These institutions typically offer a full range of baccalaureate programs, are committed to graduate education through the doctorate degree, and give high priority to research. During the period studied, they awarded at least 50 or more doctoral degrees per year across at least 15 disciplines.

> Doctoral/Research Universities-Intensive: These institutions typically offer a wide range of baccalaureate programs, and they are committed to graduate education through the doctorate. During the period studied, they awarded at least 10 doctoral degrees across three or more disciplines.

> Master's College and Universities I: These institutions typically offer a wide range of baccalaureate programs and are committed to graduate education through the master's degree. During the period studied they awarded 40 or more master's degrees per year across three or more disciplines.

> Master's Colleges and Universities II: These institutions typically offer a wide range of baccalaureate programs and are committed to graduate education through

the master's degree. During the period studied they awarded 20 or more master's degrees per year across three or more disciplines.

Baccalaureate Colleges-Liberal Arts: These institutions are primarily undergraduate colleges with major emphasis on baccalaureate programs. During the period studied they awarded at least half of their baccalaureate degrees in liberal arts fields.

Baccalaureate Colleges-General: These institutions are primarily undergraduate colleges with major emphasis on baccalaureate programs. During the period studied they awarded less than half of their baccalaureate degrees in liberal arts fields.

Baccalaureate / Associate's Colleges: These institutions are undergraduate colleges where the majority of conferrals are below the baccalaureate level (associate's degrees and certificates). During the period studied, bachelor's degrees accounted for at least ten percent of undergraduate awards.

Associate's College: These institutions offer associate's degrees and certification programs but, with exceptions, award no baccalaureate degrees. This group includes institutions where, during the period studied, bachelor's degrees represented less than 10 percent of all undergraduate degrees.

Specialized Institutions: These institutions offer degrees ranging from the bachelor's to the doctorate typically award a majority of degrees in a single field. Specialized institutions include: Theological, Medical, schools of engineering, schools of business and management, teachers colleges (The Carnegie Foundation, 2000).

Of the 4600 email addresses in the database, 4544 were successfully sent an initial email message**.** Successfully sent emails (4544) is the number that were sent out from the server. The initial message was sent on July 31, 2007 and the final reminder was sent electronically on August 31, 2007. Traditionally, many college professors are away from their computers during the summer break so that the email messages may have reached their email box but not been read until after the survey administration ended. Another issue that occurred which decreased the number of emails reaching participants was that some emails were caught in junk mail and virus protection filters and did not reach the participant's inbox.

Response Rates

Strategies for raising response rates for electronic surveys include multiple contacts, personalized contacts, and offering alternative modes of responding. Response rates for electronic surveys are higher when the sample members are experienced users of the internet (Fowler, 2002).

Participants in this study were contacted four times in order to prompt a higher response rate. The use of multiple contacts is one of the most successful techniques to increase response rates (Porter, 2004). The first contact was a personalized, stand-alone email message that invited recipients to participate in a survey of instructional strategies. Results from meta-analyses (Porter, 2004) indicate that a pre-notification message increased response rates between 8 and 29 percentage points.

One week after the pre-notification message, the survey invitation, consent letter (See Appendix C) and survey were emailed to each professor in the database. The survey invitation asked professors if they have taught mathematics courses in which prospective grades 7-12 teachers were enrolled. If they responded "no," then they were asked to click on the hypertext link which prompted a blank email to me with "no" in the subject line of the email. If they responded "yes" to the qualifying question, then they were asked to scroll down, read the consent letter and access the survey. This step eliminated them from further contact and qualified them to be a respondent.

In addition, another technique I used to motivate participants to complete the survey was to offer a prize for responding. If an individual completed the survey he/she could request to be included in a raffle for a one year license of Mathematica 6.0 software, a popular tool used by college mathematics professors. One hundred seventeen participants requested to be included in the raffle.

Because there is no reliable information on the number of U.S. mathematics professors who both belong to the AMS or the MAA and teach mathematics courses in which prospective grades 7-12 teachers enroll, I cannot estimate my population size. Consequently, it is difficult to estimate the number of eligible participants within the N= 4600 database. However, during data collection, 31% of the 4544 (successfully sent emails) reported that they were *ineligible* to participate in the survey because they were: (1) a math professor but did not teach courses in which prospective teachers enrolled, or (2) they no longer taught courses, or (3) they were a professor in some other department such as computer science or physics.

Ultimately, the number of professors who responded “yes” to the screening question and submitted a survey constitute the sample. Professors who did not respond to the qualifying question or who responded “yes” but declined to answer the survey were classified as non-respondents. To improve response rates, reminders to complete the survey were e-mailed fourteen and twenty-one days after the survey invitations were sent.

The response rate was computed using the following method (American Association for Public Opinion Research, 2008). I calculated the number of non-respondents: 4575 (total surveys sent) – 1417 (respondents ineligible) – 877 (eligible respondents) = 2281. Calculate the percentage of non-respondents who were likely to be ineligible: 2281 (non-respondents) x .31 (rate of reported ineligibility) = 707. Calculate the number of eligible non-respondents: 2281 (non-respondents) – 707 (ineligible respondents) = 1574. Thus, the response rate was calculated as 877 (eligible respondents)/1574 (eligible non-respondents) = .56[1].

Alternative Modes to Respond to Survey

To make the survey user-friendly, I provided two possible formats for completing it: online using the WebSurveyor software or emailing me to request a paper copy and stamped return envelope. One participant requested a paper copy be sent to him and he returned a completed survey by mail. Participants' questions about the survey were sent to me and I replied in a timely manner. Results of the study will be made available to participants at their request; 113 participants requested the results be sent to them.

[1]A more conservative method to compute the response rate avoids the possible miscalculation of eligible and ineligible non-respondents, and simply assumes that all non-respondents were eligible participants. Thus, the response rate was calculated as 877 (eligible respondents)/2281 (non-respondents) = .38.

CHAPTER 4 DATA ANALYSIS

The purpose of this study was to examine the self-reported instructional strategies of college mathematics professors. Using a survey, I sent email invitations to a national sample of college mathematics professors. The Instructional Strategies survey items are divided into three parts, demographic, modified Approaches to Teaching Inventory-Revised (ATI-R), rank order, and open-ended questions. Descriptive and inferential statistical procedures were used to analyze the data and an exploratory factor analysis was done on the Instructional Strategies survey to confirm a hypothesized factor structure.

Context of Survey Participant's Responses

Three questions were posed to focus participant's responses on a particular course and to determine the context in which the course was taught. First, survey respondents were asked to provide the name of the mathematics course in which secondary teachers were enrolled, and to list the mathematics topics covered in that course. Second, respondents were asked the approximate number of students enrolled in the course, as well as the approximate number of secondary preservice teachers in this course.

The University of Iowa classifies undergraduate mathematics courses as either lower-division or upper-division. I used this classification system to categorize the courses reported on in this study. Table 1 displays mathematics course titles by level as reported by respondents. 46% of the courses surveyed in my study were advanced undergraduate mathematics courses.

Table 1. Frequency of Mathematics Course Titles by Level

Level	**Mathematics Course Titles**	**Frequency**
Introductory	College Algebra, Pre-Calculus, Quantitative Reasoning, Calculus	180
Advanced	Abstract Algebra, Geometry, Analysis Courses, Discrete Math, Differential Equations, Logic and Proof Courses	404
Courses for Teachers	Advanced Math for High School Teaching, Education Capstone	59
Other	e.g., Dynamical Systems	36
Total		879

The second and third questions posed to respondents requested the approximate number of students and secondary preservice teachers enrolled in these 879 courses. See Table 2 for student enrollment in the 879 courses. These questions provided a measure of the average number of preservice secondary math teachers enrolled in undergraduate math courses. For my sample, the average number of preservice secondary math teachers enrolled in the courses is 9, with a minimum of 1 and a maximum of 100. The average number of all students enrolled in the courses was 23, with a minimum of 1 and a maximum of 150.

Table 2. Total Number of Students and Teachers Enrolled in Courses

Enrollment	**Total**	**Mean**
Students	20,392	23
Prospective Secondary Teachers	8,080	9

The class sizes of these 879 courses are divided into three categories of 1-25, 26-50, and 51-150 students in a course. See Table 3 for the frequency of these class size categories. The majority of the 879 course had a class size of 1-25 students. Since 43% of these classes have 50 students or less these results should not be generalized to teachers teaching large lecture-type classes.

Table 3. Frequency of Class Size Categories

Number of Students	**Frequency of Courses**
1-25	616
26-50	234
51-150	28
Missing	1
Total	879

Following the questions on the context of the mathematics course, the instructional strategies survey contained four types of items: Demographic questions, Likert scale items, a rank-order item, and two open-ended questions.

Demographic Questions

The respondents were surveyed on their academic rank, frequency of teaching courses in which preservice secondary teachers enroll, graduate degrees, professional development activities, years of mathematics teaching experience, institutional and personal factors that influence their teaching, gender, and the state in which they work. In sections to follow I examine the relationships between demographic items and Likert scale items. The frequency and percentage of the academic ranks of respondents are displayed in Table 4. Over 96% of the respondents of the survey were tenured or tenure-track faculty, thus this sample of preservice secondary math teachers is primarily receiving instruction from full-time faculty members.

Table 4. Professional Rank of Respondents

Rank	**Frequency**
Full Professor	408 (46.7)
Associate Professor	273 (31.3)
Assistant Professor	172 (19.7)
Visiting Professor	7 (0.8)
Lecturer	6 (0.7)
Adjunct	1 (0.1)
Graduate Teaching Assistant	4 (0.5)
Other	2 (0.2)

Following the question on academic rank, respondents were asked to estimate how frequently they teach undergraduate mathematics courses in which preservice math teachers enroll. See Table 5 for the frequency of courses taught per year to preservice teachers. Approximately 69% of the respondents teach two or more classes a year in which preservice teachers enroll. For this sample, faculty are coming into regular contact with preservice secondary teachers. Thus the reported instructional strategies represent a reasonable view of instructional strategies preservice secondary teachers are exposed to in their undergraduate math classes.

Table 5. Frequency of Courses Taught Per Year

Frequency	**Frequency**	**Percent**
One class per year	262	29.8
Two classes per year	247	28.1
More than two classes per year	366	41.6
Missing	5	0.6
Total	880	100.0

Respondents were surveyed on the discipline of their graduate degrees. The Master's degree disciplines of respondents are displayed in Table 6. Some of these professors did not receive a Masters degree as their Masters and Ph.D. programs were combined, which might explain the high number of respondents who did not designate a discipline.

Table 6. Master's Degree Discipline of Respondents

Discipline	**Frequency**
Mathematics	426
Physics	5
Statistics	5
Computer Science	5
Mathematics Ed/Secondary Teaching	3
Engineering	3
Did not designate	419
None or NA	13
Total	879

The Ph.D. disciplines of respondents are displayed in Table 7. This question was confusing to respondents and many gave the institution name and or year that the degree was awarded. Of those that listed a discipline, the majority earned Ph.D.s in mathematics.

Table 7. Ph. D. Degree Discipline of Respondents

Discipline	**Frequency**
Mathematics	233
Mathematics Ed/Secondary Teaching	10
Statistics	6
Physics	4
Higher Education	2
Engineering	2
Ed. D. Curriculum and Instruction	1
Operations Research	1
Did not designate a discipline	620
Total	879

The next demographic question asked respondents to select professional development activities from a provided list. Respondents could select multiple activities from the list. See Table 8 for the percentage of respondents who selected each professional development activity. Overall, there is a high level of engagement in these educationally relevant professional development activities. Over 50% of these respondents read material published by the National Council of Teachers of Mathematics, which most likely indicates an interest in teaching. In addition, over 91% of this sample regularly talks to colleagues about teaching issues.

Table 8. Percentage of Sample Who Participate in Professional Activities

Activity	**Percent Who Engage in Activity**
Regularly talk with colleagues about teaching issues	91.1
Read articles in the AMS *Notices* about education	81.3
Attended departmental seminars related to teaching and learning mathematics	65.0
Read reports from the MAA's Committee on Undergraduate Programs in Math (CUPM)	62.8
Read articles about *The Principles and Standards for School Mathematics* sponsored by NCTM	52.2
Read articles sponsored by the MAA RUME SIG	33.4

Respondents were then asked to report the number of years they have taught college mathematics. The reported mean is 23.3 years of mathematics teaching experience with a standard deviation of 11.9 years. The minimum number of years of teaching experience reported was 1, with a maximum of 55 years. As a whole, this is an experienced group of college and university mathematics professors.

Respondents were asked to select institutional factors that influenced their teaching practices from a list provided in the survey. Respondents could select multiple factors. See Table 9 for the frequency and percentage of factors that were selected.

Class size, textbook, and instructional time are factors that a majority of respondents report influence their teaching practices. For this study, a large enrollment mathematics class is considered to be 50 or more students. Of the 879 classes reported here, 464 (53%) were large enrollment classes. Of those 464 classes, 22 (approximately 9%) had enrollments of 50 or more students. The minimum number of students enrolled in any classes was 1, with a maximum of 150; the minimum number of preservice teachers enrolled was 1, with a maximum of 100. It is of note that class size was the most frequently selected institutional factor since this is a factor that teachers cannot usually control. The least frequently chosen factor was moral support from colleagues. This may indicate that college math professors do not view moral support from colleagues as an institutional factor.

Table 9. Frequency and Percent of Responses of Institutional Factors

Institutional Factors	**Frequency**	**Percent**
Class size	690	78.4
Textbook	553	62.8
Instructional time	553	62.8
History of how the course has been taught	437	49.7
Resources (e.g., technology)	429	48.8
Departmental curriculum committee	327	37.2
Departmental support	324	36.8
Moral support from colleagues	250	28.4
Other	91	10.3

Table 10 displays the professional development activities selected by respondents, broken down by gender and years of teaching experience. Respondents with more than 31 years of teaching experience engage in more professional development activities than their colleagues, except for a slight decline in talking to their colleagues. In terms of reading the CUPM (MAA) material, the percentage increased as teachers gained more years of experience. In terms of gender differences, the largest difference is that 14% more women than men read the Principles and Standards document (NCTM).

Table 10. Percentage of Selected Professional Activities By Gender and Experience

Professional Activities	**Male**	**Female**	**0-15**	**16-30**	**31+**	**Overall**
Talk with Colleagues	91.3	91.5	94.3	90.9	89.5	91.1
AMS Notices	81.1	83.4	75.7	83.7	86.2	81.3
Attended Department Seminar	64.1	68.8	64.6	64.0	67.8	65.0
CUPM (MAA)	61.6	67.8	48.2	62.5	82.0	62.8
Principles & Standards NCTM)	49.2	63.6	39.3	53.8	64.9	52.2

Respondents were asked to select personal factors that influenced their teaching practices from a provided list. Respondents could select multiple factors that influenced their teaching practices. See Table 11 for the frequency and percent of responses.

Table 11. Frequency and Percent of Responses of Personal Factors

Personal Factors	**Frequency**	**Percent**
Experiences as a teacher	680	77.3
Teaching style	667	75.8
Experiences as a student	442	50.2
Student expectations	401	45.6
Time to prepare	383	43.5
Professional standards from organizations	207	23.5

The majority of respondents reported that their experiences as a teacher and their teaching style influence their teaching practices. In addition, approximately 50% reported that their experiences as a student influence their teaching practices. This supports the idea that a preservice teacher’s experience as a mathematics student in college may later influence their own teaching practices. Furthermore, this is especially notable given that this is a sample of experienced college math professors, and it is far from their student days.

The final two demographic questions asked respondents their gender and the name of the state in which they work. Table 12 lists the frequency and percent of male and female respondents, showing that over 75% of respondents are male. This number is not surprising given the smaller number of tenured and tenure track female mathematics professors. In 2005, 23% of tenured or tenure track college mathematics professors in the United States were female (Conference Board of the Mathematical Sciences Survey 2005). Thus, this sample of college mathematics professors is representative of the U.S. population in terms of gender.

Table 12. Gender of Survey Respondents

	Frequency	**Percent**
Male	667	75.8
Female	199	22.6
Missing	14	1.6
Total	880	100.0

The last demographic question asked respondents the name of the state in which they work. The survey respondents work in 46 states plus the District of Columbia. There were no responses from institutions in Georgia, Hawaii, Idaho, and Illinois. Apparently these institutions had filters on their university and college email software that prevented the survey from reaching the inboxes of college math professors. Institutions in New York, Indiana, Massachusetts, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, and Texas submitted more than 30 survey responses. For a complete list of state names and frequencies see Appendix D.

Modified Approaches to Teaching Inventory-Revised
(ATI-R) Scores

The ATI-R is comprised of two conceptually discrete dimensions of approaches to teaching by way of two scales: (a) the Information Transmission/Teacher-focused scale (ITTF), and (b) the Conceptual Change/Student-focused scale (CCSF). Thus the ITTF scale and the CCSF scale are independent scales and are not opposite ends of a single scale (Gibbs and Coffey, 2004), and it is possible for a teacher to score high on both scales at the same time. The purpose of the ATI-R is to report the extent to which college teachers described themselves as teacher-focused and student-focused in their approach to teaching.

Each of these two approach scales contains a subscale distinguishing the intentions of the instructor and the strategies used during instruction. The four resulting subscales are considered to be discrete, but not necessarily conceptually independent, dimensions of variation:

$A_{1:}$ conceptual change intention
A_2: student-focused strategy

B_1: information transmission intention
B_2: teacher-focused strategy

Analysis of ATI-R Scores and Subscale Scores

Descriptive statistics were computed for the responses to Likert scale items of the modified ATI-R. The demographic items were used to create categories for examining results from the Likert items.

The modified ITTF scale contains 12 items and the modified CCSF scale contains 18 items. An exploratory factor analysis was conducted to determine the structure or the dimensional nature of the survey items of the modified ATI-R instrument.

Factor Analysis

A factor analysis is a statistical procedure for reducing the information originally contained in a large number of items to a more manageable and conceptually clearer number of variable or factors. At the start of this study, drawing on Trigwell, Prosser, and Taylor, I speculated that I would have two factors, ITTF and CCSF. A distribution of scores could be arranged this way only if the nature of the survey items were two-dimensional in nature. Based on the exploratory factor analysis, the modified ATI appears to have three factors or dimensions.

By definition, there are going to be as many factors as there are items on the survey. So, mathematically, there are 31 factors with loadings. However, some factors have higher loadings (or more impact) than others. A scree plot was used to show the number of factors. In a scree plot, each factor (all 31 possible factors) has an associated eigenvalue. The output of the factor analysis was obtained by rotating the initial solution. A *varimax* rotation was used to obtain more interpretable results.

Factors (or dimensions) that have large eigenvalues are considered "important," whereas those with small eigenvalues are considered "negligible." The plot itself contains an index from 1 to 31 along the x-axis and the eigenvalues on the y-axis. The eigenvalues are ordered by size. X = 1 corresponds to the largest eigenvalue, X=2 corresponds to the next largest eigenvalue, and so on.

In the current factor analysis, after X = 3, the eigenvalues drop in value by a very large amount. That is a sign that the first three factors (dimensions) seem to be explaining the majority of the variability in the data. From the scree plot, a three-factor solution was found to be adequate. Thus, based on the factor analysis, the modified ATI-R has three dimensions or factors.

Looking at the items that make up each factor, I propose the following names for the three dimensions. The three factor names are: Factor 1 *Conceptual Change Student Focused (CCS)*, Factor 2 *Conceptual Change Teacher Focused* (CCT), and. Factor 3

Information Transmission Teacher Focused (IT). Items with loadings of .3 and higher are included and were used to characterize each individual factor. Tables 13, 14, and 15 list the items and loadings on the three factors.

The three scales: CCS, CCT, and IT can be conceptualized by comparing the college math professor's role in the classroom and the way in which they think of or understand student learning. In the CCS scale, the questions focus more on what the college math professor asks the students to do to promote student conceptual change. Further, five of the ten items in this scale ask how often the teacher promotes interaction among students. In the CCT scale, the questions focus more on what the instructor does in the classroom to promote student conceptual change. In contrast, the IT scale questions focus more on what the college math professors does in the classroom to promote the students receiving information. The question stem for many of the CCS scale likert items is "How often did you have students…?" whereas the question stems for CCT likert scale items is "How often did you…?" Similarly, the question stem for the IT scale likert items is "How often did you…?"

Thus the college math professors who scored high on the CCS or CCT scale focus on students developing and changing their mathematical conceptions. However, they appear to differ in the way in which they implement their ideas of student learning in their classroom. The CCS scale questions are about what the students are doing in the classroom, whereas the CCT scale are about what the teacher is doing in the classroom. On the other hand, the college math professors who scored high on the IT scale focus on transmitting information to students to promote learning. A small group of college math professors scored high on all three scales, which means that they indicate that they frequently engage in many different types of instructional strategies.

Table 13.ATI-R Modified Survey Items and Loadings on CCS Factor

CCS Item Number	**Factor 1 (CCS)**	**Factor 2 (CCT)**	**Factor 3 (IT)**
32. In class small group work *	0.74629		
14. How often was interaction in this mathematics class between students, rather than you and the students?	0.71033	0.34873	
6. In this mathematics course, how often did you have students problem solve in class?	0.67287		
32. Student to student discussions *	0.65202	0.31695	
29. In this mathematics course, how often did you orchestrate conversations among students?	0.64403	0.43243	
26. In teaching this mathematics course, how often did you ask students to learn new mathematical concepts or methods by solving problems during class time?		0.58036	
28. In this mathematics course, how often did you ask students to understand other students' thinking and compare with their own thinking or formal mathematical knowledge?	0.57879	0.50839	
32. Student presentations *	0.38818	0.30256	
9. In this mathematics course, how often did you encourage debate and discussion?	0.36444	0.63142	
32. Student projects *	0.32985		

*Item #32 is a rank order item which listed seven factors and asked respondents to rank them as very important, important, somewhat important, or not very important.

Table 14. ATI-R Modified Survey Items and Loadings on CCT Factor

CCT Item Number	**Factor 1 (CCS)**	**Factor 2 (CCT)**	**Factor 3 (IT)**
19. In this mathematics course, how often did your teaching help students question their own understanding of mathematical ideas?		0.72288	
8. In this mathematics course, how often did you encourage students to restructure their existing knowledge in terms of new ways of thinking about mathematics?		0.65551	
13. How often was teaching time in this mathematics class used to question students' ideas?		0.64461	
12. In this mathematics course, how often did you make opportunities available for students to discuss their changing understanding of mathematical ideas and methods?		0.6307	
22. In this mathematics course, how often did you ask students to make a logical argument, either through individual response, in-class discussions or group-work?		0.53616	
20. In this mathematics course, how often did your teaching encourage students to figure out a concept or method on their own with some guidance from you?		0.53458	
3. How often in your interactions with students did you try to develop a conversation with them about the topics being studied?		0.50971	
32. Whole class discussions *	0.32708	0.45211	
17. In this course, how often was it important for you to monitor students' developing understanding of mathematical ideas?		0.40393	
31. How often did your teaching in this mathematics course include helping students find their own learning resources?		0.32365	
24. When teaching this mathematics course, how often did you present or ask students to use more than one representation in order to understand a given mathematical idea (e.g., tables, graphs, equations, diagrams, physical models, etc.)?		0.30688	

Table 15. ATI-R Modified Survey Items and Loadings on IT Factor

IT Item Number	**Factor 1 (CCS)**	**Factor 2 (CCT)**	**Factor 3 (IT)**
18. How often in your teaching of this mathematics course did you focus on delivering what you know to the students?			0.69648
23. How often did you provide the students with the information they would need to pass the course assessments?			0.66597
32. Well organized lectures *			0.66183
15. In this mathematics course, how often did your teaching focus on the presentation of information to your students?		0.39423	0.63027
10. How often did you organize your teaching in this mathematics course so that students get a good set of notes?			0.60114
21. In this mathematics course, how often did you present material to enable students to build up an information base in mathematics?			0.58175
11. How often did your formal assessments in this course reflect mathematical information you've directly provided students?			0.5556
5. How often did you present information to students so that they would know what had to be learned in this mathematics course?			0.55346
7. In this mathematics course, how often did you concentrate on covering information that might be available from a textbook or other material from the publisher?			0.46302
32. Practice problems and tests *			0.41693

*Item #32 is a rank order item which listed seven factors and asked respondents to rank them as very important, important, somewhat important, or not very important.

Three items did not load on factor 1 (CCS), factor 2 (CCT) or factor 3 (IT). The three items are listed in Table 16. These items will not be included in analysis that involves the three scales factors.

Table 16. Items that did not load on the three factors

Item Number
1. In this mathematics course, how often did you ask students to focus their study on what you provided to them as opposed to outside material (e.g., textbook) ?
2. In this mathematics course, how often did you characterize this mathematics course to students in terms of specific objectives that relate to your course assessments (e.g., tests)?
4. How often was it better in this mathematics course for students to generate their own notes rather than copy your notes?

Tables 17, 18, and 19 list the means and standard deviations for scale items. The survey Likert scale choices were:

1 – this item was only rarely true for me in this course

2 – this item was only sometimes true for me in this course

3 – this item was true for me about half the time in this course

4 – this item was frequently true for me in this course

5 – this item was almost always for me in this course

In Table 17 the highest mean occurred in an item about how often instructors encourage debate and discussion. This may indicate that encouraging students to debate and discuss is an important feature of student centered instruction.

Table 17. Mean and Standard Deviation of CCS Likert Scale Items

Item Number	Mean	Std.
9. In this mathematics course, how often did you encourage debate and discussion?	3.3	1.3
6. In this mathematics course, how often did you have students problem solve in class?	3.1	1.3
26. In teaching this mathematics course, how often did you ask students to learn new mathematical concepts or methods by solving problems during class time?	2.9	1.3
28. In this mathematics course, how often did you ask students to understand other students' thinking and compare with their own thinking or formal mathematical knowledge?	2.5	1.3
29. In this mathematics course, how often did you orchestrate conversations among students?	2.4	1.2
14. How often was interaction in this mathematics class between students, rather than you and the students?	2.4	1.1

In Table 18 the highest mean occurs in the item about the importance of making connections among mathematical ideas. This may indicate that an important feature of CCT is the emphasis the teacher places on making connections between math ideas for the students. In contrast to the CCS teacher, who often has students debate (and presumably develop) their own ideas, the CCT teachers are providing the conceptual connections for the students. None the less, both groups are emphasizing the conceptual aspects of mathematics.

Table 18. Mean and Standard Deviations of CCT Likert Scale Items

Item Number	Mean	Std.
25. When teaching this mathematics course, how often did you emphasize the importance of making connections among mathematical ideas?	4.2	0.9
3. How often in your interactions with students did you try to develop a conversation with them about the topics being studied?	4.1	1.0
22. In this mathematics course, how often did you ask students to make a logical argument, either through individual response, in-class discussions or group-work?	4.0.	1.0
17. In this course, how often was it important for you to monitor students' developing understanding of mathematical ideas?	3.9	1.0
16. In this mathematics course, how often were your teaching activities designed to help students develop new ways of thinking about mathematical ideas and methods?	3.8	1.0
8. In this mathematics course, how often did you encourage students to restructure their existing knowledge in terms of new ways of thinking about mathematics?	3.7	1.1
19. In this mathematics course, how often did your teaching help students question their own understanding of mathematical ideas?	3.5	1.0
20. In this mathematics course, how often did your teaching encourage students to figure out a concept or method on their own with some guidance from you?	3.4	1.1
27. In this mathematics course, how often did you ask students to communicate their own mathematical thinking during class?	3.2	1.2
24. When teaching this mathematics course, how often did you present or ask students to use more than one representation in order to understand a given mathematical idea (e.g., tables, graphs, equations, diagrams, physical models, etc.)?	3.2	1.4
12. In this mathematics course, how often did you make opportunities available for students to discuss their changing understanding of mathematical ideas and methods?	2.9	1.3
13. How often was teaching time in this mathematics class used to question students' ideas?	2.7	1.1
31. How often did your teaching in this mathematics course include helping students find their own learning resources?	2.1	1.1

In table 19, the highest mean occurs in the item about presenting information to students so that they know what needs to be learned. A feature of the items in this scale is the emphasis on “presenting”, “providing”, “delivering”, and “covering” information for students. However, the emphasis on conceptual understanding in the CCT scale items is missing here.

Table 19. Mean and Standard Deviation of IT Likert Scale Items

Item Number	Mean	Std.
5. How often did you present information to students so that they would know what had to be learned in this mathematics course?	4.0.	1.1
23. How often did you provide the students with the information they would need to pass the course assessments?	3.9	1.1
18. How often in your teaching of this mathematics course did you focus on delivering what you know to the students?	3.7	1.1
15. In this mathematics course, how often did your teaching focus on the presentation of information to your students?	3.7	1.0
10. How often did you organize your teaching in this mathematics course so that students get a good set of notes?	3.7	1.2
5. How often did you present information to students so that they would know what had to be learned in this mathematics course?	4.0.	1.1
23. How often did you provide the students with the information they would need to pass the course assessments?	3.9	1.1
18. How often in your teaching of this mathematics course did you focus on delivering what you know to the students?	3.7	1.1
15. In this mathematics course, how often did your teaching focus on the presentation of information to your students?	3.7	1.0
10. How often did you organize your teaching in this mathematics course so that students get a good set of notes?	3.7	1.2
5. How often did you present information to students so that they would know what had to be learned in this mathematics course?	4.0.	1.1
23. How often did you provide the students with the information they would need to pass the course assessments?	3.9	1.1
18. How often in your teaching of this mathematics course did you focus on delivering what you know to the students?	3.7	1.1

Each instructor has a score on the CCS, CCT, and IT scale. I used a median split procedure to categorize instructors as high or low on each scale, that is, I calculated the median score for each scale and then designated each instructor as above or below the median. For example, the median score on the CCS scale is 2.5. If a respondent's scale score was less than 2.5 then that person is a member of the CCS Low group. If they again scored lower than the median on the CCT and IT scales then that individual is a member of the LLL median split group. So, each instructor was categorized as high or low on each of the three scales.

To test whether the high and low groups for each scale were drawing from different populations, t-tests were conducted. Note that for each of these tests, Levene's test for Homogeny of Variance shows that equal variances should not be assumed. The results are presented below in Tables 20, 21, and 22.

Table 20. *T*-Test of the High and Low Median Split CCS Group

	Mean	**Std.**	***T*-statistic**	**df**	***p*-value**
Low	1.85	.46	44.88	774.7	< 0.001
High	3.57	.67			

Table 21. *T*-test of High and Low Median Split CCT Group

	Mean	**Std.**	***T*-statistic**	**df**	***p*-value**
Low	3.05	.47	42.19	839.2	< 0.001
High					

Table 22. *T*-test of High and Low Median Split IT Group

	Mean	**Std.**	***T*-statistic**	**df**	***p*-value**
Low	3.26	.60	36.44	692.2	< 0.001
High	4.40	.29			

The *t* distributions created from the *t* tests are like a normal distribution which means that very large or small values of the *T* statistic indicate significance. The CCS high and low group has a mean difference of 1.72 with a 95% confidence interval of (1.65, 1.81). The effect size for the *T*-statistic is 3.04. The CCT high and low group has a mean difference of 1.16 with a 95% confidence interval of (1.11, 1.22). The effect size for the *T*-statistic is 2.83. The IT high and low group has a mean difference of 1.14 with a 95% confidence interval of (1.08, 1.20). The effect size for the *T*-statistic is 2.56.

Thus from these tests we can say that the mean "low" group is different from the mean "high" group for each of the scales. From here on, the abbreviations such as "LHL" refer to Low and High on the three factors of CCS, CCT, and IT in that order. Table 23 displays the number of respondents in each group using the median split method.

Table 23. Number of Respondents in Median Split Groups

Median Split Group	**Respondents**
LLL	135
LLH	180
LHL	48
LHH	80
HLL	93
HLH	48

HHL	187
HHH	103

There is a relatively high number of respondents in the LLH (respondents scored low on both conceptual scales and high on IT) and HHL (respondents scored high on both conceptual scales and low on IT) groups, along with the relatively small number of respondents in the groups LHL and HLH. These latter groups seem somewhat inconsistent or at least unlikely. For example, HLH means the instructor reports engaging frequently in activities focusing on students' learning and on the transmission of information, but not on their own activities to promote student learning.

Table 24. Mean of Subscale Scores on CCS, CCT, and IT Factors

Median Split Group	**Mean (CCS)**	**Mean (CCT)**	**Mean (IT)**	**Overall Mean**
LLL	1.89 (0.46)	2.97 (0.50)	3.44 (0.47)	2.76 (.48)
LLH	1.78 (0.47)	2.99 (0.48)	4.38 (0.28)	3.05 (.41)
LHL	1.98 (0.47)	4.00 (0.28)	3.48 (0.40)	3.13 (.38)
LHH	1.86 (0.42)	4.09 (0.32)	4.46 (0.28)	3.47 (.34)
HLL	3.18 (0.45)	3.20 (0.35)	3.22 (0.57)	3.20 (.46)
HLH	3.21 (0.48)	3.17 (0.41)	4.32 (0.28)	3.57 (.39)
HHL	3.84 (0.67)	4.25 (0.35)	3.08 (0.68)	3.72 (.57)
HHH	3.61 (0.62)	4.32 (0.33)	4.41 (0.29)	4.11 (.37)

Table 25 displays the professional development activities selected by respondents broken down by median split score. The LLH group reports the lowest percentage of all the professional development activities except for reading AMS articles. Over twice as many respondents in the HHL group reported reading the MAA/RUME materials as in the LLH group, and 25% more reported reading the NCTM standards. Thus the groups who focus more on conceptual understanding (CCS and CCT) are more likely to read documents related to teaching undergraduate mathematics and mathematics education.

Table 25. Percentage of Selected Professional Activities By Median Split Group

	LLL	**LLH**	**LHL**	**LHH**	**HLL**	**HLH**	**HHL**	**HHH**	**Overall**
Colleagues	90.4	88.3	91.7	93.8	95.7	91.7	92.0	93.2	92.1
AMS	76.3	79.4	89.6	87.5	88.2	60.4	80.7	90.3	81.5
Department Seminars	57.8	57.8	68.8	65.0	69.9	72.9	73.3	64.1	66.2
MAA/CUPM	60.0	55.0	72.9	57.5	67.7	62.5	71.1	63.1	56.9
Standards	51.1	41.1	56.2	48.8	60.2	41.7	64.2	51.5	51.9
MAA/RUME	90.4	88.3	91.7	93.8	95.7	91.7	92.0	93.2	92.1

Table 26 displays the percentage of selected institutional factors by median split score. A relatively low percent of all respondents selected moral support, whereas a relatively high percentage selected class size as an important factor. Further, comparing the LLH and HHL groups on textbook importance, almost two times as many LLH members said the textbook, which may result from their greater emphasis on the presentation of information to students.

Table 26. Percentage of Selected Institutional Factors By Median Split Group

Institutional Factors	**LLL**	**LLH**	**LHL**	**LHH**	**HLL**	**HLH**	**HHL**	**HHH**	**Overall**
Class Size	77.8	78.9	85.4	78.8	75.3	72.9	80.7	78.6	78.5
Textbook	70.4	76.1	52.1	71.2	68.8	60.4	42.8	62.1	63.0
Instructional Time	64.4	68.9	58.3	65.0	60.2	58.3	58.8	65.0	62.4
History of Course	60.0	59.4	45.8	51.2	48.4	52.1	36.4	44.7	49.8
Technology	46.7	49.4	33.3	40.0	52.7	43.8	55.1	54.4	47.0
Department Curriculum Committee	40.7	36.7	27.1	37.5	38.7	41.7	32.6	43.7	37.3
Departmental Support	34.1	31.1	33.3	37.5	31.2	39.6	44.4	43.7	36.9
Moral Support	32.6	23.9	27.1	16.2	23.7	25.0	36.4	34.0	27.4
All of the Above	20.7	13.9	2.5	5.0	17.2	20.8	15.5	24.3	17.5

Table 27 lists the percentage of selected personal factors that influence teaching practices by median split score. Table 27 shows that over 75% of the instructors indicate that teaching style and experience as a teacher influence their teaching practice, and 50% list experience as a student as a factor. Percentages for the LLH and HHL are similar in most categories, except that experience as a student is 14% higher for the LLH group. The largest difference between these groups is that “reading professional standards” is more than two times as likely for HHL members.

Table 27. Percentage of Selected Personal Factors by Median Split Groups

Personal Factors	**LLL**	**LLH**	**LHL**	**LHH**	**HLL**	**HLH**	**HHL**	**HHH**	**Overall**
Experience As a Teacher	80.7	78.9	81.2	75.0	69.9	72.9	78.1	79.6	77.0
Teaching Style	78.5	77.8	79.2	70.0	72.0	68.8	75.9	81.6	75.5
Experience as a student	48.1	57.8	58.3	55.0	39.8	37.5	43.9	61.2	50.2
Student Expectations	48.1	46.1	41.7	40.0	35.5	41.7	45.5	59.2	44.8
Time To Prepare	47.4	44.4	45.8	36.2	44.1	31.2	40.6	53.4	42.9
All of the Above	23.7	20.6	31.2	22.5	30.1	25.0	25.7	25.2	25.5
Professional Standards	20.0	15.0	25.0	20.0	28.0	12.5	34.2	28.2	22.9

Below I compare contrasting median split groups to highlight the differences between groups. The groups are compared in the following order: LLL and HHH, LLH and HHL, LHL and HLH, and LHH and HLL. The groups are compared in terms of gender, professional development activities, personal and institutional factors that influence their teaching practice and the elements of instruction ranked in terms of importance. The elements of instruction item listed seven instructional activities which they were asked to rank in order of importance.

First, the LLL group contains 26 females and 108 males compared with the HHH group of 37 females and 64 males. These two groups are similar in terms of their reported professional development activities except for a slightly greater percentage of the HHH group who read articles from the AMS and MAA/RUME associations. The institutional factors selected by these two groups are similar except for a higher percent of the LLL group reported that the history of how the course has been taught influenced their teaching and a higher percent of the HHH group reported that departmental support influenced their teaching. The elements of instruction that are different between these two groups are whole class discussion and student to student discussion. Twenty percent of the LLL group reported that whole class discussion was not very important while only 1% of the HHH group reported the same. Twenty-three percent of the LLL group reported that student to student discussions are not very important while only 3% of the HHH group reported the same.

The second comparison involves the LLH and the HHL groups. The LLH group contains 16 females and 162 males while the HHL group contains 64 females and 120 males. These two groups reported slight differences in the professional development activities of attending department seminars and reading MAA/CUPM and Standards documents. The largest difference in their professional development activities is that 20% more of the HHL group reported reading MAA/RUME articles. There are a number of differences in the institutional factors that influence their teaching. Specifically, 35% more of the LLH group reported being influenced by the textbook. Further, 23% more of the LLH group reported that the history of how the course has been taught influenced their own teaching. The personal factors that influenced their teaching that vary for the two groups are experience as a student and professional standards. Fourteen percent more of the LLH group reported that their teaching was influenced by their experience as a student. The HHL group reported twice as often that professional standards from organizations influence their teaching practices. The importance of all of the elements of instruction were varied for these groups; 20% more of the LLH group reported that well-organized lectures were very important, whereas 30% more of the HHL group reported that student projects were very important. Seventeen percent more of the LLH group reported that practice problems and tests were important. The largest differences were reported in the last four elements of instruction which are displayed in Table 28

.

Table 28. Percentage of Response Rated as Very Important

Elements of Instruction	LLL	HHL	Difference
In-Class Small Group Work	1%	53%	52%
Student Presentations	3%	51%	48%
Whole-class Discussion	4%	48%	44%
Student-to-Student Disc.	4%	56%	52%

The third comparison is between the LHH and HLL groups. The LHH group contains 7 females and 71 males while the HLL group contains 28 females and 64 males. The differences between these two groups in their professional development activities are slight with the only difference that 10% more of the HLL group read the standards more than the LHH group. There were also only slight differences between these groups in terms of institutional factors influencing their teaching practices, and the only difference in personal factors reported is that their experience as a student influenced 15% more of the LHH group. The elements of instruction that vary for these two groups are that 20% more of HLL group reported that well-organized lectures are important, 17% more of the HLL group reported that in class small group work is important, and 12% more of the HLL group reported that student presentations are important.

The fourth and final comparison is between the LHL and HLH groups. The LHL group contains 7 females and 40 males while the HLH group contains 12 females and 36 men. These two groups reported differences in their professional development activities with 29% more of the LHL group reading AMS articles and 15% more reading the standards documents. The only difference in the percentage of institutional factors is in technology, with 20% more of the HLH group reporting that technology influenced their teaching practice. The only difference in the percentage of personal factors is in their experience as a student, with 20% more of the LHL group reporting that it influences their teaching practice. These two groups have similar responses to the elements of instruction question with no difference of 10% or more reported. These two groups are the most similar in their responses, as well as being the smallest median split groups.

The differences in the % of instructors reporting these aspects of instruction as important are quite large. This suggests that in class small group work, whole class discussions, student to student discussions, and student presentations are characteristic of instruction emphasizing student conceptual change. The remaining elements of instruction that had smaller differences between the groups are well designed lectures, student projects, and practice problems and tests. I speculate that these elements of instruction are ranked similarly by both the LLH and HHL groups because these are instructional practices that are important in math teaching regardless of one's teaching approach.

A split plot analysis was conducted with the seven elements of instruction as the repeated measure and the median split group as the between measure. This created a 56 cell grid (7 x 8). The results of the spit plot revealed that a significant interaction occurred ($p < .05$). Because my primary interest was between the HHL and the LLH groups, I conducted post hoc analyses with these two groups.

A split plot was conducted using only the LLH and the HHL groups. Again, a significant interaction occurred (using the Huynh-Feldt statistic due to lack of sphericity). Post hoc tests were conducted to further investigate this difference. Specifically, a repeated measures ANOVA was conducted for the LLH group and a repeated measures ANOVA was conducted for the HHL group with the elements of instruction as the repeated factor. Both repeated measures ANOVAs indicated that significant differences existed between the aspects of instruction for each group. In other words, for the LLH group, the average responses for the seven elements of instruction varied significantly.

Also, for the HHL group, significant differences existed between the average responses for the seven elements of instruction.

Finding statistical significance is distinct from practical significance (Frankel, Wallen & Savin, 1999). Computing an effect size is useful to determine the practical significance of a difference in means. The effect size for the HHL and LLH groups was computed with a numerator of 3.72 - 3.05 = .67 and a denominator of 180/267 * .41 + 187/267 * .57 =.675. For an effect size of .67/.675= .99 which is considered to be a large effect size.

In each case, dependent t-tests were conducted to identify which pairs of instructional elements were significantly different from one other for each group. An alpha level of 0.05/21 = 0.002 was used to control for type I error inflation.

Table 29. T-test for the HHL Median Spit Group

	Well-organize d lectures	Student projects	Practice problems and tests	In class small group work	Student Presenta-tions	Whole-class disc.	Student to student disc.
Well-organized lectures				*L		*L	*L
Student projects			*H	*L		*L	*L
Practice problems and tests				*L	*L	*L	*L
In class small group work					*H		
Student presenta-tions						*L	*L
Whole-class disc.							
Student to Student Disc.							

*H means the column aspect was significantly higher than the row aspect; *L means the column aspect was significantly less than the row aspect.

Table 30. T-tests for the LLH Median Split Group

	Well-organized lectures	Student projects	Practice problems and tests	In class small group work	Student presenta-tion	Whole-class disc.	Student to student disc.
Well-organized lectures		*H	*H	*H	*H	*H	*H
Student projects			*L	*H	*H		
Practice problems and tests				*H	*H	*H	*H
In class small group work						*L	*L
Student presenta-tions						*L	*L
Whole-class disc.							
Student to Student disc.							

*H means the column aspect was significantly higher than the row aspect; *L means the column aspect was significantly less than the row aspect.

Correlations Between Demographic Items and Scale Scores

Correlations were calculated for the following six demographic variables: gender, type of institution, rank, years of experience, class size, number of prospective teachers, and the three scale scores. These correlations are shown in Table 30. All correlations significant at the 0.01 level are starred (**). A correlation squared (or R^2) is the variability that can be explained by that factor. For example, 8% of the variability in the CCS scale scores can be explained by gender, whereas only 2% of the variability in CCT and 1% of the IT scale scores can be explained by gender.

Table 31. Correlations Among Demographic Variables and Scale Score Items

	Conceptual Change Student Focused (CCS)	**Conceptual Change Teacher Focused (CCT)**	**Conceptual Change Student Focused (IT)**
Gender	0.283**	0.169**	-0.114**
Type of Institution	-0.020	-0.026	0.009
Rank	-0.156**	-0.040	-0.004
Years of Experience	-0.126**	0.013	0.010
Class Size	-0.60	-0.068*	-0.116*
Number of Prospective Teachers	0.067*	0.078*	-0.063

All of the demographic variables except for the type of institution are significantly correlated to at least one of the scale scores. The type of institution is designated by the institution‘s Carnegie code and was coded with a number 1-8. A code of “1” denotes a doctoral/Research Extensive institution, and a code of “7”denotes an associate’s college, and a code of “8”denotes a specialized institution. Thus the type of institution is ordered. The correlation between type of institution and CCS scale score is -0.20. This suggests that as the Carnegie code increases (becomes less research oriented or smaller in size) then the CCS scale score decreases slightly. This is a very weak correlation and caution is necessary as there are not many teachers in the higher Carnegie code categories and a smaller category size can cause the correlations to be closer to zero.

As shown in Table 31, years of experience is only correlated with the CCS scale score and only 2 % of the variably in CCS scores can be explained by years of experience. Since the correlation is negative this means that years of greater experience is associated with lower CCS scale scores.

The strongest correlation among the six variables is with gender. Because gender is a dichotomous variable, and the variable cannot be ordered (female is not greater than male) the interpretations of the statistics are:

Females typically have higher scores than males on CCS.

Females typically have higher scores than males on CCT.

Females typically have lower scores than males on IT.

Eight percent of the variability in the CCS scale scores can be explained by gender, whereas, only 3% of the variability in CCT and 1% of the IT scale scores can be explained by gender.

The demographic variable of professional rank was significantly correlated with the CCS scale score. The coding for the professional rank variable is as follows: Assistant Professor 1, Associate Professor 2, Full Professor 3, Instructor/lecturer 4, Visiting Professor 5, Teaching Assistant 6, Adjunct 7, and other category 8. The order of this coding does not lend itself to a clear interpretation; however, these data suggest that typically lower ranked tenure track professors score higher on the CCS scale.

The correlation between years of experience and CCS scale score is statistically significant at the .01 level, indicating that as years of experience increase the CCS scale score decreases. Two percent of the variability in CCS scores can be attributed to years of teaching experience. The correlations among class size and CCT and IT scales are also statistically significant at the .01 level. As class size increases, the CCS scores decrease and the IT scores increase. Finally, the correlations among the number of prospective teachers in a class and the CCS and CCT scale are significant at the .01 level. As the number of prospective teachers in class increases the CCS and CCT scores increase too.

Rank Order Item

Following the Likert scale items of the modified ATI-R, respondents were given seven elements of instruction and asked to rank order them in terms of how important each item was in her or his classroom. Table 32 lists the mean and standard deviations of the seven elements of instruction. All respondents indicated that lectures were important.

Table 32. Mean and Standard Deviation of Rank Order Item #32

Element of Instruction	**Mean**	**SD**
Well organized lectures	3.39	.86
Student projects	2.39	1.11
Practice problems and tests	2.98	1.01
In class small group work	2.29	1.17
Student presentations	2.02	1.09
Whole class discussions	2.62	1.01
Student to student discussions	2.45	1.05

Table 33 lists frequencies, percentages and averages for each median split group. Four (LLH, LHH, HLH, HHH) of the eight median split groups have high IT scores. In order to get a fuller understanding of the importance instructors place on these seven elements of instruction it may be helpful to examine the differences and similarities between these four high IT groups and the remaining four groups. While well-organized they may be a particular hallmark of the high IT groups. However, three of the four IT groups had the lowest means in the student projects, student to student discussions, whole class discussions, and student presentations category. The lowest means in these three groups is evidence that they do not rank these aspects of instruction as important compared to other respondents. The HHH median split group was the exception and may mean that this group is different because of the appearance of the high scores on both conceptual scales. Again, three out of the four high IT groups had the lowest means on in class small group work. The exception this time was the HLH group which may mean that a high score on the student conceptual scale is brought about in part by reporting that they do in class small group work. Many different activities can be accomplished in small group work and these data do not distinguish between uses of small group work. Overall, the HHH group reports many instructional formats which may be consistent with standards recommendations. Caution is necessary in interpreting these results since participants may have differing definitions of what is meant by these elements of instruction. Finally, these results are consistent with the modified ATI-R scale scores and are evidence that this survey did capture differences among groups.

Table 33.Elements of Instruction by Group Frequency, Percent and Average

	LLL	LLH	LHL	LHH	HLL	HLH	HHL	HHH	Overall
Well-Organized Lectures									
Very Important	76(15%)	153(30)	26(5)	68(13)	31(6)	38(7)	46(9)	78(15)	516
Important	44(20%)	23(10)	11(5)	10(4)	36(16)	9(4)	68(30)	23(10)	224
Somewhat Important	10(12%)	3(4)	7(8)	2(2)	23(28)	1(1)	37(45)	2(2)	83
Not Very Important	4(9%)	1(2)	3(4)	0(0)	3(7)	0(0)	34(75)	0(0)	45
Average	3.4	3.8	3.3	3.85	3.0	3.8	2.85	3.7	3.4
Student Projects									
Very Important	24(13%)	11(6)	9(5)	9(5)	23(13)	7(4)	68(38)	29(16)	180
Important	32(14%)	31(13)	12(5)	19(8)	34(15)	11(5)	59(26)	30(13)	228
Somewhat Important	35(19%)	47(25)	11(6)	23(12)	17(9)	13(7)	33(18)	27(14)	186
Not Very Important	44(17%)	91(36)	15(6)	26(10)	19(8)	17(7)	24(9)	17(7)	253
Average	2.3	1.3	2.0	2.1	2.7	2.0	2.6	2.7	2.4
Practice problems and tests									
Very Important	52(16%)	91(27)	15(4)	37(11)	19(6)	26(8)	34(10)	57(17)	331
Important	47(16%)	69(24)	17(6)	17(6)	37(13)	13(4)	55(19)	33(11)	288
Somewhat Important	21(15%)	12(8)	10(7)	11(8)	20(14)	5(3)	55(39)	7(5)	141
Not Very	15(14%)	7(7)	4(4)	11(10)	17(16)	4(4)	40(38)	6(6)	104

Table 33-continued

Important									
Average	3.0	3.3	2.9	3.1	2.6	3.3	2.5	3.4	2.8
In class small Group work	**LLL**	**LLH**	**LHL**	**LHH**	**HLL**	**HLH**	**HHL**	**HHH**	**Overall**
Very Important	5(2%)	2(1)	2(1)	2(1)	35(17)	14(7)	107(53)	34(17)	201
Important	24(17%)	17(12)	5(4)	3(2)	28(20)	15(11)	31(22)	15(11)	138
Somewhat Important	43(19%)	52(23)	16(7)	18(8)	23(10)	8(4)	31(14)	31(14)	222
Not Very Important	63(20%)	109(34)	25(8)	11(3)	6(2)	11(3)	18(6)	78(24)	321
Average	1.8	1.5	1.7	1.9	3.0	2.7	3.2	2.0	2.2
Student Presentations									
Very Important	11(8%)	4(3)	6(5)	4(3)	15(12)	2(1)	66(51)	21(16)	129
Important	15(11%)	11(8)	6(5)	10(7)	26(19)	9(6)	40(28)	23(7)	140
Somewhat Important	31(14%)	33(15)	13(6)	18(8)	31(14)	9(4)	55(25)	33(15)	223
Not Very Important	78(21%)	132(35)	23(6)	44(12)	21(5)	28(7)	24(6)	26(7)	376
Average	1.7	1.4	1.9	1.7	2.4	1.7	2.8	2.4	2.0
Whole-Class Discussions									
Very Important	9(4%)	8(4)	13(6)	16(8)	15(7)	6(3)	97(48)	36(18)	200
Important	48(17%)	35(12)	19(7)	28(10)	36(13)	18(6)	54(19)	48(17)	286
Somewhat Important	49(20%)	69(29)	13(5)	18(7)	35915)	9(4)	30(12)	17(7)	240
Not Very Important	29(20%)	66(46)	3(2)	18(12)	7(5)	15(10)	5(3)	1(1)	144
Average	1.8	1.9	2.7	2.5	2.6	2.3	3.3	3.2	2.5

Table 33-continued

Student to Student Discussions									
Very Important	2(1%)	8(4)	2(1)	5(3)	16(9)	5(3)	98(56)	38(22)	
Important	32(14%)	31(13)	13(5)	13(5)	33(14)	17(7)	59(25)	36(19)	
Somewhat Important	57(22%)	57(22)	21(8)	30(11)	38(14)	16(6)	23(9)	22(8)	
Not Very Important	44(23%)	82(42)	10(5)	29(15)	6(3)	10(5)	7(4)	6(3)	
Average	1.9	1.6	2.2	1.8	2.0	2.4	3.3	3.0	

Analysis of the open-ended responses

The modified ATI-R contains two open-ended questions: "What do you do well in terms of your teaching?" and "What do you need to improve upon in terms of your teaching?"

Responses to the two open-ended questions were coded using an emergent design. An emergent design procedure includes the development of a system for coding or identifying categories or themes based upon patterns and ideas that emerge from the data. After labeling the observed patterns and sorting, comparing, and contrasting, a system for classification emerges (Patton, 1990).

The reliability of the coding scheme was checked using inter-rater reliability. I hired and trained a graduate student in the College of Education to assist with the coding process. I trained the graduate student with a subset of the data. After training was complete, we independently coded 20% of the open-ended responses. On question #33, 90% agreement was not reached in the first attempt, so we discussed the codes on which we disagreed and coded another 20% of the data. 92% agreement was reached on the second coding. I then coded the remaining data and these codes were used for the final analyses. At most two codes were assigned to a response. Finally, I highlighted selected comments from the open-ended questions to illuminate the quantitative analyses.

Coding schemes for the open-ended questions:

1. Affective- The response mentioned a belief, attitude or emotion involved in mathematics teaching or learning. For example, a response coded as affective is "Inspiring students to appreciate the subject and go on to learn more mathematics on their own."

2. Math Content Related- The response mentioned a specific mathematics teaching or learning method or some aspect of teaching mathematics. For example, a response coded as math content related is " I try to show how to approach mathematics with both geometric intuition and logical proofs."

3. Instructional Method- The response mentioned a general teaching method or some aspect of teaching. The Instructional method category was divided into five aspects of instruction.

a. *Assessment*- Response mentioned an aspect of assessment. For example, a response coded as assessment is "make students understand that when their grades are low, they really aren't meeting the standard. Motivate students to spend enough time on the course."

b. *Interaction with students or among students*- Response mentioned an interaction with students or among students in class. For example, a response is

"I would like to get more student interaction in class. I would like to do it in the most nonthreatening way possible."

c. *Course design and management*- Response mentioned an aspect of course organization and or management. For example, a response is

"Organize well, teach the average student, communicate expectations clearly."

d. *Instructional Strategy*- Response mentioned an instructional strategy, a teaching method or some other aspect of instruction. For example, a response "I give thorough a vivid technical explanations of the rules and methods of Calculus. I maintain a strong feedback of the student's performance throughout the course."

e. *Other*- Response mentioned the use of technology or providing instructional support outside of class. For example, a response is "Present material; make it clear what students are supposed to know; provide support outside of class."

4. Student Learning Characteristics- The response mentioned some aspect of student learning. For example, a response is "Understand how to reach students who aren't doing the work."

5. Global-The response mentioned I do not know, nothing or everything. For example, a response is "I'd like to continue to improve everything."

Other- The response does not answer the question or the response does not fit into one of the other five categories. For example, a response is "I'd like to be better at giving a hint without giving the whole thing away."

The frequencies of coded responses are displayed in Tables 34 and 35.

Table 34. Frequencies of Coding Categories for Open-ended Question #1

Code Category for "What do you think you d o well in terms of your teaching?"	**Frequency**
Affective	160
Math Content Related	174
Instructional Method	
a. Assessment	42
b. Interaction with student or among students	159
c. Course management	46
d. Communication of concepts	208
e. Provide support outside of class or technology aspect of instruction	27
Student Learning	197
Global	9
Other	69

Table 35 Frequencies of Coding Categories for Open-ended Question #2

Code Category for "What do you need to improve upon in terms of your teaching?"	**Frequency**
Affective	103
Math Content Related	43
Instructional Method	
a. Assessment	65
b. Interaction with student or among students	173
c. Course management	179
d. Communication of concepts	43
e. Provide support outside of class or technology aspect of instruction	25
Student Learning	56
Global	6
Other	64

College Math Professors Report What They Do Well in Their Teaching

Examples of responses to “What do you do well in terms of your teaching?” are “I present the ideas clearly and do so in a variety of ways. I engage students in discussions in class so I know what they understand and what they don’t” and “Well-organized, coherent lectures with multiple ways of explaining topics.”

Topics that were coded as affective include: enthusiastic about learning and or teaching math, interest students in topics and or math ideas (enjoy math, motivate concepts), relating to students (rapport), help and care about students, attentive to students needs, gaining student trust, and help students with math phobias. For example, a response coded as affective is “I need to be more patient with slower students.”

Topics included in Student Learning Characteristics are: help students think rigorously for themselves, help students understand at deeper level, help students develop their mathematical intuition, encourage student creativity, and challenge and or support students.

Responses to what instructors believe they do well focus on affective, math content related, interaction with or among students, communication of concepts, and student learning, whereas responses to what they need to improve upon focused primarily on affective, interaction with and among students, and course management.

The relatively high number of math content related responses makes sense given that college math professors are content experts in mathematics. The small number of responses coded as assessment is somewhat surprising given that assessment is an area of teaching where change has been initiated by professional organizations, at least for K-12 teachers. A large number of responses mentioned “communication of a concept” as something they do well, which may be due to the fact that many of the topics captured by this code were raised earlier in the survey, and thus came to mind easily for the respondents.

College Math Professors Report What They Need To Improve Upon in Their Teaching

Examples of responses to “what do you think you need to improve upon in terms of your teaching?” are “I could be better organized,” “I need to be more patient with slower students” and “Understand how to reach students who aren’t doing the work.”

Topics in this category include: making explanations, learning objectives, relevant examples, teaching strategies and lecturing. The most frequent aspect of teaching that these math instructors felt they needed to improve was course management. For example, responses mentioned covering the syllabus, pacing of the course, improve the clarity of handwriting and expectations, enforcing deadlines, and teaching large class sections. This large number of responses about classroom and course management suggests that many college math professors believe that managing or organizing the courses better will directly lead to improved understanding of the content. A high number of responses to the question about what the respondent needs to improve involved a variation on explaining concepts or methods more clearly. This indicates that many college math professors believe that explaining concepts and methods are important for student learning.

Only half as many college math professors mentioned student learning characteristics compared to affective aspects of teaching as something that they need to improve upon. The numbers of affective coded responses to both questions may be evidence that college math professors are thinking and reflecting on their teaching in terms of the emotional aspects of teaching and learning.

CHAPTER 5 CONCLUSIONS AND DISCUSSION

The purpose of this exploratory study was to gather data on the instructional practices of college and university mathematics professors when teaching undergraduate math courses. Second, I wanted to understand their own evaluations of their teaching practices.

Research Questions

The research questions of this study are:

1. What are the instructional methods that college mathematics professors use?
2. How do college mathematics professors evaluate the effectiveness of their instructional practices?

Context of the Mathematics Courses

In order to understand the results of my study it is important to first look at the context of the study. I started by asking three broad questions. First, survey respondents were asked to report the most recent undergraduate mathematics course they taught in which secondary teachers were enrolled. Forty-six per cent of the courses reported in my study were advanced undergraduate mathematics courses (e.g., Abstract Algebra, Geometry, Analysis courses, Discrete Math). The second and third question asked respondents the approximate number of students and secondary preservice teachers enrolled in these courses. This national sample of 879 college math professors taught 20,392 students of which 8,080 (25%) were prospective secondary math teachers. The average number of preservice secondary math teachers enrolled in the courses is 9, with a minimum of 1 and a maximum of 100. The average number of all students enrolled in the courses was 23, with a minimum of 1 and a maximum of 150.

The class sizes of these 879 courses were divided into three categories of 1-25, 26-50, and 51-150 students in a course. Forty-three per cent of these classes have 50 students or less, consequently, these results should not be generalized to large lecture-type classes. Following the questions on the context of the mathematics course, the instructional strategies survey contained four types of items: Likert scale items, a rank-order item, two open-ended questions, and demographic questions.

Demographic Questions

The respondents were surveyed on their academic rank, frequency of teaching courses in which preservice secondary teachers enroll, graduate degrees, professional development activities, years of mathematics teaching experience, institutional and personal factors that influence their teaching, gender, and the state in which they work. Over 96% of the respondents of the survey were tenured or tenure-track faculty, thus students in the math courses represented in the survey are receiving instruction from full-time faculty members.

Following the question on academic rank, respondents were asked to estimate how frequently they teach undergraduate mathematics courses in which preservice math teachers enroll. Approximately 69% of the respondents teach two or more classes a year in which preservice teachers enroll. For this sample, faculty came into regular contact with preservice secondary teachers. Thus the reported instructional strategies represent a reasonable view of instructional strategies preservice secondary teachers are exposed to in their undergraduate math classes. Respondents were surveyed on the discipline of their graduate degrees. The majority of respondents earned Ph.D.s in mathematics.

The next demographic question asked respondents to select professional development activities from a provided list. Overall, there is a high level of engagement in these educationally relevant professional development activities. Over 50% of these respondents read material published by the National Council of Teachers of Mathematics, which most likely indicates an interest in teaching. In addition, over 91% of this sample regularly talks to colleagues about teaching issues.

Respondents were asked to report the number of years they have taught college mathematics. The reported mean is 23.3 years of mathematics teaching experience with a standard deviation of 11.9 years. The minimum number of years of teaching experience reported was 1, with a maximum of 55 years. As a whole, this is an experienced group of college and university mathematics professors.

Respondents were asked to select institutional factors that influenced their teaching practices from a list provided in the survey. Class size, textbook, and instructional time are factors that a majority of respondents report influence their teaching practices. Respondents were asked to select personal factors that influenced their teaching practices from a provided list.

The majority of respondents reported that their experiences as a teacher and their teaching style influence their teaching practices. In addition, approximately 50% reported that their experiences as a student influence their teaching practices lending some support to the idea that a preservice teacher's experience as a mathematics student in college may later influence their own teaching. Furthermore, this is important given that this is a sample of experienced college math professors whose experiences as college students are not recent.

The final two demographic questions asked respondents their gender and the name of the state in which they work. Over 75% of respondents were male. This number is not surprising given the smaller number of tenured and tenure track female mathematics professors. In 2005, 23% of tenured or tenure track college mathematics professors in the United States were female (Conference Board of the Mathematical Sciences Survey 2005). Thus, this sample of college mathematics professors is representative of the U.S. population in terms of gender.

Instructional Methods in the Classroom

Research question one is "What are the instructional methods that college mathematics professors use? I addressed this question through analyses of Likert scale item.

Trigwell, Prosser, and Waterhouse (1999) examined teaching in college classrooms by investigating the relations between the teaching approach and the students' learning approach. They found that teachers who adopt more of an information transmission/teacher-focused approach to teaching have students who themselves report adopting more of a surface approach to learning. From this study came the *Approaches to Teaching Inventory- Revised* (ATI-R, 2004). My study documented the approaches to teaching of a national sample of U.S. college math professors using a modified version of the ATI-R.

Factor Analysis

At the start of the study, drawing on Trigwell, Prosser, and Taylor I speculated that I would have two factors, an information transmission/teacher-focused approach versus a conceptual change/student focused approach. Based on an exploratory factor analysis, the modified ATI-R appears to have three factors or dimensions. The three factor names are: Factor 1 *Conceptual Change Student Focused (CCS),* Factor 2 *Conceptual Change Teacher Focused* (CCT), and. Factor 3 *Information Transmission Teacher Focused (IT*). The three scales: CCS, CCT, and IT can be conceptualized by comparing the college math professor's role in the classroom and the way in which they think of or understand student learning. In the CCS scale, the questions focus more on what the college math professor asks the students to do to promote student conceptual change. In the CCT scale, the questions focus more on what the instructor does in the classroom to promote student learning. In contrast, the IT scale questions focus more on what the college math professors do in the classroom to promote the students receiving information.

In order to understand and categorize individual respondents on all three scales I created median split groups. Each instructor was categorized as high or low on each of the three scales. I label each respondent as H(igh) or L(ow) on the CCS, CCT, and IT in that order, thus a respondent who is scored above the median on all three factors is labeled HHH.. The number of respondents in each of the eight median split groups varied. However, there were a relatively high number of respondents in the LLH (respondents scored low on both conceptual scales and high on IT) and HHL (respondents scored high on both conceptual scales and low on IT) groups, along with the relatively small number of respondents in the LHL and HLH groups. These latter groups seem somewhat inconsistent or difficult to envision. For example, HLH means the instructor reports engaging frequently in activities focusing on students' learning and on the transmission of information, but not on their own activities to promote student learning.

The professional development activities selected by respondents were broken down by median split score. The LLH group reports the lowest percentage of all the professional development activities except for reading AMS articles. Over twice as many respondents in the HHL group reported reading the MAA/RUME materials as in the LLH group, and 25% more reported reading the NCTM standards. Thus the groups who focus more on conceptual understanding (CCS and CCT) are more likely to read documents related to teaching undergraduate mathematics and mathematics education.

Regardless of median split group, there was a low percentage of respondents who selected moral support as an institutional factor that influenced their teaching practices, whereas a relatively high percentage selected class size as an important factor. Further, comparing the LLH and HHL groups on textbook importance, almost two times as many

LLH members said the textbook was an important influence on their teaching, which may result from their greater emphasis on the presentation of information to students.

Regardless of median split group over 75% of the instructors indicate that teaching style and experience as a teacher influence their teaching practices, and 50% list experience as a student as a factor. Percentages for the LLH and HHL are similar in most categories, except that experience as a student is 14% higher for the LLH group. The largest difference between these groups is that “reading professional standards” is more than two times as likely for HHL members.

I then contrasted pairs of median split groups to highlight the differences between the groups. The groups were compared in terms of gender, professional development activities, personal and institutional factors that influence their teaching practices and the elements of instruction ranked in terms of importance. The elements of instruction item listed seven instructional activities which they were asked to rank in order of importance. The largest differences were reported between the HHL and LLH groups. Specifically, the largest differences were found in four of the elements of instruction (in-class small group work, student presentations, whole-class discussions, and student-to-student discussions). These two groups differed by about 50% for all four elements of instruction. This high percentage indicates that there are fairly large differences in the importance they place on various classroom activities.

An important finding of this study is that gender and the CCS scale are related, with females tending to score higher on the CCS scale. This is consistent with Li (1999) who suggests that female teachers tend to be more student-centered than male teachers.

Open-Ended Questions

College math professors’ top three frequent responses to what they do well in terms of teaching were analyzed and coded according to the following themes: affective, related to math content, or communicating concepts. Knowing how college math professors evaluate their own teaching is important both in the effort to understand the instructional practices of college mathematics instructors and to any efforts to create effective professional development experience for them.

Respondents Evaluate the Effectiveness of Their Instructional Methods

Research question number two asked "How do college mathematics professors evaluate the effectiveness of their instructional practices?" Two open-ended response questions were asked: (1) What do you think you do well in terms of your teaching? and (2) What do you think you need to improve upon in terms of your teaching? The use of open-ended questions is understood as prompts for sense making (Blanton, Berenson and Norwood, 2001). In this context, the open ended responses help illuminate how college mathematics professors are making sense of their teaching.

The respondents were asked what they do that is less effective or needs improvement. This is an important area since instructors are more likely to actually work on an area if they believe that growth is needed and they are motivated to work to improve. Affect, interaction with students, and course management were the most important needing improvement.

These data are important in they provide an entry point for starting an instructional dialogue with college math professors. To change one's teaching requires a philosophical shift in thinking or otherwise instructors may have limited success and revert back to the old ways. The fact that many college math professors mentioned affective aspects in their response is a sign that they are reflecting on their teaching and how it connects to what the students learn.

Discussion

Reform reports describe concerns with the preparation of math teachers and the lack of research in this area (Ball, Lubienski & Mewborn, 2001). This current study represents an exploratory step in developing an understanding of the instructional strategies of college math professors.

Of interest in the CCS scale items is that the highest mean occurred in an item about how often instructors encourage debate and discussion. In contrast, the item with the highest mean on the CCT scale is an item about making connections among mathematical ideas. These two scales may capture some of the differences that can occur in a classroom where the instructor is trying to implement student-centered teaching ideas. For example, the instructor may focus primarily on what the students are doing or they may focus on what they are doing to promote conceptual change. On the IT scale, the items with the highest means were about presenting information to students so they know what needs to be learned. The college math professors who scored high on this scale share common instructional strategies with the respondents who score high on the CCS scale.

Wu (2005), a mathematician and critic of many practices in the mathematics education community stated that "teaching prospective teachers make heavy demands on the instructor's pedagogical competence in addition to mathematical competence. This is because the teaching style of prospective teachers is more likely to be influenced by what they observe in their instructor's teaching than by what they are told" (Wu, 2005, p. 41). Further Wu states that "Unfortunately, the number of university professors who are both mathematically and pedagogically competent and are interested in professional development is not large." Wu's writing is a call to the math community on the concerns about the preparation of prospective teachers.

Study Limitations

The current study administered the modified ATI-R, an instrument based on self-reports, to college mathematics professors in 46 states. One of the main limitations of this study is that the sample is a self-selected group of college math professors. Despite this limitation, this study underscores the feasibility and importance of using a survey in which college math professors' describe their instructional practices by documenting how often they implement various strategies in their classroom. Such data provides a snapshot of the instructional practices of college math professors. These exploratory data provide an emerging picture of the types of instructional strategies pre-service teachers observed in their undergraduate mathematics classroom during the 2006-2007 academic year. However, more research is needed in this area. Although the number of responses to this survey exceeded what I anticipated receiving the response rate is considered average or low and therefore the results must be interpreted with caution.

Recommendations for Future Research

More research is needed to better understand how students make sense of effective instruction in college and university classrooms. Specifically, what models of good instruction do they take away from their exposure in college and university classrooms?

Teaching is more complex than the three scales discussed above and the results of this study provide further evidence that there are deep complications involved in teaching and teaching research.

Based on the findings and conclusions from this study, the following recommendations are developed:

1. Research is needed to understand the rationale college professors have for their instructional decisions. First, I suggest contacting retired college math

professors. This population of retired instructors has the time and appears willing and interested in helping current faculty, students and math departments. In my opinion, this population is an untapped source of knowledge and experience. I know of no past or current studies which examine the instructional rationales held by retired college math professors.

2. In-class observational studies might yield insights on the actual instructional strategies implemented in college mathematics classrooms. Video and audio tapes might provide vivid pictures of the classroom culture and could be utilized to improve the instructional strategies of college math professors and thereby improve the instructional strategies observed by prospective teachers.

3. Studies are needed to document those math departments with faculty who use a variety of instructional approaches and teach with a wider range of instructional strategies that engage undergraduate students. Profiles of these departments may shed light on effective mathematics instruction.

4. Interview retired college math professors to better understand the culture in math departments and the kind of professional support that would help current faculty.

5. Interviews with college math professors might shed light on the ways that math departments can collaboratively explore effective instruction that engages students.

6. Design faculty development programs that use a pre and post measures to account for growth in and support for implementing student centered teaching strategies in the college math classroom. These data could inform departmental discussions for improved student learning.

APPENDIX A APPROACHES TO TEACHING INVENTORY-REVISED

This inventory is designed to explore a dimension of the way that academics go about teaching in a specific context or subject or course. This may mean that your responses to these items in one context may be different to the responses you might make on your teaching in other contexts or subjects. For this reason we ask you to describe your context.

Please name the subject/course of your response: . . . .

For each item please circle one of the numbers (1-5). The numbers stand for the following responses:

1 this item was **only rarely or never** true for me in this subject.

2 this item was **sometimes** true for me in this subject.

3 this item was true for me **about half the time** in this subject.

4 this item was **frequently** true for me in this subject.

5 this item was **almost always or always** true for me in this subject.

Please answer each item. Do not spend a long time on each: your first reaction is probably the best one.

	Only Rarely				Almost Always
1. In this subject students should focus their study on what I provide them.	1	2	3	4	5
2. It is important that this subject should be completely described in terms of specific objectives that relate to formal assessment items.	1	2	3	4	5

3. In my interactions with students in this subject I try to develop a conversation with them about the topics we are studying.	1	2	3	4	5
4. It is important to present a lot of facts to students so that they know what they have to learn for this subject.	1	2	3	4	5
5. I set aside some teaching time so that the students can discuss, among themselves, key concepts and ideas in this subject.	1	2	3	4	5
6. In this subject I concentrate on covering the information that might be available from key texts and readings.	1	2	3	4	5
7. I encourage students to restructure their existing knowledge in terms of the new way of thinking about the subject that they will develop.	1	2	3	4	5
8. In teaching sessions for this subject, I deliberately provoke debate and discussion.	1	2	3	4	5
9. I structure my teaching in this subject to help students to pass the formal assessment items.	1	2	3	4	5
10. I think an important reason for running teaching sessions in this subject is to give students a good set of notes.	1	2	3	4	5

11. In this subject, I provide the students with the information they will need to pass the formal assessments.	1	2	3	4	5
12. I should know the answers to any questions that students may put to me during this subject.	1	2	3	4	5
13. I make available opportunities for students in this subject to discuss their changing understanding of the subject.	1	2	3	4	5
14. It is better for students in this subject to generate their own notes rather than copy mine.	1	2	3	4	5
15. A lot of teaching time in this subject should be used to question students' ideas.	1	2	3	4	5
16. In this subject my teaching focuses on the good presentation of information to students.	1	2	3	4	5
17. I see teaching as helping students develop new ways of thinking in this subject.	1	2	3	4	5
18. In teaching this subject it is important for me to monitor students' changed understanding of the subject matter.	1	2	3	4	5
19. My teaching in this subject focuses on delivering what I know to the	1	2	3	4	5

students.					
20. Teaching in this subject should help students question their own understanding of the subject matter.	1	2	3	4	5
21. Teaching in this subject should include helping students find their own learning resources.	1	2	3	4	5
22. I present material to enable students to build up an information base in this subject.	1	2	3	4	5

APPENDIX B MODIFIED APPROACHES TO TEACHING INVENTORY-REVISED

INSTRUCTIONAL STRATEGIES SURVEY

Answer the following survey questions in reference to the most recent course you taught in which prospective grades 7-12 teachers were enrolled.

Please name the course title and topics taught in this course.

The approximate number of students in this course

The approximate number of prospective grades 7-12 teachers in this course

This inventory is designed to explore dimensions of the way you teach in a specific course. This may mean that your responses to these items in this course may be different to the responses you might make on your teaching in other courses.

Answer the following questions in reference to the course listed on the previous page.

1 - this item was only rarely true for me in this course
2 - this item was only sometimes true for me in this course
3 - this item was true for me about half the time in this course
4 - this item was frequently true for me in this course
5 - this item was almost always true for me in this course

Please answer each item. As you respond, consider this course as a whole. Do not spend a long time on each item. Your first reaction is probably the best one.

1) In this mathematics course, how often did you ask students to focus their study on what you provided to them as opposed to outside material (e.g. textbook)?

- 1
- 2
- 3
- 4
- 5

2) In this mathematics course, how often did you characterize this mathematics course to students in terms of specific objectives that relate to your course assessments (e.g. tests)?

- 1
- 2
- 3
- 4
- 5

3) How often in your interactions with students did you try to develop a conversation with them about the topics being studied?

- 1
- 2
- 3
- 4
- 5

4) How often was it better in this mathematics course for students to generate their own notes rather than copy your notes?

- 1
- 2
- 3
- 4
- 5

1 - this item was only rarely true for me in this course
2 - this item was only sometimes true for me in this course
3 - this item was true for me about half the time in this course
4 - this item was frequently true for me in this course
5 - this item was almost always true for me in this course

5) How often did you present information to students so that they would know what had to be learned in this mathematics course?

- [ ] 1
- [ ] 2
- [ ] 3
- [ ] 4
- [ ] 5

6) In this mathematics course, how often did you have students problem solve in class?

- [ ] 1
- [ ] 2
- [ ] 3
- [ ] 4
- [ ] 5

7) In this mathematics course, how often did you concentrate on covering information that might be available from a textbook or other material from the publisher?

- [ ] 1
- [ ] 2
- [ ] 3
- [ ] 4
- [ ] 5

1 - this item was only rarely true for me in this course
2 - this item was only sometimes true for me in this course
3 - this item was true for me about half the time in this course
4 - this item was frequently true for me in this course
5 - this item was almost always true for me in this course

8) In this mathematics course, how often did you encourage students to restructure their existing knowledge in terms of new ways of thinking about mathematics?

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

9) In this mathematics course, how often did you encourage debate and discussion?

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

10) How often did you organize your teaching in this mathematics course so that students get a good set of notes?

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

11) How often did your formal assessments in this course reflect mathematical information you've **directly** provided students?

- 1
- 2
- 3
- 4
- 5

12) In this mathematics course, how often did you make opportunities available for students to discuss their changing understanding of mathematical ideas and Methods?

- 1
- 2
- 3
- 4
- 5

13) How often was teaching time in this mathematics class used to question students' ideas?

- 1
- 2
- 3
- 4
- 5

14) How often was interaction in this mathematics class between students, rather than you and the students?

- 1
- 2
- 3
- 4
- 5

1 - this item was only rarely true for me in this course

2 - this item was only sometimes true for me in this course

3 - this item was true for me about half the time in this course

4 - this item was frequently true for me in this course

5 - this item was almost always true for me in this course

15) In this mathematics course, how often did your teaching focus on the presentation of information to your students?

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

16) In this mathematics course, how often were your teaching activities designed to help students develop new ways of thinking about mathematical ideas and methods?

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

17) In this course, how often was it important for you to monitor students' developing understanding of mathematical ideas?

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

1 - this item was only rarely true for me in this course
2 - this item was only sometimes true for me in this course
3 - this item was true for me about half the time in this course
4 - this item was frequently true for me in this course
5 - this item was almost always true for me in this course

18) How often in your teaching of this mathematics course did you focus on delivering what you know to the students?

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

19) In this mathematics course, how often did your teaching help students question their own understanding of mathematical ideas?

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

20) In this mathematics course, how often did your teaching encourage students to figure out a concept or method on their own with some guidance from you?

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

21) In this mathematics course, how often did you present material to enable students to build up an information base in mathematics?

- ☐ 1
- ☐ 2
- ☐ 3

- 4
- 5

1 - this item was only rarely true for me in this course
2 - this item was only sometimes true for me in this course
3 - this item was true for me about half the time in this course
4 - this item was frequently true for me in this course
5 - this item was almost always true for me in this course

22) In this mathematics course, how often did you ask students to make a logical argument, either through individual response, in-class discussions or group-work?

- 1
- 2
- 3
- 4
- 5

23) How often did you provide the students with the information they would need to pass the course assessments?

- 1
- 2
- 3
- 4
- 5

24) When teaching this mathematics course, how often did you present or ask students to use more than one representation in order to understand a given mathematical idea (e.g., tables, graphs, equations, diagrams, physical models, etc.)?

- 1
- 2
- 3
- 4
- 5

25) When teaching this mathematics course, how often did you emphasize the importance of making connections among mathematical ideas?

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

26) In teaching this mathematics course, how often did you ask students to learn new mathematical concepts or methods by solving problems during class time?

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

27) In this mathematics course, how often did you ask students to communicate their own mathematical thinking during class?

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

28) In this mathematics course, how often did you ask students to understand other students' thinking and compare with their own thinking or formal mathematical knowledge?

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

29) In this mathematics course, how often did you orchestrate conversations among students?

- 1
- 2
- 3
- 4
- 5

30) In this mathematics course, how often did you explain mathematical definitions, theorems and methods as part of your instructional presentation?

- 1
- 2
- 3
- 4
- 5

31) How often did your teaching in this mathematics course include helping students find their own learning resources?

- 1
- 2
- 3
- 4
- 5

32) Rank the following factors in terms of importance when you teach this mathematics course.

	Very Important	Important	Somewhat Important	Not Very Important
well organized lectures				
student projects				
practice problems and tests				
in class small group work				
student presentations				
whole-class discussions				
student to student discussions				

33.) What do you think you do well in terms of your teaching?

34.) What do you need to improve upon in terms of your own teaching?

Demographic Section

35) What is your current professional rank?

- ○ Assistant Professor
- ○ Associate Professor
- ○ Full Professor
- ○ Instructor/Lecturer
- ○ Visiting Professor
- ○ Graduate Teaching Assistant
- ○ Adjunct
- ○ Other

36) How frequently do you teach undergraduate mathematics courses in which prospective grades 7-12 teachers enroll?

- ○ More than 2 classes per year
- ○ 2 classes per year
- ○ 1 class per year
- ○ Less than 1 class per year

Please list your graduate degrees.

Masters degrees [ ]

Doctoral degrees [ ]

37) Please select all that apply.

- ☐ I have attended departmental seminars related to teaching and learning mathematics
- ☐ I have read articles sponsored by The Mathematical Association of America's Special Interest Group on Research in Undergraduate Mathematics Education (RUME)
- ☐ I have read reports from The Mathematical Association of America's Committee on the Undergraduate Program in Mathematics (CUPM)
- ☐ I have read articles in the American Mathematical Society Notices about education
- ☐ I have read articles about The Principles and Standards for School Mathematics sponsored by the National Council of Teachers of Mathematics

☐ I regularly talk with colleagues about teaching issues

40) Years of mathematics teaching experience is

[ ]

41) Please select all the **institutional** factors that influence your teaching practices in mathematics courses prospective grades 7-12 teachers enroll in.

☐ Departmental curriculum committee

☐ class size

☐ Moral support from colleagues

☐ Departmental support

☐ History of how the course has been taught

☐ Textbook

☐ Instructional time

☐ Resources (e.g. technology)

☐ All of the above

☐ Other (please specify)

If you selected other, please specify:

[ ]

42.) Please select all the **personal** factors that influence your teaching practices in mathematics courses prospective grades 7-12 teacher enroll in.

☐ Teaching style

☐ Student expectations

☐ Time to prepare

☐ My experience as a student

- Professional standards from organizations
- My experience as a teacher
- All of the above

43) Gender?

Male Female

44) Please select the name of the state in which you work.

Thank you for completing this survey.

If you want to be included in the drawing for the NEW Wolfram Mathematica 6 software, send a blank email to Kelly-f-finn@uiowa.edu, with Mathematica in the subject line.

If you are interested in receiving your survey results and/or the findings from this study, contact Kelly Finn at Kelly-f-Finn@uiowa.edu. Please specify what you want sent in the subject line.

Submit Survey 100%

APPENDIX C PRENOTIFICATION AND CONSENT LETTER

Kelly Finn

The University of Iowa

N259 North Lindquist Center

Iowa City, Iowa 52242-1529

Dear Professor __________:

In one week a survey will be sent to you that takes approximately 15 minutes to complete. By completing the survey you can enter to win the New Wolfram Mathematica Pro 5.2 software.

If you have questions about the research study, please contact:
Kelly-f-Finn@uiowa.edu, Joyce Moore, Ph.D. at Joyce-L-Moore@uiowa.edu or Carolyn Colvin, Ph.D. at Carolyn-Colvin@uiowa.edu.

SURVEYY INVITATION

Kelly Finn
The University of Iowa
N259 North Lindquist Center
Iowa City, Iowa 52242-1529
Reference Number ______
Dear Professor _________:

We are writing to invite you to participate in a research study. The purpose of the study is to describe how college mathematics professors teach undergraduate mathematics courses and how their self-reported rationale underlies their instructional decisions.

Your participating in this study is voluntary. If you agree to take part in this study, your involvement will last for approximately 10-15 minutes.

All information collected from this study will be kept confidential. Before beginning the survey, you will be asked one qualifying question and asked to read an Informed Consent Document which has additional information about the study.

If you have questions about the research study, please contact: Kelly-f-Finn@uiowa.edu or Carolyn Colvin, Ph.D. at Carolyn-Colvin@uiowa.edu.

The qualifying question is: **Do you or have you taught undergraduate mathematics courses K-12 pre-service teachers enroll in?**

Yes (next screen will be the consent letter and survey)

No (next screen will say "Thank you for your participation" and exit them from the site)

Thank you for your participation in this research study.

Sincerely,
Kelly Finn

CONSENT LETTER

Project Title: College Mathematics Professors' Instructional Strategies

Research Team: **Kelly Finn, Professor Carolyn Colvin, and Professor Joyce Moore**

This consent form describes the research study to help you decide if you want to participate. This form provides important information about what you will be asked to do during the study, about the risks and benefits of the study, and about your rights as a research subject.

We are inviting you to participate in this research study because you are a college mathematics professor and you have taught undergraduate mathematics courses K-12 pre-service teachers enroll in. We obtained your name and email address from the combined membership list of the American Mathematical Society. We have permission to use these email addresses in this research study.

The purpose of this research study is to examine the instructional strategies of college math professors in undergraduate mathematics courses in which K-12 pre-service teachers enroll.

Approximately 10 people will take part in this study at the University of Iowa. The total number of subjects expected to participate nationwide is 1000. If you agree to take part in this study, your involvement will last for 10-15 minutes.

You are invited to participate in a research study of college mathematics professor's instructional strategies. Your only participation in this study involves answering an online survey. You are free to skip any questions that you would prefer not to answer.

There are no foreseeable risks to participating in this study. You will not benefit from being in this study. However, we hope that, in the future, other people might benefit from this study because knowledge about teaching is important. You will not have any cost for being in this research study.

You will not be paid for being in this research study. The University and the research team are receiving no payments from other agencies, organizations, or companies to conduct this research study.

We will keep your participation in this research study confidential to the extent permitted by law. However, it is possible that other people may become aware of your participation in this study. For example, federal government regulatory agencies, auditing departments of the University of Iowa, and the University of Iowa Institutional Review Board (a committee that reviews and approves research studies) may inspect and copy records pertaining to this research. Some of these records could contain information that personally identifies you.

To help protect your confidentiality, we will use an ID code number on each survey and will use password-protected computer files.

If we write a report or article about this study or share the study data set with others, we will do so in such a way that you cannot be directly identified. Taking part in this research study is completely voluntary. You may choose not to take part at all. If you decide to be in this study, you may stop participating at any time. If you decide not to be in this study, or if you stop participating at any time, you won't be penalized or lose any benefits for which you otherwise qualify.

We encourage you to ask questions. If you have any questions about the research study itself, please contact: Kelly Finn at Kelly-f-finn@uiowa.edu or Professor Carolyn Colvin at Carolyn-Colvin @uiowa.edu.

If you have questions, concerns, or complaints about your rights as a research subject or about research related injury, please contact the Human Subjects Office, 340 College of Medicine Administration Building, The University of Iowa, Iowa City, Iowa, 52242, (319) 335-6564, or e-mail irb@uiowa.edu. General information about being a research subject can be found by clicking "Info for Public" on the Human Subjects Office web site, http://research.uiowa.edu/hso.

By submitting this survey, you are indicating that this research study has been explained to you, that your questions have been answered, and that you agree to take part in this study.

Thank you for participation in this research study.

Sincerely,
Kelly Finn

http://survey.uiowa.edu/..

APPENDIX D LIST OF STATE NAMES AND FREQUENCIES

State Name	Frequency	Percent
Alabama	12	1.4
Alaska	1	.1
Arizona	5	.6
Arkansas	6	.7
California	1	.1
Colorado	20	2.3
Connecticut	16	1.8
D.C.	3	.3
Delaware	3	.3
Florida	19	2.2
Indiana	33	3.8
Iowa	19	2.2
Kansas	15	1.7
Kentucky	12	1.4
Louisiana	18	2.0
Maine	6	.7
Maryland	16	1.8
Massachusetts	44	5.0
Michigan	51	5.8
Minnesota	21	2.4
Mississippi	9	1.0
Missouri	23	2.6
Montana	4	.5
Nebraska	5	.6
Nevada	4	.5
New Hampshire	2	.2
New Jersey	37	4.2
New Mexico	9	1.0
New York	80	9.1
North Carolina	33	3.8
North Dakota	7	.8
Ohio	52	5.9
Oklahoma	11	1.3
Oregon	13	1.5
Pennsylvania	69	7.8
Rhode Island	3	.3
South Carolina	16	1.8
South Dakota	5	.6
Tennessee	18	2.0
Texas	51	5.8
Utah	14	1.6

Vermont	3	.3
Virginia	26	3.0
Washington	18	2.0
West Virginia	1	.1
Wisconsin	26	3.0
Wyoming	3	.3
Missing	17	1.9
Total	880	100.0

APPENDIX E CARNEGIE CLASSIFICATION CODES

During survey administration, 916 different institutions were sent email invitations. Returned surveys were received from 544 of those institutions. The Carnegie classification codes for these 544 institutions are listed in Table E1.

Table E1. Carnegie Classification Code Frequencies

Doctoral/Research Extensive	126
Doctoral/Research Intensive	75
Masters Colleges and Universities I	176
Master's Colleges and Universities II	33
Baccalaureate Colleges Liberal Arts	73
Baccalaureate Colleges General	44
Baccalaureate/Associates Colleges	3
Associates Colleges	11
Specialized Institutions	3
Total	544

These 544 Institutions of higher education represent all regions of the United States for the 2006-2007 academic year.

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