KNOWLEDGE, ATTITUDES, AND INSTRUCTIONAL PRACTICES OF MICHIGAN COMMUNITY COLLEGE MATH INSTRUCTORS: THE SEARCH FOR A KAP GAP IN COLLEGIATE MATH

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Numerous efforts in math education have attempted to convince instructors to shift their instructional practices from lecture to alternative student-centered practices, but these have not been successful on a large scale, despite professional development that focuses on increasing awareness and improving instructor attitudes about student-centered instructional practices. This may be due to a knowledge-attitude-practice gap (KAP Gap), which exists when knowledge and favorable attitude do not lead toward adoption of a practice. This study uses a quantitative approach (author-created electronic survey, response rate 21.2%) to measure knowledge, attitudes, and instructional practices of Michigan community college mathematics faculty, with the purpose of identifying the existence of a possible KAP Gap and the factors that might be influencing its existence.

The analysis includes a breakdown about how community college math faculty acquire their knowledge of instructional practices and their level of participation in a variety of formal and non-formal professional development activities. General faculty attitudes about teaching and the teaching environment are measured using survey instruments developed by Trigwell and Prosser (2004, 2008). Attitudes towards three instructional practices (collaborative learning, inquiry-based learning, and the lecture

method) are examined in depth, especially with regard to the influence of the environment, the enabling characteristics of students, and the time requirements for using the method. Finally, instructors are asked to report about their level of use of each of the three practices (allowing the use of more than one practice) using a scale developed by Henderson & Dancy (2009).

This study is one of the first to directly identify a KAP Gap for instructional practices in mathematics and to explore the variables that influence the instructional practices of college math instructors. The results suggest that knowledge plus a favorable instructor attitude is not enough to predict an instructor's use of a student-centered instructional practice (although an unfavorable attitude will predict non-use). This study also illuminated significant difference between adjunct and full-time faculty in the level of professional engagement, breadth of teaching experiences, and use of student-centered instructional practices.

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by

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CHAPTER I: INTRODUCTION

For the last thirty years, national and governmental organizations have been bemoaning that the math and science skills of U.S. students are falling behind the rest of the world (A Nation at Risk, 1983; Everybody Counts, 1989; Rising Above the Gathering Storm, 2007; NMAP Final Report, 2008). In the current knowledge- and technology-based economy, global competition makes math and science skills even more important than they have been in the past (Ferrini-Mundy, 2009; Litzinger et al., 2009). The major professional organizations for mathematics instructors (MAA, NCTM, and AMATYC) have all outlined new guidelines for curricula and suggested instructional strategies for teaching reform to help close the gap (CUPM Guide, 1981; Crossroads, 1995; CUPM Guide, 2004; EUM 2006; Beyond Crossroads, 2006; CRAFTY, 2007; Algebra: Gateway to a Technical Future, 2007).

Large grant-funded projects (e.g. NSF's Calculus Consortium) have attempted to encourage and persuade college mathematics instructors to reorganize mathematics curricula and adopt alternate student-centered methods of instruction (i.e. reorganizing course topics, using group projects, including writing assignments), but these instructional techniques have had limited success in gaining widespread adoption (Lutzer et al., 2002; Lutzer et al., 2007). On a national scale, some elements of mathematics reform, like the use of textbooks with reform elements (e.g. multiple representations of mathematics concepts), have been incorporated across the curriculum (Lutzer et al., 2007). However, the major instructional strategies of math faculty have changed little.

Data from the College Board of Mathematical Sciences 2005 Statistical Report showed that the predominant instructional modality for math instructors was still the lecture, used in roughly 80-90% of course sections (Lutzer et al., 2007).

Some technological innovations, like the use of graphing calculators, are used in more than half of mathematical course sections at 4-year schools and almost eighty percent of course sections at community colleges. However, the use of other reform instructional practices that were supported by national mathematical organizations (student-centered techniques like the use of writing assignments and group projects) have actually declined in use during the last five years of study (Lutzer et al., 2007). This could be because of implementation difficulties or because of legitimate questions about the effectiveness of these techniques.

Indeed, these student-centered instructional practices have not been as well researched as one would hope. The National Mathematics Advisory Panel Task Group on Instructional Practices (2008) performed a meta analysis on studies that directly compared teacher-directed and student-centered instruction. The panel researchers found only eight studies at the K-12 level that met their quality standards. Their meta-analysis concluded that the research "does not lead to any conclusive result about the value of student-centered instructional strategies in comparison to teacher-directed instructional strategies" (Gersten et al., 2008, p. 6-24) and they cautioned that no generalizations about which approach was better could be made from the research.

Much of the initial grant-funded research that sparked Calculus reform (which ultimately affected pre-calculus track mathematics) was supported by the NSF and took place at selective-admissions 4-year colleges like Duke, Harvard, St. Olaf College, UC

Berkeley, Purdue, and Clemson (Ganter, 2001). Instructional strategies developed at elite educational institutions may not transfer well to open-enrollment institutions, and some evidence of instructors' unease about transferability of instructional practice has been detected in qualitative studies (Dancy & Henderson, 2008; Windham, 2008). Despite the fact that most mathematics reform efforts grew out of the efforts of 4-year colleges, the adoption of reform instructional strategies is consistently higher by community college math instructors than by math instructors at 4-year institutions (Lutzer et al., 2007).

To investigate the conditions that foster (or act as barriers) to adoption of instructional innovation in math instruction, I will focus on community college instructors. These instructors have the highest adoption rates of innovative instructional techniques and are relatively unhindered by research obligations that are tied to tenure. Extrinsic motivators like tenure, job security, and promotion are tied primarily to teaching responsibilities for community college instructors (rather than research). Community college instructors are, for the most part, solely responsible for assessing how their students learn without the aid of Teaching Assistants or other instructional assistance. This makes community college math instructors an ideal population to survey about instructional beliefs, attitudes, and practices towards mathematics instructional practices because their time and values are not torn between research and teaching.

There are some studies (e.g. Ganter, 2001) that ask math instructors about their attitudes and beliefs about reform instructional strategies, but these studies rarely survey the general population of math instructors. Instead they focus on the instructors who participated in reform efforts. The CBMS statistical surveys sample the general population, but solicit information only from department heads. No other studies were found that performed a general survey of college math *instructors* to look at their beliefs and practices with regards to the adoption of reform instructional strategies.

Community colleges have open-door admissions policies – students are not screened through a competitive selection process. This results in a student population that is more diverse in their age, ethnicity, and academic skills than generally found at 4-year institutions. There are approximately 28,000 math instructors at 1,600 U.S. community colleges (including branch campuses) in the United States teaching 1.7 million students a year (Lutzer et al., 2007). The impact of these 28,000 instructors is significant – in 1997, 34% of bachelor's degree recipients in mathematics or related sciences had attended a two-year college (as cited in the MAA 2004 CUPM Curriculum Guide).

Change to mathematics instructional practice at community colleges falls primarily in the hands of the individual math faculty, who have responsibility for initiating (or resisting) reforms within their own courses and their departments. Like their colleagues at 4-year colleges, few community college math instructors receive training in learning theories and cognition (Fox & Hackerman (NRC), 2003; Sperling, 2003). Lacking a theoretical framework about student learning, most innovators simply try out ideas to see how they work, formulating a theory about how the effectiveness of a new practice based on successive years of experience (Tall et al., 2008) or a gut instinct. Often instructors experiment with new instructional techniques for a few semesters, only to boomerang back to old habits because of implementation difficulties or lack of support (Hurley et al., 1999; Johnson et al., 2009; Windham, 2008).

Statement of the Problem

Some instructional strategies in community college mathematics flourish and others flounder. For example, the use of graphing calculators, a component of reform math practices, has been widely adopted in most courses at community colleges, with close to 80% of course sections using them (Lutzer et al., 2007). Alternatively, the adoption of writing assignments has actually declined slightly from a high around 20-30% in 2000 to below 20% in 2005 (a phenomenon coined as “reform fatigue” by Bressoud in 2007). The adoption rates of these reform instructional techniques have been estimated (by percent of sections that use them) in the last four CBMS Statistical Reports (Albers et al., 1992; Loftsgaarden et al., 1997; Lutzer et al., 2002; Lutzer et al., 2007). However, this data is reported by department heads (not instructors), and only 33% of community college math programs indicated that the division head observed the classes of part-time instructors (Lutzer et al., 2007).

We don’t know how much *knowledge* community college math instructors have about alternate instructional strategies (unless they have adopted the strategies and been measured by virtue of their adoption of the practice). Ganter (2001) provides some evidence on how adopters gained their knowledge of innovative instructional practice, but we don’t know how the general population of math instructors acquire their knowledge of instructional innovation. We don’t know whether alternate instructional strategies align with the existing attitudes and beliefs of the instructors. We know a little about the adoption rates of these alternative strategies, but we don’t know what conditions are necessary for adoption of a new math instructional strategy nor do we know what impediments instructors perceive as barriers to adoption.

The goals of this study are to understand where community college math instructors' knowledge of innovative instructional practice comes from, their attitudes towards and adoption rates of those practices, and the conditions for or barriers to adoption of practices. The knowledge gained in this research can be used to improve future dissemination and reform efforts in collegiate mathematics education.

Conceptual Framework

The conceptual framework for this study is derived from the literature on adoption of innovations (by faculty in higher education, in STEM fields, and in math) and based on the adoption of innovations model for instructional practices developed for physics education research (PER) by Henderson and Dancy (2007, 2008) and the models for measuring contextual variables in teaching developed by Prosser and Trigwell (1997). The research of Henderson and Dancy shows that (in the PER context) adoption of innovation is more likely to take place if an innovation can be customized to the needs of the instructor (and vicariously, to the needs of their students). The research by Prosser and Trigwell shows that strict control of teaching, large class sizes, and heterogeneous enabling student characteristics all correlate with instructors who choose to use teacher-centered instructional techniques. This study will provide additional validation of the Henderson & Dancy instructional innovation model and their survey instrument, as well as corroborative evidence for the Prosser & Trigwell studies of contextual variables in instructional practices.

Research Questions

The purpose of this research study is to gather enough data and analysis to determine whether there is a Knowledge-Attitude-Practice Gap (KAP Gap) in the adoption of student-centered instructional practices in collegiate math (specifically, community college math at the developmental algebra and precalculus level). The research questions are designed to further this goal:

1. How knowledgeable are community college math faculty about instructional practices and how do they receive this knowledge?
2. What kinds of professional development (general and context-specific) do community college math faculty participate in?
3. What is the influence, if any, of specific demographics (work status, gender, education, experience, or exposure to ideas) on the types of training that community college math faculty receive?
4. Are there correlations between beliefs held by community college math faculty and their use (or lack of use) of instructional practices?
5. What is the influence, if any, of specific demographics (work status, gender, education, experience, or exposure to ideas) on whether math faculty chose to adopt (or reinvent) or reject an instructional practice?
6. What is the relationship, if any, of favorable (or unfavorable) attitude towards an instructional practice and actual instructional practice? Is there a KAP Gap?
7. To what extent, if any, does knowledge of instructional innovations, instructor characteristics, and level of professional development engagement differ between instructors of different levels of math courses?

8. To what extent, if any, do attitudes about instructional practices differ between instructors of different levels of math courses?
9. To what extent, if any, does the level of math taught influence the relationship between favorable (or unfavorable) attitude towards an instructional practice and actual instructional practice?

Data will be collected using an extensive quantitative survey sent to the population of Community College math instructors in the state of Michigan. The survey will collect basic demographics, information about instructor experience and engagement in professional development, a general attitude about approaches to teaching, beliefs about individual math instructional practices, and levels of use for these instructional practices. The survey will be sent via email, with an incentive drawing used to improve return rates.

Significance of the Question

Rogers (2003) describes a phenomenon called a Knowledge-Attitude-Practice Gap (KAP Gap) where knowledge of an innovation, and a favorable attitude towards it does not necessarily result in "practice" (adoption of the innovation). Many researchers have commented on their findings of a "gap" between instructors' beliefs and their actual classroom practice (Anderson, 2002; Cooney, 1985; Dancy & Henderson, 2008; Ernest, 1988; Guskey, 1986; Kennedy, 1997; Murray & Macdonald, 1997; Norton, 2005; Pajares, 1992; Shavelson & Stern, 1981; Thompson, 1984, 1992; Walker & Quinn, 1996; Windham, 2008). Yet, usually this finding is a sidenote of the research, and not a subject of investigation.

The nation and the higher education system is counting on the math community to re-engage the student population in learning math as the foundation to an economy based in science and technology. Past reform efforts in mathematics have had limited widespread impact. However, we lack a clear understanding of how instructors acquire new knowledge, what their beliefs about these practices are, and what contextual variables influence the decision to adopt new instructional practices. With a better understanding of the key players in curriculum change, the math instructors themselves, we should be able to design better reform efforts.

This study will contribute to the literature on mathematics reform by filling a gap in the literature on the conditions or barriers for the adoption of teaching innovations in mathematics. In addition, while there is some research that has examined possible conditions for or barriers to change in math faculty (DeLong & Winter, 1998; Ganter, 1997; Murphy and Wahl, 2003), there is little research to quantify how widely these conditions and barriers affect full-time and part-time community college math faculty. This research will provide a more complete picture of the foundational beliefs of math instructors regarding innovative instructional practices, the possible gap between belief and practice, and the conditions for, or barriers to, alternative instruction.

This study contributes to the faculty development literature in two ways. First, the research will fill in knowledge about how math faculty are getting context-specific training. Second, the research will provide a discipline-specific look at faculty beliefs and attitudes, and how these affect use of instructional practices. This may provide insights into instructor adoption of specific practices in other fields as well.

Summary

This study investigates the possibility of a KAP Gap in the adoption of student-centered instructional practices by community college math instructors. To define the elements of the KAP Gap, data was collected about instructor demographics and experience, knowledge of instructional practices, professional development habits, attitudes and beliefs, and classroom practice.

Chapter 2 provides a literature background for this study. Literature is drawn from (1) diffusion of innovations theory and research, (2) collegiate mathematics education, (3) demographics, motivation, and beliefs of faculty; more specifically community college, STEM, and math faculty, (4) instructional practices of math faculty, (5) reform movements in collegiate mathematics, (5) faculty development and the acquisition of knowledge, (6) contextual (or situational) variables in the teaching environment, and (7) educational research about change and instruction. Chapter 3 includes the rationale for the design, the research questions, the development of the survey tool, data collection methods, data analysis methods, limitations and delimitations, and ethical issues. Chapter 4 contains the results and analysis of the data collected by this study. Chapter 5 interprets the results, provides conclusions, and suggests future research.

CHAPTER II: REVIEW OF THE LITERATURE

The purpose of this research study is to determine whether there is a Knowledge-Attitude-Practice Gap (KAP Gap) in the adoption of student-centered instructional practices in collegiate math (specifically, community college math at the developmental algebra and precalculus level). The KAP Gap is a phenomenon whereby a person may have knowledge of an innovation, and a favorable attitude towards it, and yet, they do not adopt the innovation in practice (Rogers, 2003). We have very little information about the different elements of knowledge, attitude, and practice for community college faculty, and even less information for math faculty in particular.

However, before looking at the elements of KAP, it is important to understand the environment, the culture, and the population under investigation. After the framework for the study is presented, I will describe the literature that describes the three obvious components in the KAP relationship: knowledge, attitude, and practice. *Acquisition of Knowledge* will outline the ways that math instructors might acquire their knowledge of instructional strategies. *Instructor Attitude* will be a discussion of the beliefs, and motivation, and attitudes of faculty (math faculty in particular). *Instructional Practice* will describe the instructional practices of mathematics instructors at community colleges.

The KAP relationship for instructional practice is illustrated in Figure 1. In this diagram, there is one more piece in the KAP puzzle for instructional practice: contextual characteristics. In *Contextual Variables*, I will outline several of the variables that have been found by other research to intervene between favorable faculty attitude and actual instructional practice. In the final section of this literature review, *The KAP Gap*, I will

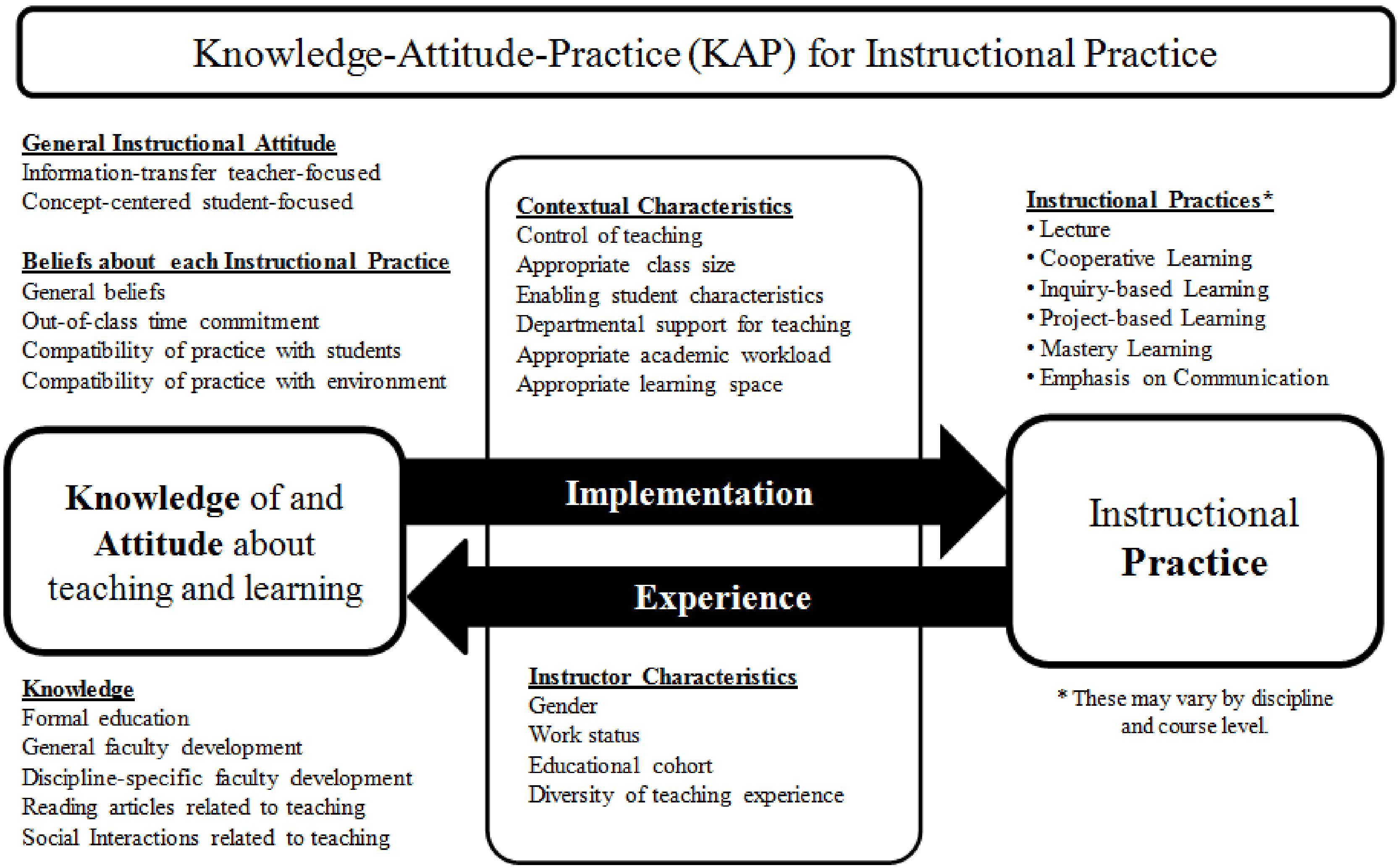

Figure 1. Knowledge-attitude-practice (KAP) for instructional practice.

provide evidence from several research studies that mention the observance of a "gap" between favorable attitude and instructional practice.

The literature review that follows draws from many different fields: (a) diffusion of innovations theory and research, (b) scholarship of teaching and learning, (c) demographics, attitudes, and beliefs of faculty, (d) faculty development and the acquisition of knowledge, (e) change and motivation, (f) reform movements in collegiate mathematics, (g) collegiate mathematics education, and (h) instructional practices of math faculty.

Environment: Mathematics at Community Colleges

In undergraduate mathematics, some courses lie on a narrow path leading to calculus and other "terminal" courses branch off of this path (see Figure 2 for an example of the flow chart describing the courses at one community college). Course enrollments at community colleges in 2005 can be found in Table 1. Remedial mathematics consists of the courses before algebra and are often taught out of a separate department (e.g. developmental studies) from the rest of the mathematics courses (Lutzer et al., 2007). Developmental algebra (elementary algebra and intermediate algebra) accounts for 42% of the math enrollments (approximately 716,000 students) at 2-year colleges (Lutzer et al., 2007). The precalculus level, as described in CBMS statistical reports, includes five courses: College Algebra, Trigonometry, College Algebra & Trigonometry (combined as one course), Intro to Mathematical Modeling, and Precalculus (when it is defined as a separate course). Precalculus-level enrollments make up 19% (approximately 321,000 students) of the total math enrollments at community colleges.

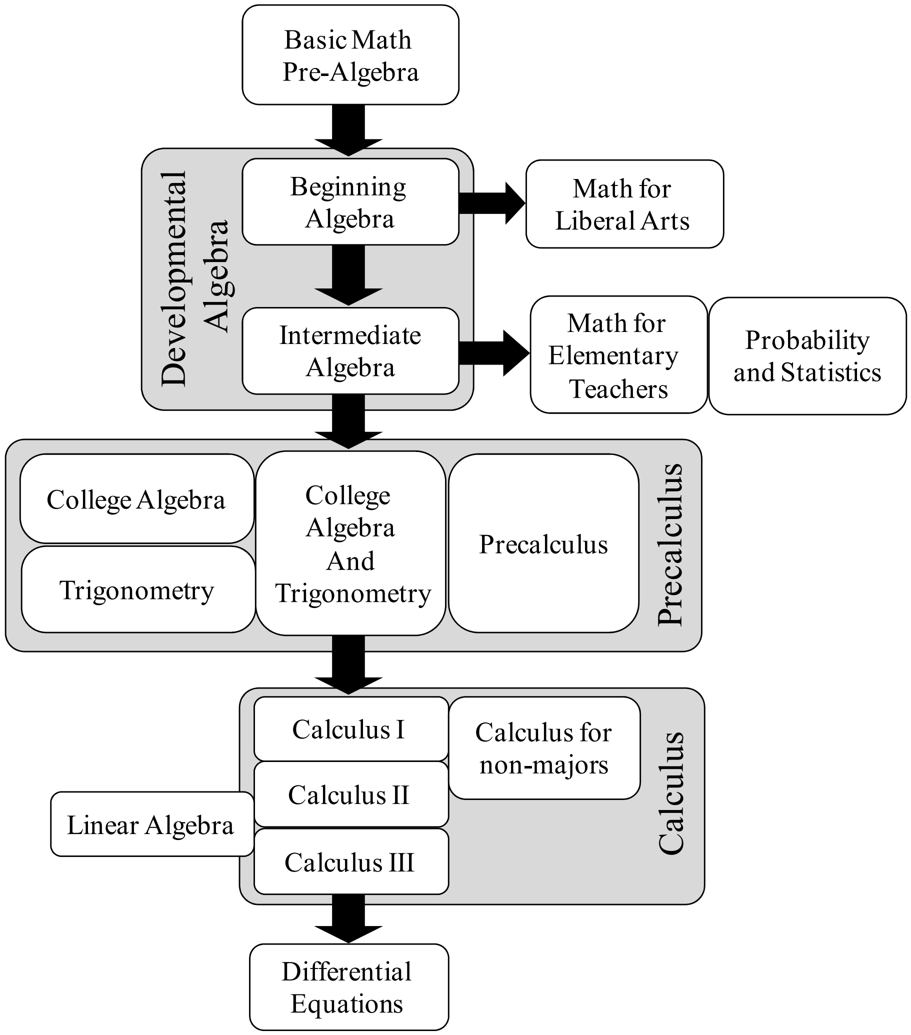

Figure 2. Core mathematics courses typically taught at a community college.

The issue of teaching remedial mathematics at the college level has been controversial since public education has already covered these courses in the K-12 system. While it would be interesting to study instructional practices of remedial math instructors, it proves difficult because the courses go by a variety of different names and are taught out of a variety of different departments (not just the math department). Calculus-level courses make up only 6% of overall math enrollments at 2-year colleges (Lutzer et al., 2007), which makes it difficult to effectively sample calculus instructors at the community college level. In this study, I will primarily focus on collecting data about the instructors and the instructional practices that are used in the categories of Developmental algebra and Precalculus, which make up approximately 61% of the math enrollments at community colleges.

Table 1

Math enrollments at community colleges in 2005

Course Level	Specific Course	Student enrollment in 2005	Percent of total math students enrolled at this level
Remedial math	Arithmetic	104,000	14%
	Pre-algebra	137,000	
Developmental algebra	Elementary Algebra	380,000	42%
	Intermediate Algebra	336,000	
Precalculus level	College Algebra	206,000	19%
	Trigonometry	36,000	
	College Algebra + Trig.	14,000	
	Intro to Math Modeling	7,000	
	Precalculus	58,000	
Calculus level	Mainstream Calc I	51,000	6%
	Mainstream Calc II	19,000	
	Mainstream Calc III	11,000	
	Non-mainstream Calc I	21,000	
	Non-mainstream Calc II	1,000	
	Differential Equations	4,000	

Note. The data in this table are excerpted from Table TYE.12 from "Statistical Abstract of Undergraduate Programs in the Mathematical Sciences in the United States: Fall 2005 CBMS Survey" by D.J. Lutzer, S.B. Rodi, E.E. Kirkman, and J.W. Maxwell, 2007, Providence, RI: American Mathematical Society. Copyright 2007 by the American Mathematical Society.

Culture: Reform and Collegiate Mathematics Instruction

Several math-specific "waves of change" have rolled through mathematics in the last 25 years, with varying levels of success: Calculus Reform (beginning with the Tulane

Conference in 1986), Crossroads in Mathematics (published by AMATYC in 1995), Math across the Curriculum (NSF Initiative launched in 1995), the recent CUPM initiatives and guidelines (published by MAA beginning in 2004), and Beyond Crossroads (published by AMATYC in 2006). While each change movement targeted specific levels and initiatives, they all shared a common thread – math instructors needed to change the way they taught and use more student-centered instructional techniques. “Mathematics faculty will foster interactive learning through student writing, reading, speaking, and collaborative activities so that students can learn to work effectively in groups and communicate about mathematics both orally and in writing” (Blair et al., 2006, p. 6). “Mathematics faculty will use multiple instructional strategies, such as interactive lecturing, presentations, guided discovery, teaching through questioning, and collaborative learning to help students learn mathematics” (Blair et al., 2006, p. 6). Unfortunately, math instructors teaching developmental algebra and precalculus-level mathematics at community colleges (and 4-year institutions) continue to predominantly use the lecture method (Lutzer et al., 2007).

Professional organizations like the American Mathematics Association of 2-year Colleges (AMATYC) outline guidelines emphasizing that instructors should use well-researched teaching strategies to enhance student learning: “Mathematics faculty will use a variety of teaching strategies that reflect the results of research to enhance student learning” (Blair et al., 2006, p. 59). However, for mathematics, there is little research evidence that any particular instructional practice is more effective on a whole than any other practice (Burrill et al., 2002; Ganter, 1997; Gersten et al., 2008).

After reviewing the research from ten years of Calculus Reform, a summary article by Ganter found that "there are a limited number of studies that document the impact of these efforts on student learning" (1997, p. 10). Ganter goes on to say that existing reforms have received mixed reviews from both students and instructors. The 2008 National Mathematics Advisory Panel (NMAP) designated a special task group to review instructional practices in mathematics at the K-12 level (note that there is no comparative study at the collegiate level for mathematics). The task group examined six instructional practices (e.g. the use of cooperative groups and peer instruction). Their conclusion: there is not sufficient evidence to support all-inclusive policy recommendations of any of the practices that they studied (Gersten et al., 2008). A meta-analysis of hundreds of studies on the effectiveness of teaching math with graphing calculators (Burrill et al., 2002, p. viii) found that "research on the use of handheld graphing technology is not robust. Individual projects look at specific pieces of the picture, but the pieces do not make a coherent whole and, in fact, often seem unrelated."

While there are high-quality studies of specific instructional practices at specific schools, these studies don't generalize well to the whole population. There is little evidence to support the use of one instructional practice over another in the general practice of teaching mathematics. To complicate this, instructional practices often get reinvented by the instructor during implementation. For example, while graphing calculators are used in the majority of math courses today (Lutzer et al., 2007), a meta-analysis of the research on graphing calculator use (Burrill et al., 2002) showed that most instructors have simply assimilated graphing calculators into the way they already taught. "Despite the opportunities offered by technology for teachers to change their teaching practice, researchers report that teachers generally use handheld graphing technology as an extension of the way in which they have always taught" (p. iv).

Critics of the "standard lecture" across all subjects have been vocal and numerous, and within mathematics instruction there has been no exception. However, one might look at the issue "to lecture or not to lecture" in mathematics from a different perspective. First, we do not know *why* math instructors continue to choose the lecture as a major component of their courses. Second, we do not know how knowledgeable math instructors are of alternate instructional practices. Third, we are not aware of how instructors experiment with and choose instructional practices in mathematics. Math instructors continue to use lecture as a primary instructional practice despite all sorts of efforts to get them to do otherwise. Thus, it is imperative that we find out why and the best source of information is likely to be the mathematics instructors themselves.

Population: Community College Faculty

Community colleges have open-door admissions policies, meaning that students are not screened through a competitive selection process. Community college faculty are responsible for teaching a student population that is more diverse than those of 4-year institutions (in their age, ethnicity, and academic skills). There are 1,195 community colleges in the United States or approximately 1,600 public community colleges when branch campuses are considered as separate entities. These campuses enroll 11.5 million students and only 41% attend full-time (AACC Website, 2009).

Community college faculty see themselves as academic faculty who are able to focus their energies on instructional practice – 95% reported their interests are primarily in or leaning towards teaching (Huber, 1998). Like their colleagues at 4-year colleges, few community college instructors receive training in learning theories and cognition (Sperling, 2003; National Research Council, 2003). Community college instructors are generally satisfied with their jobs, the courses they teach, and their relationships with their colleagues (Huber, 1998). However, approximately 68% of 2-year college faculty reported at least some stress from teaching underprepared students (Lindholm et al., 2005). While community college faculty acknowledge that their institutions "take responsibility" for educating underprepared students, only 6% agree that faculty on their campus are rewarded for their efforts to work with underprepared students (Lindholm et al., 2005).

In comparison to their colleagues at 4-year institutions, community college faculty have a higher teaching load – an average of 15 hours per week compared to 6-10 hours at other 4-year institutions (Huber, 1998). Community college faculty spend their work hours in teaching, preparation for teaching, original research or scholarship, student tutorials, and academic advising (see Table 2 for time distribution of activities that community college faculty engage in). Community college faculty are not alone in believing teaching to be their primary responsibility - 73% of 4-year college and university faculty surveyed in 1997 saw teaching as their primary responsibility as well (Huber, 1998). Thus, the distinguishing factor between instructors at community colleges and their 4-year counterparts may more fairly be "the absence of scholarship and not the presence of teaching" (Prager, 2003, p. 580).

Only 5% of community college faculty are expected to perform regular research as part of their position (Huber, 1998) and there is a direct correlation between the scholarly output of faculty at community colleges and the institutional expectation for

Table 2

How do community college instructors use their time?

Activity	Average hours per week for community college faculty
Teaching	14.8
Preparation for Teaching	11.5
Original research or scholarship	6.1
Student tutorial	5.2
Academic advising	4.2

Note. The data in this table are excerpted from Table 57 in "Community College Faculty Attitudes and Trends, 1997." by Huber, 1998, Stanford, CA: National Center for Postsecondary Improvement. Copyright 2008 by The Carnegie Foundation for the Advancement of Teaching.

scholarly work (Prager, 2003). A 1984 study conducted by Pellino, Blackburn, and Boberg concluded that 60% of community college faculty had *not* been active in research with the expectation of publication since they left graduate school (as cited in Prager, 2003). Of the roughly 40% that are engaged in scholarly work (Huber, 1998) there is little distinction made between a major work of scholarship like writing a textbook and a minor work like reviewing a textbook authored by someone else.

Faculty at community colleges may not be active at *publishing* their scholarly work, but they have shown a willingness to be innovative. Over eighty percent of community college faculty report that their department has experimented with the use of technology in instructional practice (Hubert, 1998). Change to instructional practice at community colleges falls primarily in the hands of the individual instructors, who have the responsibility for initiating (or resisting) reforms within their own courses and their departments. Community college instructors have a great deal of control over *how* they teach and interact with students and there are rarely intermediaries between themselves and students (like Teaching Assistants).

Math Faculty

There are approximately 28,000 math instructors in the United States teaching mathematics to approximately 1.7 million students a year (Lutzer et al., 2007). The impact of these 28,000 instructors is significant – in 1997, 34% of bachelor's degree recipients in mathematics or related sciences had attended a 2-year college (as cited in the MAA 2004 Curriculum Guide). The American Mathematical Association of 2-year Colleges (AMATYC) is the major national professional organization for community college math faculty (there are also 44 state affiliate organizations). In April 2009, the AMATYC office estimated there were approximately 1,930 members (Vance, B., personal communication, April 26, 2009).

Community college math instructors teach the same courses that are taught at 4-year institutions during the first two years. Yet very few of these instructors are involved in the 4-year college organizations and they hold almost no leadership roles within these 4-year organizations (Prager, 2003). Similarly, a limited number of 4-year college faculty participate in the corresponding 2-year college organizations (e.g. in April 2009, only two out of the thirteen board members of AMATYC were university faculty). Even though community college faculty are (theoretically) free to pursue scholarly work associated with instruction, they are not well-represented in the boards of scholarly journals dedicated to educational practice. To illustrate this point, Table 3 shows the makeup of editorial boards (or panels) of several *mathematics* journals that are focused on instructional practice.

Table 3

Makeup of mathematics education journal boards

Journal	Publisher	Number of editorial board members	Number of members from 2-year schools
PRIMUS (Problems, Research and Issues in Mathematics Undergraduate Studies)	Taylor & Francis	31	1
Journal for Research in Mathematics Education	NCTM	10	0
Mathematics Magazine	MAA	11	0
Mathematics Teacher	NCTM	11	0

Note. The data in this table were gathered by from examination of board/panel members on journal websites on April 12, 2009.

Only 55% of math programs at 2-year colleges required some form of continuing education or professional development for their full-time permanent faculty (Lutzer et al., 2007). Full-time faculty met their professional development requirements through activities provided by their employer (53%), activities provided by their professional associations (38%), publishing books or research (6%), and through continuing graduate education (7%). The data about specific activities was only collected if there was a *requirement* to complete professional development activities. There is no data about whether any of these activities are discipline-specific or generally focused in education. The CBMS Statistical Report survey does not include questions about self-directed learning (reading books or material on the Internet) or professional development provided by commercial sources (like textbook publishers). It is also important to note that the survey asks the department head to estimate the number of full-time faculty who engage in each of the professional development activities listed. This is not data collected directly from the faculty. Furthermore, 45% of faculty are not even represented in this data because their colleges don't *require* professional development.

Part-time Faculty

Another issue that is unique to community colleges is that 67% of the faculty work only part-time compared to between 22% and 55% at 4-year schools (Cataldi et al., 2005). The employment of part-time faculty is advantageous to community colleges not just for cost savings, but for flexibility in matching varying demand for classes. In addition, at least half of part-time instructors hold nonteaching jobs (Leslie & Gappa, 2002) bringing their "real-world experiences" to the academic environment. In general, if we compare part-time faculty to full-time faculty, they are equally satisfied with their employment, and use similar instructional strategies (Leslie & Gappa, 2002). However, there is evidence that part-time faculty members "appear less committed, accomplished, and creative in their teaching than full-time faculty" (Leslie & Gappa, 2004, p. 64).

Much of what we know about the demographics of community college part-time math instructors comes from the 2005 Conference Board of the Mathematical Sciences (CBMS) Statistical Report of Undergraduate Programs (Lutzer et al., 2007). In 2005, 44% of class sections in mathematics at 2-year colleges were taught by part-time instructors. Many community colleges have restrictions about the number of credits a part-time math instructor may teach. Because of this, part-time math instructors make up 65-68% of the population of community college math faculty even though they teach only 44% of the class sections. Nearly fifty percent of the part-time mathematics faculty at community colleges had no full-time employment (Lutzer et al., 2007). There is no data on how many of those faculty *desired* full-time employment.

Part-time instructors generally do not participate in the activities of the college outside of teaching courses (committee meetings, office hours, advising) in the same way as full-time faculty (Outcalt, 2000). Part-time faculty are less engaged with their professional communities; they belong to fewer educational associations and they read fewer education journals than their full-time counterparts (Cohen & Outcalt, 2001). However, Leslie and Gappa (2002) found that part-time faculty are not significantly different than full-time faculty in the amount of time they spend on professional development. In community college mathematics, part-time instructors make up 68% of the population, but only 6% of the membership of AMATYC (B. Vance, personal communication, April 26, 2009).

Many studies suggest that there is no difference in the quality of instruction between full-time and part-time instructors (Cohen & Brawer, 1996; Gappa & Leslie, 1993; Grubb, 1999; Leslie & Gappa, 2002). In 2002, Leslie and Gappa report that there are "almost no differences between part- and full-time faculty in the predominant instructional methods used." (p. 64). However, Cohen and Outcalt (2001) developed a construct for curriculum and instruction that demonstrated that there was a difference between full- and part-time instructors in their commitment to teaching and their expressed teaching practice. Since part-time faculty are paid considerably less than their full-time colleagues, it is not unreasonable to expect that part-time faculty may be less interested in using instructional approaches that will result in time-consuming preparation or grading practices. For example, one study indicated that part-time faculty are 50% less likely to use essay exams compared to full-time faculty (Benjamin, 1998).

According to the 2005 CBMS Statistical Survey, part-time community college math instructors are well-educated: 6% hold doctorates and 72% have a master's degree as their highest degree. Only 2% of full-time community college math faculty hold only a bachelor's degree, but this number is much higher (22%) for part-time community college math faculty. Part-time instructors are more likely than full-time instructors to teach *pre-college* mathematics courses, so the relaxation in degree requirements may be due to the low level of math that is often taught by these instructors. Forty-seven percent of part-time math faculty are women (compared to 50% for full-time faculty). About one-fifth of the part-time community college math faculty have degrees in fields outside mathematics, compared with about one-tenth for full-time faculty (Lutzer et al., 2007).

Acquisition of Knowledge

In the innovation-decision process described by Everett Rogers in his seminal work *Diffusion of Innovations* (2003), the process to adopt (or reject) an instructional innovation would begin with the acquisition of knowledge about the innovation. In the context of education, the process would be as follows: the instructor gains initial knowledge of an instructional innovation, forms an attitude about it, then makes a decision about whether they will adopt or reject the innovation. If they have decided to adopt the innovation, they implement (or reinvent) the new idea. Finally, the instructor assesses the innovation and either confirms or rejects their decision. Rogers refers to the steps in this process as *knowledge, persuasion, decision, implementation*, and *confirmation*. Throughout the innovation-decision process, there are change-agents (e.g.

colleagues, administrators, professional organizations) who advocate for the acceptance of the innovation.

One of the problems with acquiring knowledge of innovations is that instructors may consciously ignore knowledge of instructional innovations due to selective exposure or selective perception (Rogers, 2003). *Selective exposure* is defined by Rogers as the tendency to only pay attention to messages that are consistent with the individual's existing attitudes and beliefs. For example, if an instructor believes that lecturing is the only effective means of teaching the curriculum they are tasked with, then they might not ever attend a conference session on student-centered teaching. *Selective perception* (Rogers, 2003) is the tendency to interpret messages through the lens of an individual's existing attitudes and beliefs. For example, the lecture-oriented instructor might view a colleague’s classroom, where the students are engaged in an active-learning activity, as a poorly-managed lecture classroom.

It may be necessary to create a need for innovation before it is possible to be receptive to knowledge of a new innovation. Rogers (2003) describes a need for innovation as a "state of dissatisfaction or frustration that occurs when an individual's desires outweigh the individual's actualities" (p. 172). If our lecture-oriented instructor becomes increasingly frustrated with the results of student learning assessments and desires to improve learning outcomes, this may open up an opportunity for the instructor to be receptive to a new innovation. However, it is also possible for the discovery of an innovation to lead to needs. For example, the discovery at a conference of a new instructional technology may create the desire to change the way one teaches in order to use the new technology.

Formal Education

One of the greatest influences on how math faculty teach may be how they experienced learning when they were students (Baldwin, 2009). Community college math instructors have a significant level of formal education: 98% of full-time and 78% of part-time math instructors have a graduate degree (Lutzer et al., 2007). Regrettably, since most of these faculty (72% of full-time and 76% of part-time) received their graduate degrees from mathematics or statistics departments (with curriculum focused on the subject area), it is unlikely that many have received more than basic training in pedagogy or learning theory. In fact, very few college science or math instructors receive any training in pedagogy or learning theory as part of their formal education (Baldwin, 2009).

College instructors also soak up a particular set of values from the culture in which they “came of age” in academia. This effect has been termed the Cohort Model (Lawrence & Blackburn, 1985) – that is, "…professors who complete their graduate work and achieve tenure during the same historical era are enculturated with a particular set of values that remain constant over time" (Lawrence & Blackburn, 1985, p. 137). Results of the 2004-2005 Higher Education Research Institute [HERI] Faculty Survey (Lindholm et al, 2005) support this cohort model, finding evidence that early-career faculty are more likely to use student-focused instructional strategies then their mid- or advanced-career counterparts. This may be evidence that newer faculty have begun to learn alternate ways of teaching by either observing this behavior during their own student experiences or through the efforts of dedicated programs to train graduate students in the scholarship of teaching and learning.

Faculty Development

Many forms of faculty development target the *knowledge* and *persuasion* step of the innovation-decision process. For example, by distributing research materials and holding conference workshops, change agents from professional organizations hope to increase an instructor's knowledge about an instructional innovation and persuade them to use it. Faculty development programs are designed to enhance personal, professional, instructional, and/or organizational development (Alstete, 2000). There is widespread use of faculty development programs at 2-year colleges. Ninety percent of those community colleges surveyed by Grant & Keim (2002) had a formal faculty development program and they are "well planned, coordinated and supported" (p. 804). However, a survey of more than 100 community college chief academic officers about their faculty development programs found a lack of commitment from the leadership, insufficient organization, and little comprehensive strategy (Murray, 1999).

Grant & Keim (2002) surveyed faculty and asked them to rank the factors that most influenced their participation in faculty development. The results of the survey reported that 50% said release time, 47% personal and professional growth, 37% salary advancement, 37% monetary compensation, 32% professional activity credits, and 25% certificates. It is interesting to note that although faculty list release time as an important factor to influencing their participation in faculty development, there is some evidence that release time may not be all that effective for this purpose. Boice (1987) demonstrated that faculty who are given release time for scholarship purposes are unable to manage their "extra time" for meaningful purposes and that for new faculty, in particular, there were not obvious benefits from such a program. In 53% of the schools responding to

Grant and Keim’s survey, faculty were *not* compensated for faculty development activities (2002).

The CBMS 2005 Statistical Report found that only 55% of community college math faculty were *required* to participate in some form of continuing education or professional development. Of those math instructors surveyed who were required to participate in professional development, 53% did so by participating in activities provided by their institutions (Lutzer et al., 2007). However, just because faculty participate in some form of faculty development, whether it be a seminar, workshop, consultation, or mini-grant opportunity, does not mean that they have become more effective at helping students learn or have even adopted the innovations they have been exposed to in development activities.

Many faculty development activities provide *awareness-knowledge* (knowledge of the existence of an innovation) and *how-to knowledge* (how to implement the innovation). However, there is a third component to this knowledge stage called *principles-knowledge*, which gives information about the underlying principles for why an innovation works (Rogers, 2003). Because many instructors lack grounding principles in pedagogies, and many innovations are passed from one instructor to another, it is unlikely that the corresponding principles-knowledge is included as part of the diffusion process. Rogers (2003) points out that "the competence of individuals to judge the effectiveness of an innovation is facilitated by their understanding of principles know-how" (p. 173). The task of getting an innovation adopted takes more time and is more difficult when the adopters lack an understanding of the principles that underlie the innovation.

The CBMS 2005 Statistical Report found that, of the community college math faculty who were *required* to participate in some form of continuing education or professional development, 38% did so by participating in activities provided by their professional associations (Lutzer et al., 2007). There are four major mathematics professional organizations in the United States: The Mathematical Association of America (MAA), The American Mathematical Association of Two-year Colleges (AMATYC), The American Mathematical Society (AMS) and the National Council for Teachers of Mathematics (NCTM). All four organizations provide professional development to math instructors through their annual conferences, but MAA and AMATYC are the main organizations that focus on improving collegiate mathematics instruction (NCTM is focused on K-12 instruction and AMS is primarily focused on mathematics research). In addition to these national organizations, there are numerous state and regional organizations that organize conferences and workshops where math faculty can go to learn about new educational practices.

Project NeXT and Project ACCCESS are professional development programs, sponsored by MAA and AMATYC respectively, that focus on brand-new college math faculty. Project NeXT (New Experiences in Teaching) is for new or recent Ph.D.s and provides training on, among other things, improving the teaching and learning of mathematics (LaRose, 2009). Project ACCCESS (Advancing Community College Careers: Education, Scholarship, Service) is a mentoring and professional development initiative that was conceived originally as a version of Project NeXT for community college faculty. ACCCESS is now wholly administered by AMATYC, and its mission is "to provide experiences that will help new faculty become more effective teachers and active members of the broader mathematical community" (Project ACCCESS website, 2009).

Professional development is also available in the form of short courses. MAA provides professional development through PREP (the Professional Enhancement Program). Some of these PREP workshops are on topics of interest to instructors who teach math below calculus, for example, the 2009 PREP schedule includes workshops on *Arithmetic in College, Web-Enhanced Instruction with GeoGebra,* and *Refocusing and reMODELING College Algebra*. AMATYC offers summer programs that are focused on improving instructional practice. The 2009 AMATYC Summer Institutes include *Improving Instruction in Introductory Statistics* and *Mathematics Across the Community College Curriculum.*

In addition to formal professional development programs, faculty can also attend annual conferences sponsored by the national mathematics organizations, state organizations, commercial organizations, or federal organizations. At these events, faculty can attend conference presentations and participate on committees to learn about instructional strategies. For example, the annual AMATYC conference has a conference strand called "Instructional Strategies" and AMATYC has a committee on "Innovative Teaching and Learning." MAA has a Special Interest Groups (SIGMAA) on Research in Undergraduate Mathematics Education (RUME).

In mathematics, it is not uncommon for textbook publishers, software vendors, and calculator companies to provide professional development mathematics to instructors both at the community college and four year college level. Indeed, from my own personal experience, I have received more training on teaching and learning that is discipline-specific from commercial entities than I have from my institution. One major yearly conference for mathematics faculty, ICTCM (International Conference on Technology in Collegiate Mathematics), is both organized and sponsored by a textbook publisher (Pearson). Texas Instruments organizes *Teachers Teaching with Technology*™ (T^3) conferences and workshops of various lengths to train instructors in a way that is not only discipline-specific, but also level-specific. Certainly, the T^3 programs train instructors how use TI graphing calculators, but the programs also focus on instructing teachers about inquiry-based learning, cooperative learning, and emphasis on problems involving data. Cengage Learning organizes TeamUP faculty conferences and workshops where textbook authors share the pedagogical principles that underlie their textbooks with faculty who are invited to the events. This commercially-provided, discipline-specific training is an important element that must be measured as we examine the ways that mathematics instructors receive knowledge of instructional practices.

Self-directed Learning

Faculty do not have to attend an event to learn about an innovation in educational practice. There are a plethora of journals, books, magazines, websites, videos, and blogs that provide information about new instruction practices. In their *Survey of Community College Faculty*, Cohen and Outcalt compiled data on the number of journals regularly read by community college faculty (2001); a small portion of this data is reproduced in Table 4. The pattern of data does show us that both full- and part-time faculty were reading roughly three times more discipline-specific material than general educational material. Also, this data shows us that that part-time faculty tended to do slightly less reading than their full-time colleagues. The data does not tell us whether faculty were reading to gain knowledge of their subject area, to learn ways to improve instructional practices, or for some other reason.

Table 4

Mean number of journals read regularly by community college faculty

Type of journal	Full-time	Part-time
General education	0.48	0.41
Community college specific	0.28	0.18
Disciplinary journal	1.55	1.41

Note. The data in this table are excerpted from Tables 32, 33, and 34 of "A Profile of the Community College Professoriate." by A. M. Cohen and C. L. Outcalt, 2001, Los Angeles, CA: Center for the Study of Community Colleges. Copyright 2001 by The Spencer Foundation.

While we tend to think of self-directed learning as an active process of seeking out new knowledge, it need not be that way. When presented with new course materials (e.g. a new textbook), an instructor *may* go through a process of self-directed learning whereby the materials influence their knowledge of instructional practices. Indeed, Remillard (2005) suggests that in mathematics, efforts to initiate change largely focus on revising texts or curriculum materials. Unfortunately, using a text as a change agent may be largely ineffective. Windham (2008) studied the perceptions of three college math instructors who shifted from using a traditional calculus text to a reform text. Despite the fact that the text provided instructional advice for faculty who were new to teaching out of a reform text, Windham found that all three of the instructors in the study admitted to using the text as nothing more than a resource to find homework problem sets.

Instructor Attitude

Beliefs and Attitude

For every researcher who studies beliefs, there is a slightly different nuance of the definition. Pajares (1992) examined the nature of belief structures defined by key researchers in the field and synthesized their findings. “Beliefs influence how individuals characterize phenomena, make sense of the world, and estimate covariation” (Pajares, 1992, p. 310). Harvey (1986), one of the researchers cited by Pajares, provides a definition of belief that I found particularly helpful: belief is “an individual’s representation of reality that has enough validity, truth, or credibility to guide thought and behavior” (p. 313 as cited in Pajares, 1992). Despite use of words like *validity* and *truth*, we must be careful to make the distinction between beliefs and knowledge: knowledge is based on objective fact whereas belief is based on evaluation and judgment (Pajares, 1992). Pajares succinctly summarizes the findings of many researchers (citation) on the relationship between beliefs and classroom practice: “Few would argue that the beliefs teachers hold influence their perceptions and judgments, which, in turn, affect their behavior in the classroom, or that understanding the belief structures of teachers and teacher candidates is essential to improving their professional preparation and teaching practices” (p. 307).

To measure beliefs is tricky; Pajares (1992) tells us that “beliefs cannot be directly observed or measured but must be inferred from what people say, intend, and do” (p. 314). Beliefs are interconnected and build more complex cognitive structures about general topics (like education) that we call attitudes (Pajares, 1992). There is some confusion in educational research about the use of and interchangeability of the words *belief* and *attitude*. For this research, attitude will be defined as a collection or cluster of beliefs on a particular topic (Rokeach, 1968 as cited by Pajares, 1992). Pajares cautions us to be clear to delineate between educational beliefs and general beliefs of instructors (1992). Educational beliefs of instructors would include, but not be limited to: beliefs about confidence to affect students' performance, the nature of knowledge, the nature of the discipline, the causes that affect student performance, and self-confidence in the ability to perform tasks. These beliefs taken together would collectively form an educational attitude about instruction.

There is little doubt that self-experience influences beliefs (Nespor, 1987 and Goodman, 1988 as cited by Pajares, 1992). Instructors' self-experience regarding educational practice comes first from their own experiences as a student (e.g. how they experienced instruction from a students persepective), and second, from their experiences as a practitioner in the classroom (e.g. the outcomes they observed as a result of their instruction). Early experiences tend to form beliefs that are highly resistant to change (Pajares, 1992). These beliefs are so strong that people will go out of their way to avoid confronting contrary evidence or engage in discussion that might harm these beliefs (Pajares, 1992). Instructors may present particularly resilient educational beliefs because they spent *years* experiencing the system of education and likely, and *most* had positive identification with education to be motivated to pursue a career in it (Pajares, 1992; Ginsburg and Newman, 1985).

When an individual is presented with new information that is contrary to their beliefs, they deal with the new information through either assimilation or accommodation. In the process of *assimilation*, the new information becomes incorporated into the existing beliefs through some kind of modification. If the new information is so contrary that it cannot be assimilated, then existing beliefs must be either replaced or reorganized through the process of *accommodation* (Pajares, 1992). With deep beliefs (like those formed by early experience), an individual is more likely to assimilate new information than accommodate it. In order to accommodate new information, there must be a connection to other beliefs in the structure (Rokeach, 1968 as cited by Pajares, 1992). During adulthood, belief change is a relatively rare phenomenon, characterized by large gestalt shifts when it occurs (Pajares, 1992).

Another major barrier to instructional change may simply be that professors believe, for the most part, that they are already teaching exceptionally well. Bender and Weimer's 2005 survey of instructors showed that 90% of the surveyed faculty rated their teaching as either above average, well above average, or exceptional. It is, of course, unlikely that 90% of college instructors surveyed are actually “above average.” Most instructors surveyed also felt that they were successful at making instructional changes; 75% of instructors reported they were either very or extremely satisfied with the changes they made.

While most professional development efforts have traditionally focused on trying to change the beliefs of the instructor, these efforts are relatively unsuccessful at bringing about adoption of new instructional practice (Pajares, 1992). Guskey (1986) proposes an alternative model, whereby significant change in instructor beliefs and attitudes is likely to take place only after seeing evidence of a change in student learning outcomes – that is, the practice must change (facilitating self-experience) before the change in beliefs and attitudes.

Motivation to Change

Most often, for beliefs to be changed, something or someone must present new information to the instructor. Sometimes this will be the result of a professional development activity provided by: the department, the institution, a professional organization, a commercial institution, or a federal organization. However, other sources of influence on instructor beliefs (in mathematics) are students, colleagues, superiors (representatives of the institution) and the educational system itself (Ernest, 1998). We often see the influence of a single change agent within a department or institution (Lauten, 1996).

How might colleagues influence the motivation to change beliefs? Henderson (2007) found that if some members of the department are trying a new instructional practice, it is easier for others in the department to do so. Many researchers emphasize that it is the collegial sharing of ideas, experiences, failures, and successes that play a key role supporting change in instruction (Anderson, 1997; Baldwin, 2009; Bender & Weimer, 2005; Burks et al., 2009; Gess-Newsome, 2003; Huberman, 1993 as cited by Foertsch et al, 1997; Johnson et al., 2009; Medlin, 2001; Silver & Smith, 1997).

Students may also influence an instructor's motivation to change their instructional practices, although not necessarily in a positive way. There is often "student pushback" when instructors adopt an alternate instructional practice (Benvenuto, 2002; Cooney, 1985; DeLong & Winter, 1998; Henderson, 2007; Henderson & Dancy, 2007; Kennedy, 1997). This can be mitigated to some extent if the instructor can communicate the purpose of the change to the students well (DeLong & Winter, 1998; Ganter, 1997; Hurley, 1999). For mathematics, in particular, students tend to believe there is only one path to successfully resolve a problem and that the path must be clearly described by the instructor (DeLong & Winter, 1998; Ganter, 1997; Lauten, 1996).

A change in instructional methods is ultimately made because the instructor has the *desire* to do so (Wallin, 2003). Most instructors engage in professional development because they want to become better at what they do (Gurskey, 1986). Research has shown there is a positive correlation between an individual's enthusiasm (vitality) for teaching and their desire to improve teaching (Berman & Skeff, 1988). Lacking a theoretical framework about student learning, most instructors simply try out ideas to see how they work, formulating a theory about how the new practice should work based simply on their self-experience of successive years of experience (Tall et al., 2008) or a gut instinct. Self-reflection during this process of trial and error is key to facilitating change (Johnson et al., 2009). An extensive literature review conducted by Walker and Quinn (1996) concluded that instructors will be most vital when they are: competent, have sufficient autonomy, define and are assessed on goals that are challenging, and when they receive fair and equitable rewards for excellent teaching.

To be competent, instructors require skills in (1) scholarship of their discipline; (2) pedagogy; and (3) human development and interpersonal relations (Walker and Quinn, 1996). Unfortunately, few college STEM instructors receive any training in pedagogy or learning theory as part of their formal educational training (Baldwin, 2009). As a result, these instructors generally teach the way they were taught. Baldwin makes the case that STEM faculty, in particular, need access to practical, easy-to-apply information on how students learn as well as knowledge of effective instructional strategies. New instructors may be particularly insecure in their own knowledge and skills. Walker and Quinn (1996) found that new instructors with poor evaluations were also spending an average of 35 hours a week preparing lectures rather than the average of 16-20 hours per week for high-performing instructors.

A majority of faculty cited independence and freedom as a satisfying aspect of being a college instructor (Walker & Quinn, 1996). However, college instructors may not actually have as much autonomy as they need in order to stay vital and creative throughout an entire career. Instructors do not usually have much control over the environment in which they teach, the number of students in their course, or the admissions requirements of their institution. Undergraduate math and science courses cover vast quantities of information, considered essential for advanced study within the field (Baldwin, 2009). As long as these courses are required as prerequisites to more advanced courses, it will not be easy to "give back" the control of the curricula to instructors.

According to Walker and Quinn (1996), instructors will be most vital when they have well-defined goals and are assessed on them. In education, many instructors may not be aware of the goals that they set, and some goals may be difficult (or impossible) to measure or attain. If the goals of the instructor do not line up with the goals of the students, department, administration, or institution, the achievement of some goals may not be satisfying (and may in fact be cause for stress or frustration). Frequent feedback concerning progress towards goals is necessary to obtain optimal results, as is the ability for instructors to view criticism constructively.

To maintain excellence in teaching over a long career, Walker and Quinn argue that it is necessary to have meaningful recognition for teaching activities and tangible rewards like merit pay, promotion, or tenure (1996). In contrast, Deci and Flaste (1995) argue that rewards should be used "...merely to acknowledge or signify a job well done." Their research shows that "...the more the [rewards] are used as motivators ... the more likely it is that [the rewards] will have negative effects" (p. 55). Deci and Flaste emphasize that true instructional change will come from intrinsic motivation, or to put it another way, teaching is its own reward. They assert that it is essential to see a *relationship* between the behavior and the desired outcome in order to be motivated and cite a multitude of research that intrinsic motivation (or self-motivation) is "…at the heart of creativity, responsibility, healthy behavior, and lasting change" (p. 9). However, Deci and Flaste also recognize that most people believe that extrinsic motivations have the greatest effect.

It is not uncommon for college instructors to develop their own instructional practices (or changes to practice). In fact, 43% of the instructors in the Bender and Weimer survey (2005) developed their own instructional changes. Three factors were identified by more than eighty percent of the instructors surveyed as a motivator for making a change: (1) dissatisfaction with how much and how well students were learning; (2) the need to keep teaching fresh and invigorating; and (3) the need to fix an instructional problem. It is the everyday teaching experiences (student learning, invigorating instruction, and instructional difficulties) that were listed as the primary motivators for instructional change.

If everyday teaching experiences are the major motivator for faculty to change, then to develop the *need* to change, professors must first feel some discomfort or inadequacies about their current instructional practices. This state of discomfort is not easily attainable and is described by the Theory of Cognitive Dissonance (Festinger, 1957): people go to great lengths to avoid confronting the dissonance between their behavior and their self-concept. When dissonance is present, the individual is likely to avoid information and situations that would increase the dissonance. For example, if an instructor is used to teaching by lecturing, and begins to recognize that there are alternative methods of instruction that might be beneficial to students, they may actively avoid learning about these methods to avoid increasing the dissonance between their self-concept and their practice. In other words, for an instructor to accept that some new instructional method is better for student learning, they would have to also recognize the idea that their prior instructional practice was, in some way, flawed.

There are different theories about what causes the desire to change. The *behaviorist* model of motivation postulates that motivation is something that one does to people. For example, a leader is believed to motivate his or her followers. The *cognitivist* (or humanist) model claims that motivation is created from within by tapping into the deepest desires of people, creating the opportunity for them to grow.

There is some natural resistance to change as a result of the human aging process, but there is also evidence that the greatest resistance to change *in academia* seems to come from cohort effects (Lawrence & Blackburn, 1985). In the cohort effect, new propositions may be in conflict with the longstanding core beliefs of an individual, which formed during the time that they came of age in academia. Faculty careers are best explained by the cohort model – that is, "…professors who complete their graduate work and achieve tenure during the same historical era are enculturated with a particular set of values that remain constant over time" (Lawrence & Blackburn, 1985, p. 137). Further evidence of this can be found in the 2004-2005 HERI Faculty Survey, which found that there were considerable differences in the use of student-centered instruction versus teacher centered instruction across the different faculty career stages. Early-career faculty were more likely to use a variety of student-centered instructional practices (i.e. group projects, student presentations, reflective writing) and advanced-career faculty were more likely to use extensive lecturing (Lindholm et al., 2005).

The final piece in the puzzle of an instructor's motivation to change instructional practice is incentive (e.g. rewards for teaching, grant of release time, financial support, tenure). Lutzinger et al. (2009), speaking about facilitating reforms in STEM courses, point out that "A major curricular reform is costly in terms of time, energy, and finances. Resources will be needed to execute the course changes proposed" (p. 50). Murray (1999) suggests that even if there is no monetary incentive, an institution must at least recognize faculty that have attempted to improve their instruction so that the instructors know their effort is appreciated. Unfortunately, Murray's survey of 2-year colleges also showed that administrators had little or no direct knowledge of the teaching practices of their faculty (1999). Murray's survey also found that 2-year institutions made efforts to connect effective teaching with promotion and tenure decisions. Unfortunately, if evaluation is oriented towards traditional instructional practices, incentive is also oriented towards traditional practices (Benvenuto, 2002).

Instructional Practices

There are almost as many instructional practices as there are papers about instructional practice. Instructional practices are not exclusive; an instructor may employ several practices simultaneously. In mathematics, some practices evolved because of a new understanding of the science of learning (e.g. inquiry-based learning). Other practices were motivated by a significant shift in the student population (e.g. the focus on applications in Calculus reform). Still other practices evolved because of the introduction of technology (e.g. the increased use of multiple representations when graphing calculators were introduced). Regardless of the specific instructional practices, researchers have generally categorized teaching in a way that divides educational practices into two broad categories: teaching where the primary interactions are teacher-student and teaching where the primary interactions are student-student.

In this section of the literature review, I shall begin by examining these two broad categories of instructional practice, and then move to focus on three of the ten mathematics instructional practices (MIPs) that are commonly used by math faculty: lecture, cooperative learning, and inquiry-based learning (Andersen, 2009). For the scope of this study, it is unreasonable to choose more than three instructional practices and these three provide some contrast in which both teacher-directed and student-centered practices can be studied. The use of technology for instruction is illustrated in the examples of implementation of the chosen MIPs, but emphasis on technology itself is not an instructional strategy that can be easily summarized and is left to future exploration.

Teacher-directed or Student-centered Instruction

The instructional practice where the interactions are primarily between teacher and student are called by a variety of names. In the National Math Advisory Panel (NMAP) report, Gersten et al. (2008) call this group of educational practices “teacher-directed instruction.” In AMATYC’s Beyond Crossroads it is referred to as a “teacher-centered style" (Blair, 2006). Prosser and Trigwell (2004) call this cluster of teaching practices "Information Transmission Teacher Focused" (ITTF). For this research, the NMAP definitions provide a clear description of general educational practice in the context of mathematics instruction. In teacher-directed instruction, as described by the 2008 Final Report of NMAP, the instructor is primarily communicating the mathematics to the students and the majority of exchanges about the mathematics are between the teacher and the students (Gersten et al., 2008). According to NMAP, the characteristics of teacher-directed mathematics instruction are "clearly prescribed instructional sequences, consistent focus on content objectives, emphasis on explanation, assessment and correction of errors, feedback to students and assignment and review, in which the teacher is doing all of these things. In addition, teacher-directed instruction can be manifested in the way the classroom is organized, and is often associated with whole group instruction. Most important is that the teacher is doing the teaching" (Gersten et al., 2008, p. 6-13).

The student-to-student instructional practices have also been given a variety of names: "student-centered instruction" (Blair, 2006; Gersten et al., 2008) and "Concept Centered Student Focused" (CCSF) by Prosser & Trigwell (2004) to name a few. In student-centered instruction, it is primarily students who are doing the teaching of mathematics and the majority of exchanges occur between or among students (Gersten et al., 2008). According to NMAP, the characteristics of student-centered mathematics instruction include "emphasis on student responsibility and independence; acknowledgment of students' experiences, prior knowledge, and interests and motivations in the design of mathematics instruction; and the centrality of students' thinking and students teaching other students in the classroom. Teachers facilitate, encourage, and coach but do not explicitly instruct by showing and explaining how things work" (Gersten et al., 2008, p. 6-16).

The movement towards encouraging student-centered instructional practices in mathematics was motivated primarily by the declining numbers of math majors in the 1970s (Bressoud, 2001) and the subsequent pressure to pay attention to the students who were non-math majors (the vast majority of the students in undergraduate math courses). In mathematics, movements like Calculus Reform (1986-present day), and publications like *Beyond Crossroads* (2006) and the CUPM CRAFTY Guidelines (2004; 2007) have tried to encourage instructors to a variety of techniques and technologies to bring about a shift to more student-centered instructional practices.

The Lecture Method

Lecture, for the purposes of this research, shall be defined as teaching by giving a presentation on some subject for a time period longer than 20 minutes. This instructional method includes the exchange of questions and answers between the instructor and students. Three examples are provided to illustrate a range of usage in mathematics (Andersen, 2009, p. 2):

1. The instructor presents a logical narrative on exponential functions using a whiteboard. The narrative includes definitions, example problems, and application problems. The instructor periodically asks if there are any questions about the material.
2. The instructor presents a lesson on graphing lines using an overhead graphing calculator viewscreen to show students how changes to the algebraic function result in changes to the graph. The students follow along, each using their own graphing calculator, and occasionally interject questions when they have a problem with the technology.
3. The instructor uses PowerPoint and video from the Internet to present a lesson showing students how the path followed by a cannonball is modeled by a quadratic equation, and how to find that equation. Students

> with laptops click through the slides as they listen and watch the presentation.

The key characteristic is that the students rarely interact with each other during this learning process (Andersen, 2009).

In mathematics, the lecture method is still widely used across all institutions and courses in mathematics (Lutzer et al., 2007). In the most recent CBMS study (Lutzer et al., 2007), lecturing was used in 74-81% of community college course sections below calculus (see Table 5). The lecture method falls clearly into the teacher-directed instruction category, and is so core to mathematics instruction that it is referred to as the "standard lecture method" in the CBMS statistical surveys.

Cooperative Learning

Cooperative learning, collaborative learning, and group learning are often used interchangeably in the research literature. For the purpose of this research we consider them to be the interchangeable terms, and define cooperative learning as the practice of including class time for learning that engages students in working and learning together in small groups, typically with two to five members. Cooperative learning strategies are designed to engage students actively in the learning process through inquiry and discussions with their classmates (Davidson et al., 2001; Rogers et al., 2001).

Table 5

Percent of sections using the "standard lecture method" at 2-year colleges

Course level	Percent of sections taught using "standard lecture method" at 2-year colleges		
	1995[(a)]	1995[(b)]	2005[(c)]
Elem. Algebra	75	78	74
Int. Algebra	81	79	77
College Algebra	88	83	74
Trigonometry	89	89	81
Coll. Alg. & Trig.	66	75	78
PreCalculus	82	86	76

Note. The data in this table are excerpted from three sources: (a) Table TYR.10 of "Statistical Abstract of Undergraduate Programs in the Mathematical Sciences in the United States: Fall 1995 CBMS Survey" by D.O. Loftsgaarden, D.C. Rung, and A.E. Watkins, 1997, Washington, DC: The Mathematical Association of America. Copyright by The Mathematical Association of America 2011. All rights reserved. (b) Table TYR.10 of "Statistical Abstract of Undergraduate Programs in the Mathematical Sciences in the United States: Fall 2000 CBMS Survey" by D.J. Lutzer, J.W. Maxwell, and S.B. Rodi, 2002, Providence, RI: American Mathematical Society. Copyright 2002 by the American Mathematical Society. (c) Table TYE.10 of "Statistical Abstract of Undergraduate Programs in the Mathematical Sciences in the United States: Fall 2005 CBMS Survey" by D.J. Lutzer, S.B. Rodi, E.E. Kirkman, and J.W. Maxwell, 2007, Providence, RI: American Mathematical Society. Copyright 2007 by the American Mathematical Society.

To illustrate this instructional practice in the mathematics context, three examples of cooperative learning are provided (Andersen, 2009, p. 3):

1. All of the students in the class find a partner and a spot at the whiteboards in the classroom. The instructor reads a factoring problem aloud and the students work together to solve the problem at the board. The students help each other within pairs and between pairs, asking questions and providing hints to each other. The instructor occasionally provides hints to pairs of students, but it is primarily students who are answering each others' questions. Every few minutes, the instructor directs one person from each pair to move to the right, and reads a new question for the new pair of students to solve together.
2. The instructor poses the following question to an algebra class, "How do you find the least common denominator for any set of fractions?" Students are given two minutes to think about the problem on their own, and then they join a group to solve the problem. After 8 minutes, each group presents their solution to the rest of the class.

3. Class is held in a room with eight computer stations. Students work together in groups of three to complete an activity about inverses using a spreadsheet program. One student is designated as the computer-specialist, one student has responsibility for writing the responses to turn in, and the third student will present the results of their experimentation to the rest of the class.

Cooperative learning is a social activity where students learn by talking, listening, explaining and thinking with their peers. Clearly, this falls squarely into the student-centered instruction category. Working in a group makes it more likely that students will observe alternate approaches to solve problems and have to think critically about the validity of each approach. The literature review provided by Davidson et al. finds five common attributes to cooperative and collaborative learning (2001, p. 5):

1. a common task or learning activity suitable for group work;
2. small-group interaction focused on the learning activity;
3. cooperative, mutually helpful behavior among students;
4. interdependence in working together; and
5. individual accountability and responsibility.

The NCTM Guidelines for Professional Practice (1998, 2000), AMATYC Beyond Crossroads (2006), the National Math Advisory Panel (2008), and the MAA CUPM CRAFTY Guidelines (2004) all encourage instructors to utilize cooperative learning approaches as a valuable instructional practice for mathematics (though not exclusively). Cooperative learning is cited in many studies as having a positive impact on communication skills and active engagement with the material (Blair, 2006), and increased retention of minority populations. However, the use of group work is not universally accepted among math instructors (Bressoud, 2001).

The CBMS statistical reports have tracked the use of "group assignments" in math in the last three studies. Math instructors at 2-year colleges have adopted the use of group assignments at a higher rate than 4-year instructors in almost all instances and years of study (Loftsgaarden et al., 1997; Lutzer et al., 2002, 2007). In the last study (Lutzer et al., 2007), the percent of instructors using group assignments fell at almost all course levels for both groups of instructors. Bressoud (2007) coined this trend “reform fatigue.” However, since this data is reported by department heads, and not the instructors themselves, it is difficult to understand whether we are seeing a real decline in use of these practices or whether it is within just a reporting phenomenon. Table 6 shows the percent of sections that utilize group projects at 2-year colleges for the last three CBMS statistical reports.

Inquiry-based Learning

Inquiry-based learning is a student-focused instructional practice defined as designing and using activities where students learn new concepts by actively doing and reflecting on what they have done. The guiding principle is that instructors try not to talk in depth about a concept until students have had an opportunity to think about it first (Hastings, 2006). Three examples are given to illustrate inquiry-based learning for mathematics (Andersen, 2009, p. 3):

1. Students use colored red and black counters to represent negative and positive integers. Students model the additions of signed numbers by matching up and removing pairs of red & black tiles until there are no more pairs. After several problems, each student proposes a "rule" for how to add integers of various types.
2. Students use spreadsheets or the data table on graphing calculators to explore how a change in the function equation affects the data it produces. Students propose an explanation for what they see and then devise and conduct tests of their hypotheses.
3. Students use the slider bars on an interactive online model to experiment with the effect of changing a coefficient on the graph of the function. Students work in teams to come up with a precise definition for how the coefficient affects the graph.

Contextual Variables

The adoption of student focused instructional techniques in higher education is associated with the instructors' perceptions of how much control they have over the curriculum, how much control they have over the method of instruction, the class size, and how the department values teaching (Prosser & Trigwell, 1997). The Perceptions of Teaching Environment Inventory developed by Prosser and Trigwell consists of five subscales that measure contextual variables that intervene between desire to use an instructional technique and adoption of that technique: control of teaching, appropriate class size, enabling student characteristics, departmental support for teaching, and appropriate academic workload. In addition to these five subscales, appropriate learning space has also been cited extensively in the literature as a barrier to the adoption of instructional practices.

Control of Teaching

When instructors perceive that they have little control over what and how they teach, they may be less likely to adopt student centered instructional practices (Prosser & Trigwell, 1997) or instructional innovation (Hannan & Silver, 2000; Henderson & Dancy, 2007; Hockings, 2005; Weil, 1999). The "control of teaching subscale" (CoT) is designed to measure the instructor's perception about the amount of material that's included in the course and the amount of leeway for variation in course material and instruction is available (Prosser & Trigwell, 1997). Many research studies cite the restrictive curriculum requirements as a deterrence to adoption of innovative instructional practices (Foertsch et al., 1997; Johnson et al., 2009; Walker & Quinn, 1996; Windham, 2008). Mathematics courses at the community college level often have a restricted curriculum because of transferability requirements to 4-year institutions (Wood, 2001).

In mathematics, influences from the so-called “partner disciplines” may also be stifling to faculty autonomy. The *Curriculum Foundations Project: Voices of the Partner Disciplines* (Ganter and Barker, 2004), attempts to capture the concerns of a variety of math-related fields to help mathematics instructors better guide their instruction. However, the 215-page project report (summarizing feedback from biology, business, chemistry, computer science, four engineering specialties, heal-related sciences, physics, K-12 mathematics, teacher preparation, electronics, information technology, and manufacturing) might possibly be one more obstacle to autonomy for math instructors, placed on top of AMATYC, NCTM, NMAP, and MAA guidelines for effective instructional practices.

Appropriate Class Size

Teaching a large class can be a barrier to implementing student focused instructional practices, which tend to work better with small class sizes (Benvenuto, 2002; Henderson & Dancy, 2007; Hockings, 2005; Murray, 1997; Prosser & Trigwell, 1997). Walker and Quinn (1996) suggest that faculty motivation might increase if instructors had more control over the type, size, and structure of their courses. The “appropriate class size” subscale (ACS) measures the extent to which class size influences the amount of interaction between student and instructor (Prosser & Trigwell, 1997).

Enabling Student Characteristics

When the skills of students and their cultural backgrounds have a great degree of variation, this can make it difficult for instructors to use student centered instructional techniques or instructional techniques that are outside of their comfort zone (Henderson & Dancy, 2007; Hockings, 2005; Prosser & Trigwell, 1997). Student culture is described by Hockings (2005) as “the experiences beliefs and expectations of learning teaching and assessments that students share and which influence their approach to learning.” The “enabling student characteristics” subscale (ESC) focuses on the increasing variation in the ability of the student, their language background, and gender. The ESC subscale is designed to get a measure for the homogeneity or heterogeneity of the skills and background of the student population in the course. For example, if the classroom consists of students with a large variety of abilities, then this is scored negatively for enabling student characteristics (Prosser & Trigwell, 1997).

At community colleges, the open-door admissions results in an instructional challenge in the form of a significant population underprepared students (Huber, 1998). Trying to teach a large population of underprepared mathematics students demoralizes faculty (Bahr, 2008) and only 6% of community college faculty agree that they are rewarded for their efforts to work with underprepared students (Lindholm et al., 2005). The need for student remediation is cited in the 2005 CBMS report as the top problem facing mathematics departments, reported by 63% of mathematics departments (Lutzer et al., 2007). Also in the top three problems of mathematics departments (by percentage reporting) were that students don’t understand the demands of college work, and low student motivation (Lutzer, et al., 2007).

Departmental Support for Teaching

The subscale "departmental support for teaching" (DST) in the Prosser and Trigwell study (1997) was designed to focus on the possibility that lack of balance between the value placed on teaching and research was a mitigating variable in the instructor's choice to adopt a new instructional practice. The research/teaching balance beam is not an issue for the vast majority of community college mathematics instructors - only 5% of community college math instructors are expected to perform regular research as part of their position (Huber, 1998). However, department support or support from colleagues encourages instructors to try innovative or student-centered instructional practices (Henderson & Dancy, 2007; Prosser & Trigwell, 1997; Wood et al., 1991), particularly with respect to the adoption of electronic technologies (Medlin, 2001). Other departmental or institutional policies can play a role in an instructor's decision to adopt alternative instructional practices. For example, lenient policies about course drop, add, and withdrawals can force instructors to make unwanted changes in their instructional practices (Walker and Quinn, 1996).

Appropriate Academic Workload

When an instructor perceives the workload to be heavy, they are less likely to adopt new instructional techniques (Henderson & Dancy, 2007), and may actively select instructional techniques that they perceive as reducing the workload (Ramsden, 1998). Many studies cite heavy workload as a major source of stress and dissatisfaction for instructors (Baty, 2002; Hockings, 2005; Martin, 1990; Prosser and Trigwell, 1997). The original "appropriate academic workload" subscale (AAW) developed by Prosser and Trigwell (1997) measures the institutional balance between teaching and research. While academic workload does not need to factor in the research requirements for community college instructors (where less than 5% are required to perform research duties), the subscale can still be used to measure the instructor's perception of the appropriateness of the academic workload.

Appropriate Learning Space

The layout of the classroom or the availability of technology can significantly affect the ability to use innovative instructional practices (Baldwin, 2009; Burks et al., 2009; Gess-Newsome et al., 2003; Henderson & Dancy, 2007; Johnson et al., 2009). For example, if the student desks are all bolted to the floor in rows, it might be difficult to for students to work in groups. This contextual variable was not measured in the Prosser and Trigwell PTE Inventory, but significant evidence of its intervention in the adoption of instructional practice in STEM disciplines leads me to include it in this study.

The KAP Gap

Robert Menges (2000) stresses the importance of understanding how teachers make the decision to incorporate something into their classroom practice. He suggests that understanding how these decisions are made might lead to the development of better interventions to get teachers to change their practices to be more aligned with research findings. In terms of the decision-stage of the innovation-decision process, adoption is the decision to make full use of an innovation, whereas rejection is a decision not to adopt an innovation (Rogers, 2003). Some instructors may try out new teaching techniques on a partial basis or in some kind of probationary way, for instance as an extra credit assignment or for one unit instead of the whole course. If an innovation can be tried in such a way, as opposed to one which must be adopted wholly, it is generally more successful (Rogers, 2003).

During an innovation trial, if the innovation appears to have a certain level of relative advantage, then the user is more likely to adopt the innovation. Also, successful use by a colleague may provide enough exposure to the innovation to substitute for a partial trial. For example, software companies provide 30-day trials to effectively demonstrate their product; the expiration of the trial-software provides the cue-to-action to motivate the user to make a decision. A good parallel for innovative teaching would be when the professional development coordinator helps an instructor to modify a single topic to incorporate non-lecture teaching techniques. If the student outcomes for that topic are good, and the coordinator provides some kind of follow-up survey to remind the instructor why they achieved better results, this might provide a cue-to-action for the instructor to make a decision about full adoption of the technique.

There are various ways in which an innovation can be rejected at this stage of the decision process. For instance, if an instructor gains knowledge about an innovation through reading materials or a workshop, but then forgets about what they have learned, this is an example of a *passive rejection*. If an innovation has been adopted, but then is later dropped, this is defined as *discontinuance. Active rejection* is when an innovation is considered for adoption (possibly including a trial) but then is ultimately rejected (Rogers, 2003). Again, research in faculty development should consider these issues. If an instructor did not adopt a new teaching technique in the classroom after attending a workshop, was it an active rejection or a passive one? Was there a trial of the innovation before the decision was made? Would a follow-up email a month after a workshop help to avoid the passive rejection of simply forgetting about the innovation?

Implementation is the stage in which an individual puts the innovation into practice. Usually this stage directly follows the decision stage, unless there is a hold-up in the availability of resources necessary for the innovation. For example, an instructor might decide to introduce multimedia into their lectures, but a classroom with technology is unavailable for use until the following semester. During the implementation stage, the role of the change-agent would be to provide technical assistance to the individual (Rogers, 2003). A faculty development coordinator might provide ongoing technology workshops if the innovation is centered on increased technology use or regular discussion meetings if the innovation involves many faculty trying a new classroom technique.

During the implementation stage, an innovation might be re-invented to better suit the purposes of the individual user. Researchers must be careful to not only measure adoption of innovation in the manner that it was intended, but also to measure the adoption of the innovation in manners in which it was *not* intended. Re-invention of an innovation should be considered a positive count in the category of adoption of the innovation. Interestingly, a higher degree of re-invention actually leads to a faster rate of adoption for a particular innovation and a higher degree of sustainability – that is, the degree to which it continues to be used (Rogers, 2003, p. 183). In the educational field, the degree to which an innovation can be re-invented may be essential to its widespread adoption by faculty. Teaching techniques that are designed for one field must be re-invented to appropriately apply in another field. Likewise, educational research must be easily adaptable for practice – in this manner, research must be re-invented for appropriate application in the classroom.

After the implementation of an innovation, the individual may find confirmation a necessary stage if there is a great deal of dissonance involved in the adoption of an innovation. Dissonance creates an "uncomfortable state of mind" which is the result of conflicting messages (Rogers, 2003, p. 189). If an individual is experiencing dissonance about an implemented innovation, they will seek to reduce it by changing knowledge, attitudes or actions. For example, an instructor that has adopted a new online homework program, but has found that student reaction to the program was mixed, might seek out more information about the appropriate use of the program from the publisher or from colleagues in order to reduce the dissonance they experience. Again the role of the change-agent should be one of support – providing additional data, discussion opportunity, or ways to re-invent the innovation to make it more suitable.

In Rogers' Diffusion of Innovations (2003), he describes a phenomenon called a Knowledge-Attitude-Practice Gap (KAP Gap) where knowledge of an innovation, and a favorable attitude towards it does not necessarily result in "practice" (adoption of the innovation). Many researchers have commented on their findings of a "gap" between instructors' beliefs and their actual classroom practice (Anderson, 2002; Cooney, 1985; Dancy & Henderson, 2008; Ernest, 1988; Guskey, 1986; Kennedy, 1997; Murray, 1997; Norton, 2005; Pajares, 1992; Shavelson & Stern, 1981; Thompson, 1984, 1992; Walker & Quinn, 1996; Windham, 2008). Yet, usually this finding is an aside in the research, and not a subject of investigation.

One example of a well-defined KAP Gap is in physics education research. Despite thorough dissemination of new research-based instructional practices in physics, and favorable attitudes of instructors towards these strategies, the adoption of research-based instructional strategies has not been significant in introductory courses (Henderson & Dancy, 2007). In a follow-up paper, Dancy and Henderson (2008) reported that instructors were often aware of the inconsistency between their conceptions and their instructional practice, attributing the inconsistencies to "situational constraints and barriers" (what I've defined in this study as contextual variables).

There are not many studies that focus on collegiate mathematics instruction, but evidence of a possible KAP Gap can be found, at least qualitatively, in the descriptions of some studies. In 1988, Ernest wrote about the *espoused model* of learning mathematics versus the *enacted model* (actual instructional practice) and notes that there can be a "great disparity" between espoused and enacted models of teaching mathematics. In a qualitative study of instructors switching to a Calculus Reform text, Windham (2008) found that even the self-identified reform advocate in the study declined to use group work, projects, and calculator-based exploration despite having a good understanding of the instructional practices and a favorable attitude towards them.

What helps an individual to move beyond the so-called KAP Gap? Rogers (2003) suggests that the positive experience of a peer who has adopted an innovation might serve as the "cue-to-action" for adopting the innovation (p. 177). For example, suppose there is an exceptional group of outcomes on a department final exam from the students of a professor who has been trying a new teaching technique. Such evidence might motivate other faculty to make the decision to adopt the technique themselves. The results of

Bender and Weimer's 2005 survey of faculty suggest that they are motivated to change by: (a) dissatisfaction with student learning, (b) a need to keep teaching innovative, (c) and the need to fix problems with their current instruction. Student ratings, administrator comments, or institutional support were not high motivators to change.

From my personal experience meeting with groups of math faculty all over the country, I think that most math instructors *do* have knowledge of student-focused instructional practices, and they understand why, in principle, they should use lecturing less often. They may even have the desire to make this change. While there is no data to support these statements (there is also no data to refute them), we do know that all of the major math organizations have been pushing math instructors to change, and yet math instructors have low rates of adoption for student-focused instructional practices. In this study I hope to flesh out the missing data and determine whether there is a KAP Gap in the adoption of alternative instructional practices in mathematics.

CHAPTER III: RESEARCH DESIGN

Design of the Study

The intent of this study is to answer questions about community college math instructors and their knowledge of instructional practices, their attitudes about those practices, the mitigating variables that interfere or aid the implementation of practice, and their actual level of practice. Past large-scale studies of collegiate math instructors have been conducted by surveying department heads (Loftsgaarden et al., 1997; Lutzer et al., 2002; Lutzer et al., 2007). In this study, I will conduct a large-scale study of collegiate math instructors by going right to the source (the instructor) for data.

A quantitative survey was selected for this study because the potential variables have been established through the literature review and it can be reliably and inexpensively distributed to a large population and can be used to gain a better understanding of the population (Creswell, 2003). Well over half of the target population consists of part-time instructors, who are less likely to have designated office space or dedicated on-campus phone lines. For this reason, an online survey seemed the best method to reach this subpopulation, as these participants can complete the survey on their own time at either an on-campus or personal computer.

Data Collection

The survey will be administered using a reliable online survey tool called Zoomerang (www.Zoomerang.com). The only technical requirements for participants will be Internet access and a web browser. To encourage potential participants, there will be a random drawing from the pool of participants for three $100 gift certificates to

Amazon.com. Participants will have the ability to opt out of the survey and receive no further reminders. Two follow-up reminders will be sent to those who have still not answered the survey (Zoomerang tracks this information automatically) or opted out. One of the problems with conducting an electronic survey (versus a phone survey or in-person survey) is that a participant may need clarification of an item on the survey. To mitigate this, two procedural pilot surveys were conducted to try to anticipate and correct unintentionally confusing instrument items and to bring the length of the survey instrument into a reasonable completion timeframe. In addition, the researcher's contact information is included on the survey instrument in case there are any questions or technical problems with the survey instrument.

The largest anticipated problem with the survey design is the length of the survey. In the first procedural pilot, participants estimated the survey length to be 30-60 minutes. This length might cause issues with noncooperation (a type of nonresponse). For this reason, the survey instrument was rearranged and redesigned (see Figure 3). In the second procedural pilot, participants spent 15-25 minutes completing the required portion of the survey. To encourage participants to complete the entire survey, participants will be eligible to enter their email address into a raffle for one of three $100 Amazon.com gift certificates upon completion of the survey. Because so much about this population is unknown, the survey will include an optional section of questions on three additional mathematics instructional practices (MIPs) in the design (this takes an additional 10-15 minutes).

Population and Sample

Although a national sample of community college math instructors would be ideal, it is not feasible for this research study (see Table 6). There is no known list of the emails of community college math instructors and the population of part-time instructors is constantly shifting, making it a particularly difficult population to sample. However, a relatively complete list (including email addresses) of all the community college math instructors in Michigan has been compiled by the Michigan Mathematical Association of Two Year Colleges (MichMATYC) and was updated in the Fall of 2009. The MichMATYC list is updated annually by MichMATYC representatives on each community college campus and includes full-time math instructors, full-time instructors from other disciplines who teach math, and part-time math instructors. The executive board for MichMATYC has granted permission for the email list to be used for this research survey. There is some concern about selection bias in the research sample, since I work as a community college math instructor in Michigan, and likely have influence on the population in my role as president of MichMATYC. However, since the survey is lengthy, name recognition may work in my favor for this survey population, since instructors may be more likely to open and respond to the survey.

There is no way to accurately estimate the return rate for an email survey to a sample of community college math instructors. To the best of my knowledge, there have been no general surveys of college math instructors. This study relies on responses by both full-time and part-time math instructors and the return-rate of adjuncts is expected to be lower since their primary career focus may be non-academic. Based on the

Table 6

Possible samples for proposed research

Proposed Sample	Discussion of benefits or drawbacks.	Feasibility
National sample of all community college math instructors (via email)	Results can be generalized to the population.	There is no master list of the approximately 28,000 Community College math instructors in the U.S. To create such a list would be extremely costly. The most feasible way to do this would be to enlist the aid of the 44 state affiliates of AMATYC.
Sample of all community college math instructors using cluster sampling of the community colleges in the U.S. (via email)	Results can be generalized to the population.	A list of the approximately 1,600 U.S. Community College branch campuses can be obtained from the AACC. Once a cluster sample is selected, the email addresses of all math instructors for the selected colleges would need to be collected. This would be costly in terms of time and would require the cooperation of each college in the sample.
Sample or census of AMATYC members (via email)	Results cannot be generalized to the population. There are approximately 1,930 AMATYC members, but only 6% of the members are part-time instructors, whereas 65% of the population is part-time instructors. It is more likely that AMATYC members are more actively engaged in professional development than non-AMATYC members.	The AMATYC board would have to grant permission to use the member list for research purposes, subject to approval at one of two annual board meetings.
Sample or census of Michigan Community College math instructors (via email)	Results can be generalized to the population of Michigan Community College math instructors. While not generalizable to the national population, this would provide a first look into the characteristics of the CC math instructor population. If this data proves valuable, it would serve as a good pilot for a future national grant-funded study.	MichMATYC maintains a list of potential members (approximately 800 full-time and part-time community college math instructors in Michigan). This list is updated annually by the campus representatives of MichMATYC. The executive committee of MichMATYC has granted permission to use this list for this research study.

examination of other recent online surveys of college faculty (see Table 7), a response rate of 20% is estimated. Since the survey respondents will come in waves (initial wave plus two follow-up waves), the three waves will be compared to make sure there is no significant difference between groups.

Table 7

Response rates for several recent online surveys of college faculty

	Sample Size	Respondents	Response Rate
Online AMATYC Climate Survey (Collins, 2008)	4500	860	19%
Online Instructional Technology Council 2008 eLearning Survey (Lokken, 2009)	500	139	20%
Chronicle of Higher Education Survey of Adjunct Instructors (Wilson, 2009)	3,356	625	19%

There are approximately 28,000 community college math instructors in the U.S. The MichMATYC instructor list had 880 complete entries (as of October 31, 2009). Since it is no more difficult to survey the entire MichMATYC list than it is to survey a sample of the list, and the response rate is likely to be low, the invitation to participate in the research survey will be sent to *all* the instructors on the MichMATYC list. In this sense, the study is more of a census than a sample of the population of community college math instructors in Michigan.

Pilot Studies

Prior to carrying out a study using a new survey instrument, a procedural pilot (or field test) is recommended (Creswell, 2003; Fowler, 2002). In a procedural pilot, normal sampling considerations do not need to be followed since the purpose is to debug the survey of poorly-worded questions and test the length of the survey instrument. The target population will include both full-time and part-time instructors. For this reason, pilot participants were selected from the community college math instructor population to represent both of these groups and three pilot surveys were deployed with modifications to the survey instrument between each.

Survey Instrument

The survey instrument for this study is complex and lengthy (a complete copy of the survey instrument can be found in the Appendix and is diagrammed in Figure 3). The complete survey instrument for this research study builds on several existing, well-researched survey instruments: *Approaches to Teaching Inventory* (ATI, Prosser & Trigwell, 1997), *Experience of Teaching Questionnaire* (ETQ, Trigwell & Prosser, 2005), and the *2008 Survey of Physics Instructors* (Henderson & Dancy). The new questions in this survey instrument are based on the items uncovered in the review of the literature for this study. The survey instrument can be broken down into several major sections: (a) Instructor Characteristics, (b) Attitude about Instruction (c) Contextual Characteristics, and (e) Instructional Practice.

Instructor Characteristics

Instructor characteristics include formal education, participation in faculty development and self-directed learning, self-experience, influence of colleagues, and experiences with students. Some of these characteristics can be measured with commonly-used survey items (e.g. gender and years of teaching experience). Other characteristics, like self-experience, require less commonly-used survey items (e.g. asking for the year of course completion to measure a cohort effect). See Table 8 for survey questions that collect data on instructor characteristics.

Work status, full-time or part-time, is a common demographic on surveys of instructors. However, these two choices do not capture all the nuances of the work status of community college math instructors. Let me illustrate with an example from my own personal experience. On my campus, we have four full-time math instructors, but there are nine full-time instructors that teach math in our department. The five extra instructors are science instructors who teach developmental algebra classes to meet their required course load. These instructors are likely to have a lower level of engagement with the math professional community than the instructors hired to teach math full-time. One could make the argument that while these instructors do have full-time status, they might exhibit behaviors that are more like part-time math faculty. Even within part-time faculty, there are nuances that I think deserve to be measured separately. One is whether part-time status is desired by the instructor. An instructor who is happy with part-time status may exhibit different attitudes and behaviors than one who is seeking full-time status. Again, I am unable to find any prior work that breaks down work status into anything other than full time vs. part-time. In this survey, instructors will be given five

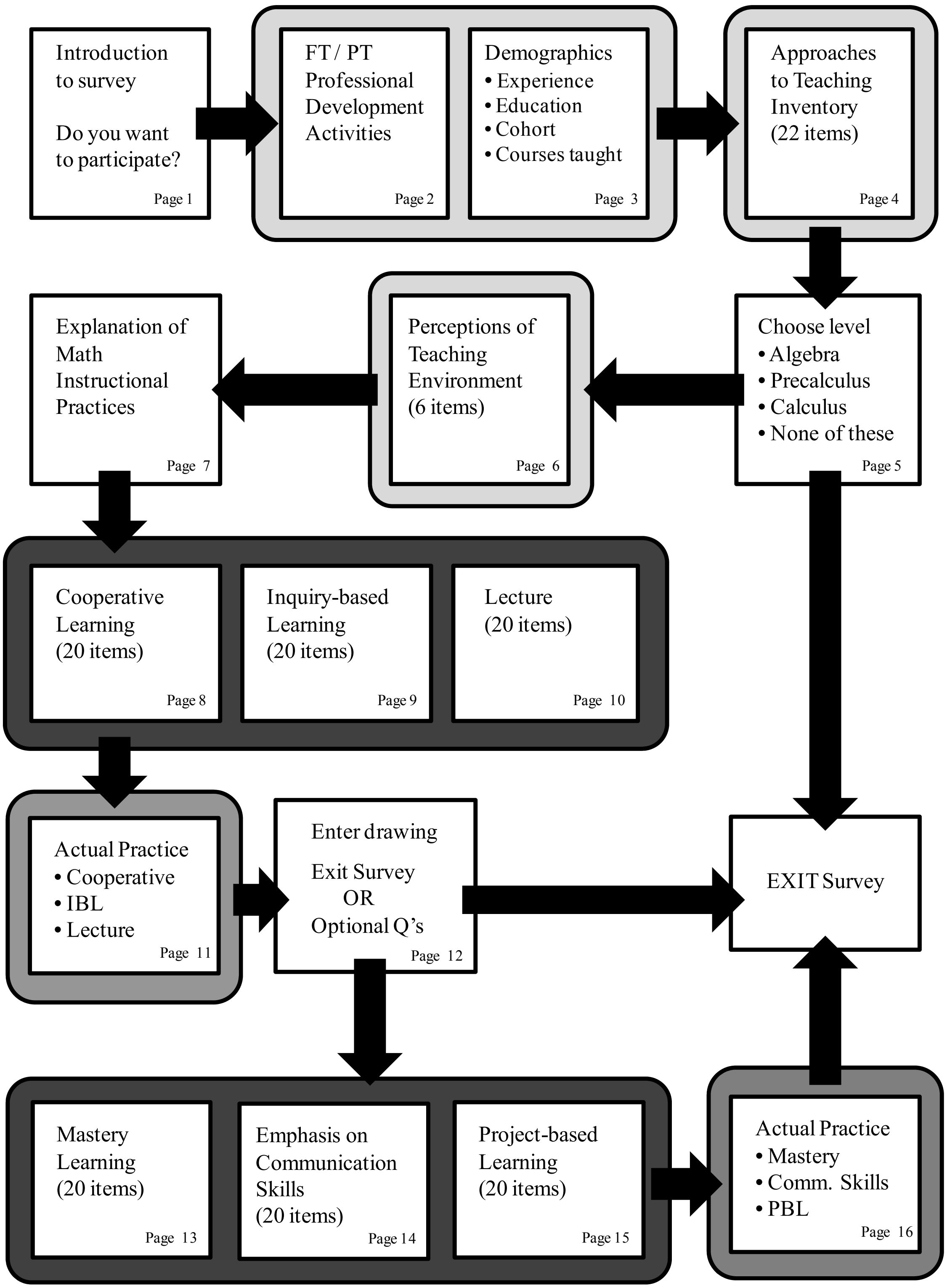

Figure 3. Design of Michigan Community College Math Faculty survey instrument.

choices of work status that capture more of the nuance in work status that occurs on community college campuses (Q.2).

Table 8

Survey questions to collect data on instructor characteristics

Category	Description of questions	Survey Questions
Work Status	FT math, FT non-math, PT-satisfied, PT-desire FT career in math, PT-desire FT career in non-math	Q.2
Gender	Male, female	Q.7
Academic experience	Highest earned degree, last year in student cohort, years of teaching experience	Q.8, Q.9, Q.10
Exposure to ideas through academic culture	Number of colleges taught at, variety of courses taught	Q.11, Q.12
Professional development	Variety of PD opportunities, level of participation in events, reading, and interaction with colleagues	Q.3, Q.4, Q.5, Q.6

The cohort effect (Lawrence & Blackburn, 1985), is measured in Q.9, whereby instructors are asked to share the year in which they completed the *coursework* for their highest earned degree – this gives us some idea of the most likely year they were focused on being a student (a “coming of age” year in academia). The cohort model would normally group instructors by the time they completed graduate school *and* the year tenure was achieved, but the community college math instructor population consists of roughly 65% part-time instructors (Lutzer et al., 2007), so a tenure measurement does not seem appropriate in this instance.

To measure how much an instructor encounters exposure to new ideas, the survey asks questions about the variety of environments in which the instructor has taught and about participation in professional development activities. Each college an instructor teaches at has its own unique culture, so logically it would follow that an instructor that teaches at more colleges has more exposure to different academic cultures (Q.11). Each unique mathematics course also provides the opportunity for exposure to new ideas (e.g. textbooks, syllabi, course coordinators, colleagues, difficulty level, academic maturity of students). A logical argument would say that the more variety in the courses that an instructor has taught, the greater their exposure to new ideas (Q.12).

There are four questions in the section of the survey about professional development activities (Q.3-Q.6). In these questions I hope to gain a clearer understanding of the variety of professional development activities undertaken by math instructors (Q.3) and the level of participation in those professional development activities (Q.4 – Q.6). To some extent, Q.3 also explores *who* is providing professional development about topics related to teaching math. There is an additional question in each MIP subsection (Q.59, 79, 99) that measures the instructors' comfort level with specific math practices (cooperative learning, inquiry-based learning, and lecture).

Attitude about Instruction

To measure a general attitude about teaching, the *Approaches to Teaching Inventory* (Trigwell & Prosser, 2004) will be used. This 22-item inventory contains four subscales of interest: (a) intention for information-transfer teacher focused (ITTF), (b) strategy for ITTF, (c) intention for conceptual-change student-focused (CCSF), and (d) strategy for CCSF). The ATI has been through validity and reliability testing and is designed to measure approaches to university-level teaching. In particular, the *intention* subscales will be used to gauge a general attitude about whether an instructor leans more towards a teacher-centered (ITTF) or student-centered (CCSF) approach.

There is some indication that approaches to teaching vary based on the level of instruction. Trigwell and Prosser (2004) found that instructors described approaches for teaching graduate students that were quite different than their approaches with first-year students. For this reason, I have chosen to have instructors focus on a particular level of mathematics for answering questions about the control of teaching and items related to specific MIPs. There are three levels to choose from in the survey: (a) algebra, (b) precalculus, and (c) calculus. However, calculus sections make up only 6% of the sections taught at community colleges (Lutzer et al., 2007), and it is likely there will not be enough data for this level. The real focus of the analysis (see Table 14) will be to see if there is any distinguishable difference between the developmental algebra level and the precalculus level, which account for approximately 61% of the community college math sections (Lutzer, et al., 2007). The ATI survey items were modified slightly for this research survey to be subject-specific. Favorable attitude about specific instructional practices is also measured in the MIP subsections of the survey instrument (see Table 9).

Table 9

Items measuring attitude towards instructional practices in MIP subsection

Survey item description	CL	IBL	Lecture
[Instructional practice] is effective for student learning.	Q.43	Q.63	Q.83
Students will enjoy learning with [instructional practice].	Q.44	Q.64	Q.84
[Instructional practice] makes good use of class time.	Q.45	Q.65	Q.85

Contextual Characteristics

The knowledge-attitude-practice relationship (see Figure 1, Chapter 1) is affected by at least six contextual characteristics: (a) control of teaching (CoT), (b) appropriate class size, (c) enabling student characteristics (ESC), (d) departmental support for teaching, (e) appropriate academic workload, and (f) appropriate learning space.

The survey section called "control of teaching" asks questions about how much choice the instructor has in designing the learning experience. Some of these questions are modified slightly from questions in the *Experience of Teaching Questionnaire* (ETQ) (Prosser & Trigwell, 2008). I considered using the entire ETQ (and did so in the first procedural pilot), but many of the questions are repetitive and participants seemed to get annoyed about this. In order to cut the length of the survey, I chose to focus on core questions (see Table 10) to get a description of the flexibility in teaching that an instructor has. The rest of the questions that collect data on contextual characteristics (see Table 11) are based on issues identified in the literature review and loosely based on the style of wording used in the ETQ.

Instructional Practice

Instructional practice is the one of the more difficult items to measure in a quantitative survey. Instructors' perception of what they do in the classroom can be different from their actual practice (Henderson & Dancy, 2009). For example, the instructional practice of lecture has become increasingly politically unpopular in mathematics, and thus instructors are likely to want to underestimate their use of lecture and overestimate their use of alternative techniques. The survey items about actual practice are grouped together and placed last. It is my hope that instructors will have had sufficient chance to "vent" their frustrations about the system in which they teach that they feel comfortable admitting that they lecture or admitting that they do not use alternative teaching practices. Indeed, this *was* the case in the procedural pilots. There is no reasonable way to measure actual classroom practice within the framework of this study. The scale used for the instructional practice items comes from the 2008 Henderson and Dancy survey about physics instructional practices. The scale asks instructors to rate their frequency of use in a given time period: never, once or twice, several times, weekly, for nearly every class, or multiple times every class.

Table 10.

Modified ETQ items to measure control of teaching at a level of math

ETQ Item	Michigan CC Math Faculty Survey
1. I have very little say in how this course is run.	36. I have very little say in how the courses at this level are run.
3. The department allows me considerable flexibility in the way I teach this course.	37. The department allows me considerable flexibility in the way I teach courses at this level.
7. I feel a lack of control over what I teach in this course.	38. I have control over the **content** that I teach in these courses.
16. I feel a lack of control over how I teach in this course.	39. I have control over the **way** I choose to teach in these coruses.
NA	40. I am able to choose my classroom setting for courses at this level (e.g. fixed rows, tables & chairs, type of available technology).
17. I feel it difficult to cover the syllabus for this course in the allotted time.	41. I feel it difficult to cover the content of these courses in the allotted time.

Table 11

Contextual characteristics and related survey items

Contextual characteristic	General survey item description	Survey items
Control of teaching (CoT)	See Table 10.	Q.36 – Q.41
	If there were less content to cover in courses at this level of math, I would be more inclined to use [instructional practice] (or use it more often).	Q.60, 80, 100
Appropriate class size	It would be easy for me to use [instructional practice] with large class sizes (above 30 students).	Q.46, 66, 86
Enabling student characteristics (ESC)	I would be able to use [instructional practice] even when some students do not complete their assignments.	Q.48, 68, 88
	It would be easy for me to use [instructional practice] even when some students miss a lot of class.	Q.49, 69, 89
	It would be easy for me to use [instructional practice] when the students vary a great degree in skill level.	Q.50, 70, 90
	[Instructional practice] would be easy for me to use with students who are taking the course for the first time.	Q.51, 71, 91
	[Instructional practice] would be easy for me to use with students who are repeating the course.	Q.52, 72, 92
	[Instructional practice] would be easy for me to use if my class contained both students who are seeing the math for the first time AND students who are repeating the course.	Q.53, 73, 93
	It would be easy for me to use [instructional practice] with students that have poor reading and writing skills.	Q.54, 74, 94
Departmental support for teaching	If I wanted to, I would be allowed by my department to use [instructional practice] at this level of math (algebra, precalculus, calculus).	Q.58, 78, 98
Appropriate academic workload	The amount of time it would take me to prepare for class using [instructional practice] would make me hesitant about using it.	Q.55, 75, 95
	The amount of time that I would have to spend grading would make me hesitant to use [instructional practice].	Q.56, 76, 96
	The amount of time that I would spend outside of class interacting with students in order to use [instructional practice] would make me hesitant about using it.	Q.57, 77, 97
Appropriate learning space	I would be able to use [instructional practice] in any classroom that I am assigned.	Q.47, 67, 87

Research Analysis

Nine research questions are proposed in this study. The proposed is summarized in Tables 12, 13, and 14. Analysis will include descriptive data, sometimes broken into levels (e.g. level of math), Chi-square tests for frequency data, ANOVA for belief and attitude data, and logistic regression analysis. The research analysis was performed using the statistical software package SPSS.

Table 12

Description of data analysis for each research question: What are the characteristics of the population and how do they engage in professional development?

Research Question	Survey Items	Data Analysis
1. How knowledgeable are community college math faculty about instructional practices and how do they receive this knowledge?	Q.42 (CL) Q.62 (IBL) Q.82 (LEC)	Q.42, Q.62, and Q.82 tell us where instructors receive knowledge of the instructional practice. Q.82 is "standard" practice for math. Q.62 is the most innovative practice measured in the research and Q.42 is somewhere in between. Descriptive statistics will be provided for all items. Chi-square tests can be used to test for differences between responses to Q.42, Q.62, and Q.82.
2. What kinds of professional development (general and context-specific) do community college math faculty participate in?	Q.3-6 Q.59, 79, 99	Q.3-6 measure variety of professional development activities and level of participation in those activities. Q.59, 79, and 99 measure the current comfort level of instructors with specific MIPs. Descriptive statistics will be provided for all items. Chi-square tests can be used to test for differences between responses. In addition, a variety of PD frequency measurement can be calculated for Q.3. The higher the number, the more variety in the PD activities for that instructor.
3. What is the influence, if any, of specific demographics (work status, gender, education, experience, or exposure to ideas) on the types of training that community college math faculty receive?	Q.42, 62, 82 Q.3-6 Q.2 Q.7-12	Frequency analysis can be performed breaking out work status (Q.2), gender (Q.7), education (Q.8), experience (Q.9, Q.10), and exposure to ideas (Q.11, Q.12). Chi-square tests can be used to test for differences in group responses for Q.42, Q.62, Q.82, and Q.3-6 based on work status (Q.2), gender (Q.7), education (Q.8), experience (Q.9, Q.10), and exposure to ideas (Q.11, Q.12). Some subgroup analysis with chi-square tests may be appropriate here to measure interaction effects between variables (like work status).

Note. CL = Cooperative learning, IBL = Inquiry-based learning, L = Lecture, ATI = Approaches to Teaching Inventory, and CoT = control of teaching

Table 13

Description of data analysis for each research question: What influences adoption or rejection of practice?

Research Question	Survey Items	Data Analysis
4. Are there correlations between beliefs held by community college math faculty and their use (or lack of use) of instructional practices?	Q.102 (CL) Q.103 (IBL) Q.104 (LEC) Q.13-34 (ATI) Q.36-41 (CoT) Q.42-61 (CL) Q.62-81 (IBL) Q.82-101 (LEC)	Use reliability analysis to test the pieces of the survey instrument (ATI, CoT, and AMIP). Break instructors into three groups for use of each MIP: None (1), Infrequent (2-3), and Frequent (4-6). Provide descriptive statistics for ATI (Q.13-34), control of teaching (Q.36-41), beliefs about cooperative learning (Q.42-61), beliefs about IBL (Q.62-81), and beliefs about lecture (Q.82-101). Use ANOVA to look for group differences between on use of each MIP on ATI (Q.13-34), control of teaching (Q.36-41), beliefs about CL (Q.42-61), beliefs about IBL (Q.62-81), and beliefs about LEC (Q.82-101).
5. What is the influence, if any, of specific demographics (work status, gender, education, experience, or exposure to ideas) on whether math faculty chose to adopt (or reinvent) or reject an instructional practice?	Q.102 (CL) Q.103 (IBL) Q.104 (LEC) Q.2 Q.7-12	Break instructors into three groups for **each** MIP: None (1), Infrequent (2-3), and Frequent (4-6). Provide descriptive statistics for each group on work status (Q.2), gender (Q.7), education (Q.8), experience (Q.9, Q.10), and exposure to ideas (Q.11, Q.12). Use MANOVA to look for group differences on work status (Q.2), gender (Q.7), education (Q.8), experience (Q.9, Q.10), and exposure to ideas (Q.11, Q.12). Some two-factor ANOVA may be appropriate here to measure interaction effects for work status.
6. What is the relationship, if any, of favorable (or unfavorable) attitude towards an instructional practice and actual instructional practice? Is there a KAP Gap?	Q.102 (CL) Q.103 (IBL) Q.104 (LEC) Q.13-34 (ATI) Q.36-41 (CoT) Q.42-61 (CL) Q.62-81 (IBL) Q.82-101 (LEC)	Create composite beliefs measurement for each AMIP (GEN, ENV, ESC, and TOOC). Use regression and ANOVA to see if there is a significant relationship between beliefs (ATI, CoT, or MIP items) and practice (Q.102-104). Look for subscales within MIPs that provide statistically significant relationships (with regression) with practice (e.g. enabling characteristics of students).

Note. CL = Cooperative learning, IBL = Inquiry-based learning, L = Lecture, ATI = Approaches to Teaching Inventory, and CoT = control of teaching

Table 14

Description of data analysis for each research question: What is the effect of level of math course?

Research Question	Survey Items	Data Analysis
7. To what extent, if any, does knowledge of an instructional practice, instructor characteristics, and level of professional development engagement differ between instructors of different levels of math courses?	Q.35 (Math Level) Q.2 Q.3 – Q.6 Q.7 – Q.12 Q.42 (CL) Q.62 (IBL) Q.82 (LEC)	If response rate permits, go back through research questions #1-3 breaking instructors into groups by math level (developmental algebra, precalculus, calculus). Use ANOVA to test for differences between math levels on work status (Q.2), professional development activities (Q.3-6), gender (Q.7), education (Q.8), experience (Q.9, Q.10), and exposure to ideas (Q.11, Q.12), adoption of CL (Q.42), adoption of IBL (Q.62), and adoption of LEC (Q.82).
8. To what extent, if any, do attitudes about instructional practices differ between instructors of different levels of math courses?	Q.35 (Math Level) Q.13 – Q.34 (ATI) Q.36 – Q.41 (CoT) Q.42-61 (CL) Q.62-81 (IBL) Q.82-101 (LEC)	If response rate permits, go back through research questions #4-5 breaking instructors into groups by math level (developmental algebra, precalculus, calculus). Use ANOVA to test for differences between math levels on ATI (Q.13-34), control of teaching (Q.36-41), beliefs about CL (Q.42-61), beliefs about IBL (Q.62-81), and beliefs about LEC (Q.82-101).
9. To what extent, if any, does the level of math taught influence the relationship between favorable (or unfavorable) attitude towards an instructional practice and actual instructional practice?	Q.102 (CL) Q.103 (IBL) Q.104 (LEC) Q.13 – Q.34 (ATI) Q.36 – Q.41 (CoT) Q.42-61 (CL) Q.62-81 (IBL) Q.82-101 (LEC)	If response rate permits, go back through research question #6, breaking instructors into groups by math level (developmental algebra, precalculus, calculus). Create composite beliefs measurement for each MIP (roughly average of statistically significant items). Use logistic regression and ANOVA to see if there is a significant relationship between beliefs (ATI, CoT, or MIP items) and practice (Q.102-104). Look for subscales within MIPs that provide statistically significant relationships (with regression) with practice (e.g. enabling characteristics of students).

Note. CL = Cooperative learning, IBL = Inquiry-based learning, L = Lecture, ATI = Approaches to Teaching Inventory, and CoT = control of teaching

CHAPTER IV: RESULTS

This chapter describes the survey process and the results of analysis of the survey data relevant to the research questions. All of the research questions are designed around painting a complete picture of all the elements of a possible Knowledge-Attitude-Practice Gap (KAP Gap). The sections lay out instructors' knowledge of MIPs and the origin of this knowledge, their professional development activities, the beliefs about individual MIPs and general attitude towards student-centered instructional practice, and environmental pressures that may influence instructional choices. After the analysis of the individual KAP elements, the final section examines the existence of a KAP Gap and the variables that are important in developing a prediction model for use or non-use of specific math instructional practices.

Description of Sample

The research survey, entitled *Michigan Community College Math Faculty Survey*, was distributed online February 23, 2010 to a list of 948 community college math instructors in Michigan (45 of these email addresses were removed because of bouncebacks, leaving an email population of 903 instructors). This email list represents all reported full-time and part-time community college math instructors in Michigan (updated Fall 2009). Reminders were sent to instructors who had not responded or opted out on March 7 and March 23. The survey was closed at midnight on April 1, 2010. The response rate was 21.3%, with 192 responses, although not all the respondents provided complete data (174 provided complete data). There were three waves of major responses, each one immediately following an email notification. The three "waves" of respondents were compared (using chi-square tests) on gender, work status, and responses to questions about knowledge and use of MIPs. No significant differences between the three waves of responses were found.

The respondents were split almost exactly by gender. Full-time instructors (FT) made up 28.1% of the sample, part-time instructors who were satisfied with that work status (PTS) were 41.1% of the survey and the remainder (30.7%) were part-time instructors who desired full-time employment (PTU). The 2005 CBMS Survey (Lutzer et al., 2007) estimated that part-time instructors made up 65-68% of the population of community college math faculty in 2005, and found that nearly fifty percent of part-time math faculty had no full-time employment. However, the CBMS studies do not estimate what percentage of part-time faculty desire full-time employment. This research study now provides an estimate for that: in the sample, 57% of part-time faculty were satisfied with their status as part-time employment and 43% desired a full-time teaching position in mathematics.

The subgroups of PTS and PTU were compared (using chi-square tests) on gender, participation in various types of professional development, and responses to questions about knowledge and use of MIPs. While PTS instructors were slightly less participatory in professional development than the PTU instructors, no significant differences between the two groups were found for these questions. The two groups were merged into one PT group for the remaining analysis. A report of all general demographic, educational background, and teaching background can be found in Table 15.

In general, the sample was equally distributed on gender, split roughly one-third to two-thirds for full-time and part-time instructors, and about 90% of the instructors had at least a Master's degree (not surprising since this is generally the requirement for teaching at a community college). Only 61.5% of the instructors possessed a math or statistics degree, half possessed some kind of education or education-related degree, and almost 30% had earned a degree in some kind of math-related partner discipline (keep in mind that an instructor can have multiple degrees). A clear majority of instructors in the sample have taught remedial mathematics (80.6%) and algebra (91.6%), while less than half have taught calculus and courses above calculus. More than half of the instructors had only taught at one or two colleges in their career and 88.5% of instructors had taught at least three different types of math courses in their career. When asked to choose a survey level, a majority (65.1%) of the participants chose the algebra level, with only 13.4% choosing precalculus and 10.2% choosing calculus. The remaining participants did not teach any of these three courses within the last year.

Significance of Work Status

Work status is a tricky characteristic of instructors, because it makes a significant difference in what instructors teach, the professional development they participate in, and their overall experience. Work status makes a difference (almost always significant) in the types of courses an instructor has taught, the variety of math an instructor has taught, and what kind of degree the instructor has (Table 16). For example, almost 90% of full-time instructors have taught Calculus, while a little under one-third of part-time instructors have taught this course. On average, full-time instructors have taught a wider

Table 15

Demographics and characteristics of survey participants

Characteristic	Percent	*n*
Female	49.5	92
Male	50.5	94
Full-time (FT)	28.1	54
Part-time satisfied (PTS)	41.1	75
Part-time unfulfilled (PTU)	30.7	57
Highest degree earned was Bachelors	9.1	17
Highest degree earned was Masters	80.6	150
Highest degree earned was PhD-level	10.2	19
Completed coursework 2000-2010	35.7	65
Completed coursework 1990-1999	31.9	58
Completed coursework 1980-1989	17.0	31
Completed coursework prior to 1980	15.4	28
0-4.5 years of FTE experience	24.2	45
5-9.5 years of FTE experience	24.7	46
10-19.5 years of FTE experience	23.7	44
20+ years of FTE experience	27.4	51
Has math or statistics degree	61.5	118
Has education or ed-related degree	49.0	94
Has partner-discipline degree	29.2	56
Has taught remedial mathematics	80.6	154
Has taught algebra	91.6	175
Has taught precalculus-level math	68.1	130
Has taught off-track math courses	61.8	118
Has taught calculus-level math	48.2	92
Has taught post-calculus math	25.1	48
Has taught at 1 college	35.3	66
Has taught at 2 colleges	28.9	54
Has taught at 3 colleges	18.2	34
Has taught at 4 or more colleges	17.6	33
Has taught 1-2 different math courses	11.5	22
Has taught 3-5 different math courses	29.7	57
Has taught 6-10 different math courses	32.8	63
Has taught > 10 different math courses	26.0	50
Survey Level: Algebra	65.1	121
Survey Level: Precalculus	13.4	25
Survey Level: Calculus	10.2	19
Survey Level: None of these	11.3	21

Table 16

Teaching experience and educational background of Michigan community college math instructors

	Full-time	Part-time	Overall
Instructor has taught a course at this level	n=54	n=137	N=191
Remedial Math	88.9%	77.4%	80.2%
*Algebra	100%	88.3%	91.6%
*Precalculus	88.9%	59.9%	68.1%
*Off-track	81.5%	54.0%	61.8%
*Calculus	88.9%	32.1%	48.2%
*Post-calculus	46.3%	16.8%	25.1%
*How many different math courses has the participant taught?	n=54	n=138	N=192
1-2 different math courses	0%	15.9%	11.4%
3-5 different math courses	9.3%	37.7%	29.7%
6-10 different math courses	35.2%	31.9%	32.8%
More than 10 different math courses	55.6%	14.5%	26.0%
*Years of Experience	n=54	n=132	N=186
0-4.5 years of experience	5.6%	31.8%	24.2%
5-9.5 years of experience	18.5%	27.3%	24.7%
10-19.5 years of experience	31.5%	20.5%	23.6%
20 or more years of experience	44.4%	20.5%	27.4%
Educational Cohort	n=54	n=132	N=186
Completed coursework in 2000-2010	29.6%	38.6%	36.0%
Completed coursework in 1990-1999	37.0%	28.8%	31.2%
Completed coursework in 1980-1989	18.5%	16.7%	17.2%
Completed coursework prior to 1980	14.8%	15.9%	15.6%
**Highest degree earned ($p < 0.05$)	n=54	n=138	N=192
Bachelors	1.9%	13.0%	9.9%
Masters	90.7%	73.9%	78.6%
PhD, EdD, or EdS	7.4%	10.8%	9.9%
Presence of specific type of degree	n=54	n=138	N=192
*Has a math or stats degree	87.0%	51.4%	61.5%
*Has a math partner-discipline degree	13.0%	35.5%	29.2%
Has an Ed or Ed-related degree	46.3%	50.0%	49.0%
	n = 54	n = 132	N = 186
Female	55.6%	44.9%	49.5%

Note. Significance by chi-square analysis is indicated by * $p < .01$ and ** $p < .05$

variety of courses during their career and have had opportunity to teach more terminal (off-track) math courses (e.g. Math for Elementary Teachers, Statistics, or Math for Liberal Arts) and high-level courses. Full-time instructors are more likely to have a Masters degree (90.7% vs. 73.9%), more likely to possess a math or statistics degree (87.0% vs. 51.4%) and are less likely to possess a math-related partner discipline degree (13.0% vs. 35.5%). Interestingly, neither group of instructors is more likely to have an education or education-related degree. While there was a slight gender difference between the FT and PT groups, it was not significant.

Work status also makes a significant difference in the participation in different sorts of professional development. In general, full-time faculty participate in math-specific PD events at about twice the rate of part-time faculty. Full-time faculty are significantly more likely to read articles related to teaching math than their part-time counterparts (85.2% vs. 54.3%) and they are more likely to engage in more social interactions related to teaching math (83.3% vs. 60.9%).

Examining the time commitment to math-specific professional development makes the importance of work status clear (Table 18). For example, in the overall sample, 36% of instructors spend less than 2 hours a year attending presentations, discussions, workshops, or webinars about topics related to math instruction. This is shocking and one would hope for a much lower percentage for this category, but when we break the sample down by work status, we can see that only 7.4% of full-time instructors fall into this category while 47.1% of part-time instructors fall here. The time commitment (or lack thereof) to math-specific PD activities is starkly different for instructors depending on their work status.

Table 17

Participation of Michigan community college math faculty in formal and informal professional development activities

Instructor participated in this professional development (PD) activity in the last year	Full-time n = 54	Part-time n = 138	Overall N = 192
General PD**	96.3%	58.0%	68.8%
On-campus**	94.4%	52.9%	64.6%
Off-campus**	31.5%	14.5%	19.3%
Math-specific PD**	87.0%	39.9%	53.1%
On-campus	38.9%	27.5%	30.7%
Off-campus**	75.9%	19.6%	35.4%
Reading articles related to teaching math**	85.2%	54.3%	63.0%
Paper-format*	64.8%	40.6%	47.4%
Web-based format*	66.7%	42.0%	49.0%
Social interactions related to teaching math*	83.3%	60.9%	67.2%
Face-to-face social interactions*	81.5%	58.7%	65.1%
Online social interactions	22.2%	13.0%	15.6%
Informal online activities (reading or social)	66.7%	44.9%	51.0%

Note. Symbols denote level of significance for chi-square analysis between FT and PT groups. * $p < .01$, and ** $p < .001$

Table 18

Time commitment to professional development activities related to teaching math, including work status

Professional development activity	Full-time	Part-time	Overall
Attending presentations, discussions, workshops, or webinars about topics related to math instruction (in the last year)	$n = 54$	$n = 138$	$N = 192$
$\chi^2(2, N = 192) = 33.145, p < .001$			
Less than 2 hours	7.4%	47.1%	35.9%
Between 2 and 20 hours	55.6%	42.0%	45.8%
More than 20 hours	37.0%	10.9%	18.2%
Reading about topics related to teaching math (in an average week)	$n = 53$	$n = 138$	$N = 191$
$\chi^2(2, N = 191) = 9.603, p < .01$			
Less than 15 minutes	28.3%	52.9%	46.1%
Between 15 min and 2 hours	64.2%	40.6%	47.1%
More than 2 hours	7.5%	9.4%	6.8%
Interacting with colleagues about topics related to teaching math (in an average week)	$n = 54$	$n = 138$	$N = 192$
$\chi^2(2, N = 192) = 11.659, p < 0.01$			
Less than 15 minutes	13.0%	37.0%	30.2%
Between 15 min and 2 hours	74.1%	49.3%	56.3%
More than 2 hours	13.0%	13.8%	13.5%

Knowledge of Math Instructional Practices

The extent to which community college math faculty receive knowledge of math instructional practices can be found in Table 19. For both cooperative learning (CL) and inquiry-based learning (IBL), the difference in the level of knowledge between full-time and part-time instructors is significant. Full-time instructors in the sample had a higher knowledge of CL (98.1% vs. 88.9%) and a higher knowledge of IBL (100% vs 77.4%). The level of knowledge for the lecture method is so high in both groups that there is no significant difference and further analysis for the lecture method yields no interesting results.

Table 19

Instructors' knowledge of math instructional practices

Knowledge of	Full-time	Part-time	Overall
Inquiry-based learning	$n = 51$	$n = 124$	$N = 175$
$\chi^2(1, N = 175) = 13.710, p < .001$	100.0%	77.4%	84.0%
Cooperative learning	$n = 53$	$n = 126$	$N = 179$
$\chi^2(1, N = 179) = 4.135, p < .05$	98.1%	88.9%	91.6%
Lecture method	$n = 51$	$n = 123$	$N = 174$
(no significant difference)	100.0%	99.2%	99.4%

Tests for significant differences for the student-centered instructional practices (CL and IBL) were performed using chi-square analysis and the results can be found in Table 20 and Table 21. From these results, it is evident that work status is the most significant factor in having knowledge of either cooperative learning or inquiry-based learning. Because work status is so intricately linked with other variables, the subgroup of part-time faculty was also examined if any variable was found to have significant differences in the general sample. The full-time faculty group was not examined individually since the knowledge levels for full-time instructors were so high on student-centered instructional practices.

Within the part-time subgroup, there were four findings that remained significant: (1) knowledge of cooperative learning is related positively to having taught a remedial math course, (2) knowledge of inquiry-based learning is related to gender (females report greater knowledge than males), (3) knowledge of inquiry-based learning is positively related to the presence of an education or education-related degree, and (4) knowledge of inquiry-based learning is positively related to the recentness of completing educational coursework. Knowledge of cooperative learning was found to be significantly higher for females than males in the general population, but within the part-time instructor population, there was no longer a significant difference based on gender. While differences in knowledge of MIPs were found for the factors just presented, all of these were found non-significant within the subgroup of part-time instructors. Several variables were found to differentiate significant differences in the general population for knowledge of inquiry based learning, but were no longer significant when looking only at part-time instructors: presence of a math or statistics degree, presence of a degree from a math-related partner discipline, whether the instructor has taught calculus, and the variety of courses an instructor has taught.

Does the level of math taught effect the distribution of knowledge of instructional practices? The majority of participants who chose a set survey level chose the algebra level (Table 22). Because so few instructors chose the precalculus or calculus levels, these participants have been regrouped as a combined precalc-calc group. When the choice of math level was crossed with knowledge of instructional practices (Table 23), no significant differences were found. Level of use (for those who had knowledge of the practice) was also examined for the math level taught and again, no significant differences were found.

Table 20

Instructors' knowledge of cooperative learning by demographics and characteristics

Variable	Knowledge of cooperative learning in general sample	Knowledge of cooperative learning for PT subgroup
Work status	$\chi^2(1, N = 179) = 4.135, p < .05$ Full-time, 98.1% Part-time, 88.9%	NA
Gender	$\chi^2(1, N = 176) = 4.582, p < .05$ Female, 96.5% Male, 87.8%	Not significant.
Educational cohort	Not significant.	
Has math or statistics degree	Not significant.	
Has math-related partner-discipline degree	Not significant.	
Has education-related degree	Not significant.	
Has taught remedial math	$\chi^2(1, N = 178) = 4.995, p < .05$ Has taught remedial, 93.8% Has not taught remedial, 81.8%	$\chi^2(1, n = 125) = 4.21, p < .05$
Has taught algebra	Not significant.	
Has taught precalculus	Not significant.	
Has taught off-track math	Not significant.	
Has taught calculus	Not significant.	
Has taught post-calculus math	Not significant.	
Variety of courses	Not significant.	
Years of experience	Not significant.	

Note. No analysis of the FT subgroup could be performed since 100% of full-time instructors reported knowledge of cooperative learning.

Table 21

Instructors' knowledge of inquiry-based learning by demographics and characteristics

Variable	Knowledge of inquiry-based learning in general sample	Knowledge of inquiry-based learning for PT subgroup
Work status	$\chi^2(1, N = 175) = 13.710, p < .001$ Full-time, 100% Part-time, 77.4%	NA
Gender	$\chi^2(1, N = 172) = 14.194, p < .001$ Female, 95.3% Male, 74.7%	$\chi^2(1, n = 121) = 12.72, p < .01$
Educational cohort	$\chi^2(3, N = 171) = 11.121, p < .05$ Coursework 2000-2010, 94.8% Coursework 1990-1999, 83.0% Coursework 1980-1989, 78.1% Coursework prior to 1980, 67.9%	$\chi^2(3, n = 120) = 13.03, p < .01$
Has math or statistics degree	$\chi^2(1, N = 175) = 3.853, p < .05$ Has math/stats degree, 88.2% Does not have math/stats, 76.9%	Not significant.
Has math-related partner-discipline degree	$\chi^2(1, N = 175) = 7.500, p < .01$ Has partner degree, 72% Does not have partner deg, 88.8%	Not significant.
Has education-related degree	$\chi^2(1, N = 175) = 8.144, p < .01$ Has ed-related degree, 92.0% Does not have ed degree, 76.1%	$\chi^2(1, n = 124) = 9.64, p < .01$
Has taught remedial	Not significant.	
Has taught algebra	Not significant.	
Has taught Precalculus	Not significant.	
Has taught off-track	Not significant.	
Has taught calculus	$\chi^2(1, N = 174) = 11.768, p < .001$ Has taught Calculus, 94.1% Has not taught Calculus, 75.3%	Not significant.
Has taught post-calc	Not significant.	
Variety of courses	$\chi^2(1, N = 175) = 8.667, p < .05$ 1-2 courses, 70.6% 3-5 courses, 78.2% 6-10 courses, 83.6% More than 10 courses, 95.8%	Not significant.
Number of colleges	Not significant.	
Years of experience	Not significant.	

Table 22

Chosen math level differentiated by work status

	Number of participants $N = 165$	FT who chose this category $n = 53$	PT who chose this category $n = 112$
Algebra	121	29	92
Precalculus	25	12	13
Calculus	19	12	7
Algebra	121	29	92
Precalculus or Calculus	44	24	20

Table 23

Instructors' knowledge of math instructional practices by level of math

Knowledge of this instructional practice	Algebra	Precalculus or Calculus
Inquiry-based learning (not significant)	$n = 116$ 82.8%	$n = 41$ 90.2%
Cooperative learning (not significant)	$n = 120$ 90.8%	$n = 41$ 90.2%
Lecture method (not significant)	$n = 116$ 99.1%	$n = 40$ 100.0%

Acquisition of Knowledge

For the lecture method, instructors primarily learned about the instructional practice (90.8% of them) first through their experiences as a student. This is very different than for the student-centered practices (CL and IBL), where only 7.3% of instructors reported experiencing CL and 6.1% reported experiencing IBL as a student. Because so many participants were unaware where they learned first about the CL (29.9%) and IBL (25.1%) instructional methods, it did not make sense to look for significant differences in the method of knowledge acquisition. However, it *is* clear that the lecture method has a very different knowledge acquisition profile than those of cooperative learning or inquiry-based learning. For these two practices, instructors reported professional training as the most common known vehicle of knowledge. For CL instructional practices, many instructors also reported learning from colleagues (13.4%) or experimentation (12.8%). For IBL, many instructors also listed learning from a colleague (8.2%) or reading (13.0%) as vehicles of knowledge acquisition. Even though it is difficult to justify the use of a statistical test to verify significance (because of the large unknown category), it is interesting to see how knowledge of student-centered MIPs is gained (see Table 24).

Table 24

Acquisition of knowledge of math instructional practices

For instructors who knew of the MIP, how did they first learn about it?	Lecture n = 173	Cooperative Learning n = 164	Inquiry-based Learning n = 147
Learned this way as a student	90.8%	7.3%	6.1%
Learned from a colleague	0.6%	13.4%	8.2%
Learned in professional training	3.4%	32.3%	42.9%
Learned by reading about this method	0.0%	4.3%	13.0%
Learned through experimentation	3.4%	12.8%	4.8%
Do not remember how they first learned	1.7%	29.9%	25.1%

Professional Development Activities

At the time of the survey, just over half of community college math faculty in the survey reported receiving math-specific professional development (PD) in the last year, about evenly split between on- and off-campus PD. About 63% of math faculty read articles related to teaching math, and 67% engaged in conversations related to teaching math. However, when work status was considered, the participation in PD activities was very different between the full-time (FT) and part-time (PT) groups, with full-time faculty participating more in every kind of activity (see Table 17) and spending more time engaged in math-specific professional development activities (see Table 18).

Significant differences for subgroups can be found with regard to participation in general professional development (Table 25), participation in math-specific professional development (Table 26), and participation in off-campus math-specific professional development (Table 27). However, when the effect of work status is taken into consideration, almost no other factors are found to be significant. The one exception is the relationship between educational cohort and participation in general professional development, which was still significant within the subpopulation of part-time instructors. That is, those instructors who have recently completed coursework were more likely to participate in general professional development than those who have been out of school longer.

When the math-specific professional development is held off-campus (see Table 27), the gap between full-time and part-time faculty becomes wider, with a very low participation rate for part-time instructors in off-campus activities. Again, factors that seem significant on a surface level are no longer significant once the analysis is performed within the full-time or part-time subgroups. Next, the participation rates for non-formal math-specific professional development were analyzed. Two types of activities were measured in the survey: reading articles specifically related to teaching math (Table 28) and engaging in social interactions specifically related to teaching math (Table 29). For both the general survey sample and within the part-time subgroup,

Table 25

Participation in general professional development

Variable	Participation in general professional development in general sample	Participation in general professional development within PT or within FT subgroups
Work status	$\chi^2(3, N = 186) = 26.535, p < .001$ Full-time, 96.3% Part-time, 58.0%	NA
Gender	Not significant.	
Educational cohort	$\chi^2(3, N = 186) = 9.881, p < .05$ Coursework 2000-2010, 65.7% Coursework 1990-1999, 72.4% Coursework 1980-1989, 87.5% Coursework <1980, 51.7%	PT: $\chi^2(3, n = 132) = 11.00,$ $p < .05$ FT: Not significant.
Has math or statistics degree	$\chi^2(1, N = 192) = 8.061, p < .01$ Has math/stats degree, 76.3% Does not have, 56.8%	PT: Not significant. FT: Not significant.
Has partner-discipline degree	Not significant.	
Has education-related degree	Not significant.	
Has taught remedial math	Not significant.	
Has taught algebra	Not significant.	
Has taught precalculus	$\chi^2(1, N = 191) = 5.227, p < .05$ Has taught precalculus, 73.8% Has not taught, 56.6%	PT: Not significant. FT: Not significant.
Has taught off-track math	Not significant.	
Has taught calculus	$\chi^2(1, N = 191) = 13.784, p < .001$ Has taught calculus, 81.5% Has not taught calculus, 56.6%	PT: Not significant. FT: Not significant.
Has taught post-calculus	$\chi^2(1, N = 191) = 6.471, p < .05$ Has taught post-calc, 83.3% Has not taught post-calc, 63.6%	PT: Not significant. FT: Not significant.
Variety of courses taught	$\chi^2(3, N = 192) = 11.482, p < .01$ 1-2 courses, 50% 3-5 courses, 63.2% 6-10 courses, 66.7% More than 10 courses, 86.0%	PT: Not significant. FT: Not significant.
Years of experience	Not significant.	NA

Table 26

Participation in math-specific professional development

Variable	Percent of instructors who participated in math-specific professional development in general sample	Participation in math-specific professional development within FT or within PT subgroup
Work status	$\chi^2(1, N = 192) = 34.70, p < .001$ Full-time, 87.0% Part-time, 39.9%	NA
Gender	Not significant.	
Educational cohort	Not significant.	
Has math or statistics degree	$\chi^2(1, N = 192) = 9.39, p < .05$ Has math/stats degree, 61.9% Does not have math/stats, 39.2%	PT: Not significant. FT: Not significant.
Has math-related partner-discipline degree	$\chi^2(1, N = 192) = 6.08, p < .05$ Has partner degree, 39.3% Does not have partner deg, 58.8%	PT: Not significant. FT: Not significant.
Has education-related degree	Not significant.	
Has taught remedial math	$\chi^2(1, N = 191) = 4.468, p < .05$ Has taught remedial, 57.1% Has not taught remedial, 37.8%	PT: Not significant. FT: Not significant.
Has taught algebra	Not significant.	
Has taught precalculus	Not significant.	
Has taught off-track math	Not significant.	
Has taught calculus	$\chi^2(1, N = 191) = 6.629, p = .01$ Has taught calculus, 63.0% Has not taught calculus, 44.4%	PT: Not significant. FT: Not significant.
Has taught post-calculus	Not significant.	
Variety of courses	$\chi^2(3, N = 192) = 7.724, p = .052$ 1-2 courses, 45.5% 3-5 courses, 57.4% 6-10 courses, 55.9% More than 10 courses, 60.6%	PT: Not significant. FT: Not significant.
Years of experience	Not significant.	

Table 27

Participation in off-campus math-specific professional development

Variable	Participation in math-specific off-campus professional development in general sample	Participation in math-specific off-campus professional development within FT or within PT subgroups
Work status	$\chi^2(1, N = 192) = 53.901, p < .001$ Full-time, 75.9% Part-time, 19.6%	NA
Gender	Not significant.	
Educational cohort	Not significant.	
Has math or statistics degree	$\chi^2(1, N = 192) = 12.077, p < .001$ Has math/stats degree, 44.9% Does not have math/stats, 20.2%	PT: Not significant. FT: Not significant.
Has math-related partner-discipline degree	$\chi^2(1, N = 192) = 5.146, p < .05$ Has partner degree, 23.2% Does not have partner deg, 40.4%	PT: Not significant. FT: Not significant.
Has education-related degree	Not significant.	
Has taught remedial	Not significant.	
Has taught algebra	Not significant.	
Has taught precalculus	Not significant.	
Has taught off-track math	$\chi^2(1, N = 191) = 4.725, p < .05$ Has taught off-track, 41.5% Has not taught off-track, 26.0%	PT: Not significant. FT: Not significant.
Has taught calculus	$\chi^2(1, N = 191) = 9.602, p < .01$ Has taught calculus, 46.7% Has not taught calculus, 25.3%	PT: Not significant. FT: Not significant.
Has taught post-calculus math	$\chi^2(1, N = 191) = 5.797, p < .05$ Has taught post-calc, 50.0% Has not taught post-calc, 30.8%	PT: Not significant. FT: Not significant.
Variety of courses	$\chi^2(3, N = 192) = 12.292, p < .01$ 1-2 courses, 9.1% 3-5 courses, 19.5% 6-10 courses, 38.1% More than 10 courses, 50.0%	PT: Not significant. FT: Not significant.
Years of experience	$\chi^2(3, N = 186) = 8.014, p < .05$ 0-4.5 years of experience, 24.4% 5-9.5 years of experience, 28.3% 10-19.5 yrs of experience, 40.9% 20+ years of experience, 49.0%	PT: Not significant. FT: Not significant.

Table 28

Reading articles specifically related to teaching math

Variable	Participation in reading articles specifically related to teaching math in general sample	Participation in reading articles specifically related to teaching math within PT or within FT subgroups
Work status	$\chi^2(1, N = 192) = 15.837, p < .001$ Full-time, 85.2% Part-time, 54.3%	NA
Gender	$\chi^2(1, N = 186) = 5.405, p < .05$ Female, 71.7% Male, 55.3%	PT: $\chi^2(1, n = 132) = 4.688,$ $p < .05$ FT: Not significant.
Educational cohort	Not significant.	
Has math or statistics degree	Not significant.	
Has math-related partner-discipline degree	Not significant.	
Has education-related degree	Not significant.	
Has taught remedial math	$\chi^2(1, N = 191) = 4.272, p < .05$ Has taught remedial, 66.9% Has not taught remedial, 48.6%	PT: $\chi^2(1, n = 137) = 4.158,$ $p < .05$ FT: Not significant.
Has taught algebra	Not significant.	
Has taught precalculus	Not significant.	
Has taught off-track math	$\chi^2(1, N = 191) = 6.494, p < .05$ Has taught off-track, 70.3% Has not taught off-track, 52.1%	PT: Not significant. FT: Not significant.
Has taught calculus	Not significant.	
Has taught post-calculus math	Not significant.	
Variety of courses	Not significant.	
Years of experience	Not significant.	

Table 29

Engaging in social interactions specifically related to teaching math

Variable	Engaging in social interactions specifically related to teaching math in general sample	Engaging in social interactions specifically related to teaching math within PT or within FT subgroups
Work status	$\chi^2(1, N = 192) = 8.884, p < .01$ Full-time, 83.3% Part-time, 60.9%	NA
Gender	$\chi^2(1, N = 186) = 10.097, p < .001$ Female, 78.3% Male, 56.4%	PT: $\chi^2(1, n = 132) = 7.02,$ $p < .01$ FT: Not significant.
Educational cohort	Not significant.	
Has math or statistics degree	$\chi^2(1, N = 192) = 5.942, p < .05$ Has math/stats degree, 73.7% Does not have math/stats, 56.8%	PT: Not significant. FT: $\chi^2(1, n = 54) = 9.49,$ $p < .01$
Has math-related partner-discipline degree	Not significant.	
Has education-related degree	Not significant.	
Has taught remedial math	Not significant.	
Has taught algebra	Not significant.	
Has taught precalculus	$\chi^2(1, N = 191) = 7.385, p < .01$ Has taught Precalculus, 73.8% Has not taught Precalc, 54.1%	PT: Not significant. FT: Not significant.
Has taught off-track math	$\chi^2(1, N = 191) = 8.754, p < .01$ Has taught off-track, 75.4% Has not taught off-track, 54.8%	PT: $\chi^2(1, n = 137) = 3.92,$ $p < .05$ FT: Not significant.
Has taught calculus	Not significant.	
Has taught post-calculus math	Not significant.	
Variety of courses	$\chi^2(3, N = 192) = 11.993, p < .01$ 1-2 courses, 40.9% 3-5 courses, 61.4% 6-10 courses, 71.4% 10+ courses, 80.0%	PT: Not significant. FT: Not significant.
Years of experience	Not significant.	

females were more significantly more likely to read articles specifically related to teaching math ($p < .05$) and more likely to engage in social interactions ($p < .001$). There is some indication that factors like teaching specific math courses (e.g. remedial math) may correlate with likely participation in non-formal PD activities, but the results are not consistent across both the reading and social interaction categories, and the significance becomes questionable when work status is considered.

The last piece of the professional development analysis is to examine how much time instructors devote to formal and non-formal PD activities looking at specific demographics (Table 30, Table 31, and Table 32). The interesting part of this analysis is what *doesn't* matter, and after examining the FT and PT subgroups, no other demographic has a clear significant correlation with the amount of time spent on various activities. Personally, I found it shocking that 28.3% of full-time faculty spend 15 minutes or less per week reading about their chosen profession (and this includes the possibility of reading online). This is a bit more excusable for part-time faculty, but still, more than half of PT faculty spend less than 15 minutes a week simply reading about teaching math.

Table 30

Annual time attending math-specific professional development activities

Variable	Time spent participating in math-specific professional development activities in general sample	Time spent participating in math-specific PD activities within PT or within FT subgroups
Work status	$\chi^2(2, N = 192) = 33.145, p < .001$ Less than 2 hours per year FT, 7.4%; PT, 47.1% Between 2 and 20 hours per year FT, 55.6%; PT, 42.0% More than 20 hours per year FT, 37.0%; PT, 8.9%	NA
Gender	$\chi^2(2, N = 186) = 6.187, p < .05$ Less than 2 hours per year Female, 27.2%; Male, 44.7% Between 2 and 20 hours per year Female, 52.2%; Male, 39.4% More than 20 hours per year Female, 20.7%; Male, 16.0%	PT: Not significant. FT: Not significant.
Educational cohort	Not significant.	
Has math or statistics degree	Not significant.	
Has math-related partner-discip. degree	Not significant.	
Has education-related degree	Not significant.	
Has taught remedial math	$\chi^2(2, N = 191) = 11.406, p < .01$ Less than 2 hours per year Has, 32.5%; Has not, 48.6% Between 2 and 20 hours per year Has, 51.9%; Has not, 21.6% More than 20 hours per year Has, 15.6%, Has not, 29.7%	PT: Not significant. FT: $\chi^2(2, n = 54) = 11.48$, $p < .01$
Has taught algebra	Not significant.	
Has taught precalculus	Not significant.	
Has taught off-track	Not significant.	
Has taught calculus	Not significant.	
Has taught post-calculus math	$\chi^2(2, N = 191) = 8.710, p < .05$ Less than 2 hours per year Has, 18.8%; Has not, 41.3% Between 2 and 20 hours per year Has, 54.2%; Has not, 43.3% More than 20 hours per year Has, 27.1%; Has not, 15.4%	PT: Not significant. FT: Not significant.
Variety of courses	Not significant.	
Years of experience	Not significant.	

Table 31

Average weekly time spent on reading articles related to teaching math

Variable	Time spent in an average week on reading articles related to teaching math in general sample	Time spent in an average week on reading articles related to teaching math within PT or within FT subgroups
Work status	$\chi^2(2, N = 192) = 9.603$, $p < .001$ Less than 15 min per week FT, 28.3%; PT, 52.9% Between 15 min & 2 hrs per week FT, 64.2%; PT, 40.6% More than 2 hours per week FT, 7.5%; PT, 6.5%	NA
Gender	Not significant.	
Educational cohort	Not significant.	
Has math or statistics degree	Not significant.	
Has math-related partner-discipline degree	Not significant.	
Has education-related degree	Not significant.	
Has taught remedial math	Not significant.	
Has taught algebra	Not significant.	
Has taught precalculus	Not significant.	
Has taught off-track math	Not significant.	
Has taught calculus	Not significant.	
Has taught post-calculus math	Not significant.	
Variety of courses	Not significant.	
Years of experience	Not significant.	

Table 32

Average weekly time spent engaging in social interactions related to teaching math

Variable	Time spent in an average week engaged in social interactions related to teaching math in general sample	Time spent in an average week engaged in social interactions related to teaching math within PT or within FT subgroups
Work status	$\chi^2(2, N = 192) = 11.659, p < .01$ Less than 15 min per week FT, 13.0%; PT, 37.0% Between 15 min & 2 hrs per week FT, 74.1%; PT, 49.3% More than 2 hours per week FT, 13.0%; PT, 13.8%	NA
Gender	Not significant.	
Educational cohort	Not significant.	
Has math or statistics degree	Not significant.	
Has math-related partner-discipline degree	Not significant.	
Has education-related degree	Not significant.	
Has taught remedial math	Not significant.	
Has taught algebra	$\chi^2(2, N = 191) = 8.954, p < .05$ Less than 15 min per week Has, 27.4%; Has not, 62.5% Between 15 min & 2 hrs per week Has, 58.9%; Has not, 25.0% More than 2 hours per week Has, 13.8%; Has not, 12.5%	PT: Not significant. FT: Cannot run test within FT subgroup since 100% have taught algebra.
Has taught precalculus	$\chi^2(2, N = 191) = 7.113, p < .05$ Less than 15 min per week Has, 24.6%; Has not, 42.6% Between 15 min & 2 hrs per week Has, 59.2%; Has not, 49.2% More than 2 hours per week Has, 16.2%; Has not, 8.2%	PT: Not significant. FT: Not significant.
Has taught off-track math	$\chi^2(2, N = 191) = 10.346, p < .05$ Less than 15 min per week Has, 22.0%; Has not, 43.8% Between 15 min & 2 hrs per week Has, 61.9%; Has not, 46.6% More than 2 hours per week Has, 16.1%; Has not, 9.6%	PT: Not significant. FT: $\chi^2(2, n = 137) = 7.48$, $p < .05$

Table 32 – Continued

Average weekly time spent engaging in social interactions related to teaching math

Variable	Time spent in an average week engaged in social interactions related to teaching math in general sample	Time spent in an average week engaged in social interactions related to teaching math in sample by work status
Has taught calculus	Not significant.	
Has taught post-calculus math	Not significant.	
Variety of courses	$\chi^2(6, N = 192) = 12.798, p < .05$ Less than 15 min per week 1-2 courses, 54.5% 3-5 courses, 36.8% 6-10 courses, 27.0% More than 10 courses, 16% Between 15 min & 2 hrs per week 1-2 courses, 36.4% 3-5 courses, 52.6% 6-10 courses, 57.1% More than 10 courses, 68% More than 2 hours per week 1-2 courses, 9.1% 3-5 courses, 10.5% 6-10 courses, 15.9% More than 10 courses, 16%	PT: Not significant. FT: Not significant.
Years of experience	Not significant.	

Who's Using the Instructional Practices?

At the end of the attitudes and beliefs portion of the survey, participants were asked to categorize their level of use for each instructional practice. These levels were broken into three general categories of use: never, infrequently, and frequently (results shown in Table 33). As expected, almost all the participants (91.2%) reported using the lecture method frequently in their courses. This percentage of frequent use decreased with cooperative learning (50.2%) and inquiry-based learning (20.0%). Generally, it would be reasonable to assume that knowledge must precede instructional practice, but with instructional practices, there is the possibility that experimentation can lead to independent discovery of an instructional practice. Indeed, the majority of those who said they had no knowledge of a practice did not, in fact, use it.

Table 33

Use of MIPs and knowledge of MIPs

	Percent that said they did not use it at all	How many said they used it infrequently	How many said they used it frequently
Entire Sample			
Cooperative Learning, *N*=175	12.6%	37.1%	50.3%
Inquiry-based Learning, *N* = 175	29.1%	50.9%	20.0%
Lecture Method, *N*=175	1.1%	7.4%	91.4%
Those instructors who had knowledge of the MIP			
Cooperative Learning, *n*=161	8.7%	36.6%	54.7%
Inquiry-based Learning, *n* = 146	19.9%	58.2%	21.9%
Lecture Method, *n*=173	1.2%	7.5%	91.3%
Those instructors who had no knowledge of the MIP			
Cooperative Learning, *n=13*	61.5%	38.5%	0%
Inquiry-based Learning, *n* = 26	73.1%	15.4%	11.5%
Lecture Method, *n=1*	0%	0%	100.0%

Because work status made such a difference in the knowledge of instructional practices and professional development activities, the use data was also analyzed by work status (Table 34). Full-time faculty were significantly more likely to frequently use both student-centered instructional practices. Gender also played a role in knowledge of student-centered practices and participation in non-formal math-specific professional development activities (like reading articles). Gender analysis was also crossed with use of instructional practices (Table 34), showing that females are more likely to use both student-centered instructional practices (of course, the full-time sample of instructors also contained a larger proportion of females).

Finally, does the level of math taught change the use of a particular instructional practice? When the use-data was examined by survey level (Table 35), no significant differences were found on the use of math instructional practices, and because the survey level distribution is so uneven and highly influenced by work status, no further analysis based on survey level was conducted.

Table 34

Use of MIPs by work status and gender

	Never	Infrequently	Frequently
Lecture Method			
Work status			
Full-time, n = 52	1.9%	7.7%	90.4%
Part-time, n = 123	0.8%	7.3%	91.9%
Gender			
Female, n = 85	1.2%	8.2%	90.6%
Male, n = 87	1.2%	6.9%	92.0%
Cooperative Learning			
*Work status $\chi^2(2, p = 0.056) = 5.77$			
Full-time, n = 52	3.8%	36.5%	59.6%
Part-time, n = 123	16.3%	37.4%	46.3%
*Gender $\chi^2(2, p = 0.053) = 5.89$			
Female, n = 85	7.1%	35.3%	57.6%
Male, n = 87	17.2%	40.2%	42.6%
Inquiry-Based Learning			
*Work status $\chi^2(2, p < 0.05) = 6.85$			
Full-time, n = 52	15.4%	59.6%	25.0%
Part-time, n = 123	35.0%	47.2%	17.9%
*Gender $\chi^2(2, p < 0.05) = 7.73$			
Female, n = 85	18.8%	57.6%	23.5%
Male, n = 87	37.9%	44.8%	17.2%

Note. Some significant difference (either below 0.05 or close to 0.05) is indicated by the symbol *.

Table 35

Instructors' use of MIPs by level of math (for those who had knowledge)

Use of this MIP	Algebra $n = 107$	Precalculus or Calculus $n = 36$
Inquiry-based learning		
Frequent	55.1%	47.2%
None or infrequent	44.9%	52.8%
Cooperative learning		
Frequent	18.7%	25.0%
None or infrequent	81.3%	75.0%
Lecture method		
Frequent	91.6%	94.4%
None or infrequent	8.4%	5.6%

Note. None of these are significant differences (chi-square).

Beliefs and Attitudes about Instructional Practices

Reliability statistics (Cronbach's Alpha) for various survey instrument scales and subscales are found in Table 36. These statistics show that the Approaches to Teaching Inventory (ATI), and the Attitudes about Mathematics Instructional Practice (AMIP) instruments used in the survey instrument had good internal reliability. The Control of Teaching Inventory (CoT) had acceptable internal reliability ($\alpha = 0.605$), but could be improved for future use. Within the AMIP instrument, four subindexes were created to break out general beliefs about the practice (GEN), beliefs related to the teaching environment (ENV) and situation, beliefs related to enabling student characteristics (ESC), and beliefs related to time necessary outside of class (TOOC).

The CoT subscale was measured at the survey level (Algebra, Precalculus, or Calculus) and results for these levels can be found in Table 37. Only one item had significant differences between the levels of math, but when retested in full-time and part-time subgroups, not even this item was significant. Within the CoT inventory, there are two distinct groups of questions. One group of questions asks about the design of the course in general (CoT-DESIGN is items 1, 3, and 5) and the other group of questions asks about the amount of teaching freedom given to the instructor (items 2 and 4). Item 6 on the CoT is highly related to item 18 in AMIP. The topics of these items received such strong reactions from participants in the comments that they were removed from the composite subscales to be analyzed separately (CoT-Time and MIP-Content). Looking at the data within any level of math, instructors feel they have much more control over the way they teach (items 2 and 4) than the content and time-constraints (items 3 and 6). On average, instructors at all levels surveyed reported that they did not have control of the content of these courses. While calculus instructors were neutral to the idea that they could easily cover the content in the allotted time, algebra and precalculus instructors felt more pressed for time. Because analysis to this point has already shown significant differences between instructors based on work status, the Control of Teaching items were also examined on this variable (Table 38). Part-time instructors report (on a significant level) that they have less say in how courses are run, and while they report slightly less control on all other items, none of the other items have significant differences on work status.

In order to measure an attitude about each math instructional practice, subscales of the beliefs questionnaire were assembled (Table 39) to create a general beliefs subindex (GEN), an environment beliefs subindex (ENV), an enabling characteristics of students beliefs subindex (ESC), and a time-outside-of-class beliefs subindex (TOOC).

Table 36

Reliability analysis for various survey instruments and subscales

Survey Instrument	Items	*N*	Cronbach's Alpha
ATI	22	169	0.733
ATI-ITTF	11	177	0.707
ATI-CCSF	11	176	0.800
CoT (items 1-5)	5	183	0.605
CoT-Design	3	183	0.450
CoT-Teach	2	183	0.509
AMIP-CL (items 1-17)	17	165	0.943
CL GEN (items 1-3)	3	176	0.862
CL ENV (items 4-5,16)	3	170	0.699
CL ESC (items 6-12)	7	168	0.925
CL TOOC (items 13-15)	3	173	0.796
AMIP-IBL	17	161	0.908
IBL GEN (items 1-3)	3	176	0.715
IBL ENV (items 4-5,16)	3	171	0.574
IBL ESC (items 6-12)	7	164	0.860
IBL TOOC (items 13-15)	3	173	0.810
AMIP-LEC	17	158	0.898
LEC GEN (items 1-3)	3	173	0.807
LEC ENV (items 4-5,16)	3	170	0.737
LEC ESC (items 6-12)	7	168	0.906
LEC TOOC (items 13-15)	3	166	0.891

The mean score for each belief subindex was tested for each MIP against work status to look for any significant differences. There were no significant differences found for cooperative learning or the lecture method. For inquiry-based learning, full-time and part-time instructors were significantly different (F = 10.760, p < .001) only on the TOOC subindex. Full-time instructors were more in agreement with the belief that IBL did not create excessive out of class time pressures (3.58 out of 5) than part-time instructors (3.13 out of 5).

Table 37

At different levels of math, how much control do instructors have?

Control of Teaching Items	Algebra		Precalculus		Calculus	
	Mean	SD	Mean	SD	Mean	SD
*Item 1: I have a lot of say in how the courses at this level are run. $F(2, N=164) = 4.625, p < .05$	3.39*	1.098	3.64	1.287	4.21*	0.976
Item 2: The department allows me considerable flexibility in the way I teach courses at this level.	3.91	0.894	4.00	1.041	3.84	1.015
Item 3: I have control over the content that I teach in these courses.	2.29	1.036	2.52	1.194	2.89	1.197
Item 4: I have control over the way I choose to teach in these classes.	4.48	0.534	4.44	0.583	4.26	0.653
Item 5: I am able to choose my classroom setting for courses at this level.	2.98	1.200	3.44	1.261	2.95	1.311
Item 6: I find it easy to cover the content of these courses in the allotted time.	2.85	1.256	2.96	1.020	3.26	1.284

Note: * Indicates that ANOVA shows the difference is significant for this item for the indicated groups (using Tukey post-hoc). However, if the subgroup of part-time instructors or full-time instructors is examined, the difference is no longer significant.

Table 38

How much control do instructors say they have based on their work status?

Control of Teaching Items	Full-time		Part-time	
	Mean	SD	Mean	SD
*Item 1: I have a lot of say in how the courses at this level are run. $F(1, N=182) = 31.126, p < .001$	4.17	0.672	3.22	1.168
Item 2: The department allows me considerable flexibility in the way I teach courses at this level.	4.04	0.759	3.87	0.991
Item 3: I have control over the content that I teach in these courses.	2.57	1.135	2.32	1.073
Item 4: I have control over the way I choose to teach in these classes.	4.47	0.504	4.43	0.583
Item 5: I am able to choose my classroom setting for courses at this level.	3.13	1.210	2.93	1.265
Item 6: I find it easy to cover the content of these courses in the allotted time.	3.17	1.236	3.03	1.220

Note. * indicates that ANOVA shows the difference is significant for this item

Attitude towards a math instructional practice (LEC, CL, or IBL) is calculated by adding these four beliefs subindexes together (a scale between 4 and 20 where 12 is completely neutral). Of the three MIPs studied, instructor attitudes towards the lecture method are the highest (MIP = 15.77), followed by cooperative learning (14.18) and inquiry-based learning (12.95). Attitude for each MIP was tested using ANOVA for differences between work status and no significant differences were found.

The beliefs subscales are then used (Table 40 and Table 41) to look for significant differences in use-practices for CL and IBL. A beliefs analysis versus use was not conducted for the lecture method since almost all instructors used this frequently. The first significant difference was found on the Concept-Centered Student-Focused (CCSF) subscale of the Approaches to Teaching Inventory (ATI), and was seen for both CL and IBL. Perhaps it is not surprising that no significant difference was found on the Information-Transfer Teacher-Focused (ITTF) scale since both instructional practices in this analysis were student-focused practices. The Control of Teaching (CoT) subscales did not yield any significant results with regards to the use of CL or IBL. However, the MIP-specific beliefs subscales proved to be good differentiators between use groups. In almost all cases, each of the beliefs subscales was significantly different between the "Never" and "Frequent" groups, if not all the groups (see Tables 40 and 41).

The quantitative results show that there are strong differences in beliefs and attitudes between those who use an instructional practice and those who do not. The qualitative data, that is, comments from participants in the open comment area about each practice, also elucidate some of what is going on (Table 42, Table 43, Table 44).

Table 39

Construction of AMIP subscales and AMIP-Attitude Index

MIP-GEN Subindex	MIP-ENV Subindex	MIP-ESC Subindex	MIP-TOOC Subindex
General beliefs about MIP are favorable.	This MIP can be used in any environment or situation.	This MIP can be used regardless of the enabling characteristics of students.	This MIP does not create excessive out-of-class time pressures on the instructor.
1. This MIP is effective for student learning. 2. Students will enjoy learning with this MIP. 3. This MIP makes good use of class time.	4. It would be easy for me to use this MIP with large class sizes (above 30 students). 5. I would be able to use this MIP in any classroom that I am assigned. 16. If I wanted to, I would be allowed by my department to use this MIP at this level of math.	6. It would be easy for me to use this MIP even when some students do not complete their assignments. … 12. It would be easy for me to use this MIP with students that have poor reading and writing skills.	13R. The prep time for this MIP is not prohibitive to its use. 14R. The grading time for this MIP is not prohibitive to its use. 15R. The contact time with students outside of class for this MIP is not prohibitive to its use.
MIP-GEN= Mean of Questions 1, 2, 3 Scale 1 to 5, where 1 is a strong unfavorable belief and 5 is a strong favorable belief.	MIP-ENV = Mean of Questions 4, 5, 16 Scale 1 to 5, where 1 is a strong unfavorable belief and 5 is a strong favorable belief.	MIP-ESC = Mean of Questions 6-12 Scale 1 to 5, where 1 is a strong unfavorable belief and 5 is a strong favorable belief.	MIP-TOOC = Mean of Questions 13R, 14R, and 15R Scale 1 to 5, where 1 is a strong unfavorable belief and 5 is a strong favorable belief.

MIP-Attitude = Sum of these four MIP subindexes (scale between 4 and 20)
- 4 = Strongly unfavorable attitude about this MIP
- 8 = Somewhat unfavorable attitude about this MIP
- 12 = Neutral attitude about this MIP
- 16 = Somewhat favorable attitude about this MIP
- 20 = Strongly favorable attitude about this MIP

CL: For the sample (N=176), the mean is 14.18 (SD = 2.809).
IBL: For the sample (N=175), the mean is 12.95 (SD = 2.366).
LEC: For the sample (N=175), the mean is 15.77 (SD = 1.811).
Favorable attitude for any MIP will be arbitrarily set for values ≥ 14.
Non-favorable attitude is a mix of unfavorable and neutral, with MIP < 14.

Table 40

What are the beliefs and attitudes of instructors who know about cooperative learning as they make choices to use or not use cooperative learning?

Use of cooperative learning	Never $n = 13$		Infrequent $n = 59$		Frequent $n = 88$	
	Mean	SD	Mean	SD	Mean	SD
ATI-ITTF	3.38	0.335	3.56	0.464	3.49	0.439
*ATI-CCSF	3.43	0.611	3.69	0.460	3.96	0.401
$F(2, N=147) = 10.965$, $p < .001$						
Tukey shows that Never-Freq and Infreq-Freq differences are significant ($p < .01$)						
CoT-Design	2.69	0.710	2.90	0.800	3.03	0.822
CoT-Teach	4.00	0.809	4.08	0.730	4.26	0.533
CoT-Time	3.21	1.528	2.84	1.105	2.89	1.232
*CL-GEN	2.56	0.774	3.55	0.787	4.06	0.588
$F(2, N=160) = 28.716$, $p < .001$						
Tukey shows that all three groups differences are significant ($p < .001$)						
*CL-ENV	2.64	0.876	3.32	0.719	3.87	0.668
$F(2, N=160) = 24.116$, $p < .001$						
Tukey shows that all three groups differences are significant ($p < .001$)						
*CL-ESC	2.46	0.942	3.14	0.734	3.76	0.631
$F(2, N=160) = 24.876$, $p < .001$						
Tukey shows that all three groups differences are significant ($p < .05$)						
*CL-TOOC	3.18	1.152	3.39	0.760	3.98	0.705
$F(2, N=159) = 13.599$, $p < .001$						
Tukey shows that Never-Freq and Infreq-Freq differences are significant ($p < .01$)						
*CL-Training	2.62	1.325	3.63	0.849	4.27	0.690
$F(2, N=159) = 28.647$, $p < .001$						
Tukey shows that all three groups differences are significant ($p < .05$)						
*CL-Content	2.75	1.712	4.02	0.777	3.84	1.001
$F(2, N=158) = 8.083$, $p < .001$						
Tukey shows that Never-Freq and Never-Infreq differences are significant ($p < .001$)						
*CL-Attitude	10.85	2.461	13.40	2.326	15.67	2.150
$F(2, N=159) = 36.266$, $p < .001$						
Tukey shows that all three groups differences are significant ($p < .001$)						

Note. The symbol * indicates a significant difference using one-way ANOVA.

Table 41

What are the beliefs and attitudes of instructors who know about inquiry-based learning as they make choices to use or not use inquiry-based learning?

Use of inquiry-based learning	Never, *N*=29		Infrequent, *N*=85		Frequent, *N*=32	
	Mean	SD	Mean	SD	Mean	SD
ATI-ITTF	3.64	0.458	3.48	0.413	3.48	0.515
*ATI-CCSF	3.64	0.555	3.77	0.459	4.04	0.388
$F(2, N=135) = 8.638$, $p < .001$						
Tukey shows that Never-Freq and Infreq-Freq differences are significant ($p < .05$)						
CoT-Design	2.72	0.751	2.94	0.780	3.18	0.912
CoT-Teach	4.05	0.686	4.12	0.648	4.38	0.582
CoT-Time	3.03	1.267	2.83	1.18	2.69	1.23
*IBL-GEN	2.83	0.646	3.42	0.637	3.77	0.583
$F(2, N=145) = 17.644$, $p < .001$						
Tukey shows that all three groups differences are significant ($p < .05$)						
*IBL-ENV	2.82	0.727	3.41	0.622	3.76	0.537
$F(2, N=145) = 17.658$, $p < .001$						
Tukey shows that all three groups differences are significant ($p < .05$)						
*IBL-ESC	2.59	0.751	3.11	0.625	3.37	0.668
$F(2, N=145) = 11.308$, $p < .001$						
Tukey shows that Never-Freq and Infreq-Freq differences are significant ($p < .01$)						
*IBL-TOOC	2.94	0.787	3.33	0.804	3.74	0.806
$F(2, N=145) = 7.551$, $p < .001$						
Tukey shows that Never-Freq and Infreq-Freq differences are significant ($p < .05$)						
*IBL-Training	2.48	1.090	3.34	1.018	4.09	0.818
$F(2, N=145) = 2.015$, $p < .001$						
Tukey shows that all three groups differences are significant ($p < .001$)						
IBL-Content	3.38	1.083	3.71	0.897	3.60	0.987
*IBL-Attitude	11.17	2.227	13.28	2.078	14.64	2.168
$F(2, N=145) = 20.546$, $p < .001$						
Tukey shows that all three groups differences are significant ($p < .01$)						

Note. The symbol * indicates there was a significant difference using one-way ANOVA.

From Table 42 and 43 you can see the major issue mentioned in the comments is that participants believe that CL and IBL take a great deal of class time and there is too much content to cover in the amount of time. In Table 44, some participants comment on the great efficiency of using the lecture method, but also question the effectiveness of the method for students. Several instructors seem to interpret the lecture method as only the instructor talking, when, in fact, the description did include questions and answers between instructor and student as part of the lecture method. Many participants mentioned the use of mini-lectures or lectures mixed with a smattering of other activities. This was one of the ten identified MIPs (Collaborative Lecture), but was not included in this study because of the length of the survey.

Existence of a KAP Gap

What is the relationship, if any, of favorable (or unfavorable) attitude towards an instructional practice and actual instructional practice? In other words, is there a KAP Gap? To find out we need to analyze a subgroup of those with knowledge of an instructional practice, and a favorable attitude (MIP-Attitude $\geq$ 14) and see what proportion of these participants actually use the instructional practice (Table 45). Of the 93 participants who know of cooperative learning *and* have a favorable attitude towards it, 74.5% use cooperative learning frequently. A KAP Gap would occur if participants with knowledge of an innovation and a favorable attitude towards it did not use the innovation, therefore this data does not provide **strong** evidence for a KAP Gap for cooperative learning. However, one does pause and wonder why those 25.5% with a favorable attitude are not using cooperative learning? Of the 60 participants who both know about inquiry-based learning and have a favorable attitude towards it, only 38.3%

Table 42

Summary of participant comments about why they don't use cooperative learning

General description of issue	Example Comments	Number of participants who touch on this issue
Not enough time, too much content	"My experience with cooperative learning is not very positive in terms of learning outcomes. It takes a lot of class time ... from already limited time ..." "Not enough time to cover the required content is the most prohibitive factor in using cooperative learning." "I would be MUCH more apt to incorporate these methods if I did not feel so pressed for time to get through mass amounts of material that I am required to cover in the semester."	21
Cooperative learning is not a good fit for some students	"I find that students with learning disabilities do not like cooperative learning. Especially those with ADD/ADHD. Also, students who are more interested in socializing in class do not benefit from cooperative learning." "Students tend to either love it or hate it. Many students did hate it and didn't hesitate to let me know. On the other hand, many students found it to be great."	10
Negative reactions to cooperative learning	"Using this method you wouldn't accomplish much as far as teaching. It's the key word. People pay us to TEACH." "When I was in school, "cooperative learning" was called cheating. The best students learn from teaching others, and the poor students just copy someone's work." "Basically it's just a waste of time !!!! Social engineering is the ultimate goal …"	5
Students become dependent on each other	"Two problems arise with cooperative learning. 1) Students with better skills can leave students with poorer skills behind, and the poorer students might not force the better students to slow down to help them, and 2) students can become dependent upon each other, and then perform poorly individually."	3
Will not prepare students for next level	"Cooperative learning is useful for lower level math. at some point, students need to learn to be successful in the traditional lecture mode because that is how classes at a university are taught."	2
Difficulty with assessment of cooperative learning	"It's difficult to ensure that each student in a group participates and that all have learned from it."	2
The environment is not conducive to cooperative learning	"The amount of material that has to be covered makes it impractical, plus we really don't have enough rooms equipped for this type of teaching." "Sometimes the classrooms are so small for the number of students, or the board space is limited that it is difficult to get the students together for the cooperative learning I like to use."	2

Table 43

Summary of participant comments about why they don't use inquiry-based learning

General description of issue	Example Comments	Number of participants who touch on this issue
Not enough time, too much content	"It takes too much time most of the time." "I simply do not have the amount of time to cover all materials and do inquiry based learning effectively." ".. it would be too much time such that the total content of the course would be placed in jeopardy." "IBL is too time consuming for the results."	17
Issue with the method of IBL itself.	"I have found that research on "IBL" is mixed in terms of specific learning outcomes." "It took hundreds of years for the greatest minds to establish many of the mathematical concepts and techniques we use/teach today. So we expect our students to discover it all on their own in a semester? That's a joke." "It seems that many students would make false conclusions using this method. Once students reach ANY conclusion, changing their opinion can prove difficult."	4
Students complete activities at different rates	"Due to the great amount of time required for students to "discover" possible processes, IBL is not very efficient and often times some students grasp the concept quickly and become bored while other less-motivated students give up." "While I believe this to be a good method for learning, I am concerned that the amount of time this process would take would vary widely from student to student."	4
The students are too deficient in some skills to learn with IBL	"Inquiry-based learning is ok if you have a good quality student to begin with. However, we don't have good quality students at [name removed] College." "General reasoning skills are also lacking among my students, so inquiry-based strategies are difficult for them to employ."	4
Student pushback makes this difficult to use	"Also, many students have commented that these types of lessons make them feel like they are being treated like HS students." "I also feel that a lot of students either are intimidated or don't want to work that hard."	4
Difficult for the instructor to use.	"Writing these materials for effective and efficient learning can be difficult, I find." "I need more ideas than training."	3
Negative in general	"This approach is just not consistent with my objectives." "This type of learning could be used in elementary classes, but not in college level classes."	2

Table 44

Summary of participant comments about the lecture method

General description of issue	Example Comments	Number of participants who touch on this issue
Mentioned mini-lectures, or primarily lectures mixed with other activities	"Short mini-lectures interspersed with interactive activities work best for me." "The lecture method I use includes opportunities for students to do problems on their own (or with a classmate) sprinkled throughout the lecture."	12
Questions effectiveness of the lecture method for students	"Lecture method does not engage the students. They become bored just listening." "Lecture is ease and is the classical model, but is like a cold river of words flooding over and passing by the students."	9
Mentions ease of use	"Easier not necessarily more effective." "It would be easy for me to use this method, but not easy for the students." "While lecture is easier for me to teach…"	6
Uses a combination of instructional methods	"The questions in this survey imply that a course is taught using only one method. I incorporate all of them as appropriate to the students and what proves to be effective."	6
Feels "forced" into using lecture due to constraints	"Sometimes it seems that this is the only way to maintain any kind of schedule." "Unfortunately I use lecture the most due to the amount of content to cover."	6
The lecture method is efficient	"…it's just faster if you need to get through large amounts of information." "I think the lecture method is good at dropping a lot of information on the students, regardless of their readiness for it." "Due to the time factor and the amount of material needed to be covered, lecture works out well."	5
Mentions importance of asking and answering questions	"I prefer what might be called "interactive lecture" ... engaging students by questioning ... even allowing debate while still being the infamous "sage on the stage."" "Your description of 'lecture' is biased. In practice, many of us 'lecture' in a fashion that involves more activity from the students."	5
Lecture gives students set of notes or instructor interpretation of text	"When I have tried other methods, students have told me that they took my course because they have been told that I explain things so well, and they want that explanation, not some computer or some other students."	5
Works with any population of students	"This method does not depend on the students at all. That is, lecture is lecture for any student, so those who are new or (ahem) more experienced in the particular class have the same experience."	4

of participants use IBL frequently. This supports the existence of a KAP Gap for inquiry-based learning.

The teaching experience (that is, what types of courses an instructor has taught in the past) turned out to be the only variable that produced significant difference in the use-groups for IBL (Table 47). The lecture method was not tested against subgroups since the level of use was so high in general. Not surprisingly, the CCSF subscale of the ATI differed significantly between the three use-groups for both student-centered instructional practices (CL and IBL). Higher scores on CCSF correlated with higher frequency of use for cooperative learning and inquiry-based learning (see Tables 46 and 47).

Table 45

Does knowledge and attitude lead to practice?

Mathematics instructional practice	Percent with knowledge of and **favorable** attitude that frequently use this instructional practice	Percent with knowledge of and **non-favorable** attitude that frequently use this instructional practice
Cooperative learning	74.5% N=93	26.9% N=67
Inquiry-based learning	38.3% N=60	10.3% N=87
Lecture method	93.5% N=154	72.2% N=18

Note. Non-favorable attitude (which is both unfavorable and neutral) is taken as MIP-Attitude < 14.

Table 46

What influences the IBL KAP Gap? If an instructor has knowledge of and favorable attitude towards IBL, what frequency variables are significantly different between use and non-use?

	Does not use IBL or uses infrequently	Uses IBL frequently
Has taught 1-2 different math courses	80.0%	20.0%
Has taught 3-5 different math courses	82.4%	17.6%
Has taught 6-10 different math courses	64.7%	35.3%
Has taught >10 different math courses	38.1%	61.9%
$\chi2(3, n = 60) = 8.791, p < .05$		
Has taught an off-track math course	53.5%	46.5%
Has not taught an off-track math course	82.4%	17.6%
$\chi2(1, n = 60) = 4.29, p < .05$		
Has taught a Calculus-level course	50.0%	50.0%
Has not taught a Calculus-level course	79.2%	20.8%
$\chi2(1, n = 60) = 5.18, p < .05$		
Has taught a post-Calculus course	30.8%	69.2%
Has not taught a post-Calculus course	70.2%	29.8%
$\chi2(1, n = 60) = 6.70, p < .05$		

Table 47

What influences the IBL KAP Gap? If an instructor has knowledge of and favorable attitude towards IBL, what non-frequency variables are significantly different between use and non-use?

Use of inquiry-based learning	Uses IBL Infrequently or Never		Use IBL Frequently	
	Mean	SD	Mean	SD
CCSF $F(1, n = 55) = 7.068, p < .05$	3.74	0.479	4.07	0.379
COT Teach $F(1, n = 58) = 4.104, p < .05$	4.15	0.674	4.48	0.464
IBL Training: If I wanted to, I would feel comfortable using IBL without any additional training. $F(1, n = 59) = 3.774, p < .05$	3.92	0.924	4.43	0.507
CoT1R I have a lot of say in how the courses at this level are run. $F(1, n = 58) = 4.034, p < .05$	3.58	1.105	4.13	0.869
CoT2 The department allows me considerable flexibility in the way I teach courses at this level. $F(1, n = 58) = 4.815, p < .05$	3.81	1.009	4.39	0.583

Prediction of Use of Mathematics Instructional Practices

What is the relationship, if any, between attitude and practice for each of the instructional practices? In other words, can we use characteristics and attitudes of instructors to predict whether or not they will use a particular instructional technique? There is no point in looking at the lecture method here as it is so widely used that I can just write a prediction model that is accurate more than 90% of the time. The predictor is "are you a math instructor" and if the answer is yes, the outcome is "you will use the lecture method."

For cooperative learning and inquiry-based learning, logistic regression was employed to predict the possibility that a participant would use the instructional practice. A new set of variables, CL_Use_Freq and IBL_Use_Freq, were created with 1 = uses frequently and 0 = uses infrequently or never. Because of the theory that favorable attitude would lead to practice, an initial logistic regression was conducted using ATI-CCSF and the Attitude index for the MIP. The initial logistic regressions based only on these two dependent variables can be found in Tables 48 and 49.

Table 48

Logistic regression predicting use of cooperative learning from attitudes

Predictor	β	Wald χ^2	*p*	Odds Ratio
ATI-CCSF	0.960	4.298	.038	2.612
CL-Attitude	0.507	22.435	< .001	1.660
Constant	-10.718	23.763	< .001	

Note. A Test of this model versus a model with intercept only was statistically significant, χ^2 (2, *n* = 148) = 48.58, $p < .001$ with $R_N^2 = 0.375$. The model was able to correctly classify 69% of those who did not use CL and 77.1% of those who did use CL for an overall success rate of 73.6%.

Table 49

Logistic regression predicting use of inquiry-based learning from attitudes

Predictor	β	Wald χ^2	*p*	Odds Ratio
ATI-CCSF	1.629	8.405	.004	5.098
IBL-Attitude	0.333	8.417	.004	1.395
Constant	-12.155	20.015	< .001	

Note. A Test of this model versus a model with intercept only was statistically significant, χ^2 (2, *n* = 136) = 22.854, $p < .001$ with $R_N^2 = 0.237$. The model was able to correctly classify 95.3% of those who did not use IBL and 30% of those who did use IBL for an overall success rate of 80.9%.

Interestingly, in the actual sample, favorable attitude only seemed to predict practice for cooperative learning about 75% of the time, and that is what our logistic model does too. For inquiry-based learning, favorable attitude only led to practice 38.3% of the time, and attitude only predicted use only 30% of the time in the logistic model. This means there are other variables that could be predictors. Using a stepwise analysis (that is, trying out likely predictors one at a time), then trying combinations of these predictor variables, a revised prediction model for each instructional practice was developed (Tables 50 and 51).

The inclusion of predictor variables like the desire for more training, how much time-pressure instructors feel they are under, the variety of courses an instructor has taught, and the level of engagement in social interactions, leads to logistic regression models that improve the prediction rate for use of the instructional practice (but do not improve the prediction of non-use). From this result, it could be postulated that attitude is an excellent predictor of non-use of cooperative learning and inquiry-based learning, but attitude is not a very good predictor for use of these instructional methods. The prediction of use is dependent on many factors besides just attitude.

Revisiting the Research Questions

There were nine research questions proposed in this study. The data was sufficient to answer the first six research questions, however the unbalanced levels of math in the survey groups made it impossible to answer the last three research questions. A summary of the findings can be found in Table 52.

Table 50

Logistic regression predicting use of cooperative learning from attitude and other predictor variables

Predictor	β	Wald χ^2	*p*	Odds Ratio
ATI-CCSF	0.819	2.790	.095	2.267
CoT_Time	-0.338	3.296	.069	0.713
LVL-Variety	0.289	1.613	.204	1.335
PD-Social	0.537	1.319	.251	1.711
CL-Training	0.881	6.025	.014	2.412
CL-Attitude	0.452	11.767	.001	1.572
Constant	-13.044	24.582	< .001	

Note. A Test of this model versus a model with intercept only was statistically significant, χ^2 (6, N = 146) = 64.451, $p < .001$ with $R_N^2 = 0.478$. The model was able to correctly classify 71.9% of those who did not use CL and 84.1% of those who did use CL for an overall success rate of 78.8%.

Table 51

Logistic regression predicting use of inquiry-based learning from attitude and other predictor variables

Predictor	β	Wald χ^2	*p*	Odds Ratio
ATI-CCSF	1.650	7.377	.007	5.206
IBL-Training	0.722	4.392	.036	2.058
CoT-Time	-0.421	3.551	.060	0.656
LVL-Variety	0.347	1.600	.206	1.414
PD-Social	0.737	1.096	.295	2.090
IBL-Attitude	0.177	1.431	.232	1.193
Constant	-13.134	17.741	< .001	

Note. A test of this model versus a model with intercept only was statistically significant, χ^2 (6, N = 135) = 38.094, $p = .001$ with $R_N^2 = 0.376$. The model was able to correctly classify 93.3% of those who did not use IBL and 50.0% of those who did use IBL for an overall success rate of 83.7%.

Table 52

Summary of research findings by research question

Research Questions	Findings
1. How knowledgeable are community college math faculty about instructional practices and how do they receive this knowledge	• For FT instructors, knowledge of CL and IBL was almost 100%. PT and FT instructors had different levels of knowledge for CL ($p < .05$) and IBL ($p < .001$). • Knowledge of CL in the general sample was greater for females ($p < .05$) and those who had taught remedial math ($p < .05$), but when knowledge of CL was examined within the PT subgroup, only the characteristic of having taught remedial math was significant ($p < .05$). • Knowledge of IBL in the general sample was greater for females ($p < .001$), those in the most recent educational cohort ($p < .05$), those with a math or statistics degree ($p < .01$), those *without* a math-related partner-discipline degree ($p < .01$), those with an education-related degree ($p < .01$), those who have taught calculus ($p < .001$), and those who have taught the largest variety of courses ($p < .05$). When these factors were examined in the PT subgroup, only three factors still made a significant difference: gender ($p < .01$), educational cohort ($p < .01$), and the presence of an education-related degree ($p < .01$). • The vast majority (91%) of instructors were first exposed to the lecture method as a student. • For CL and IBL, instructors were more unsure (25-30%) how they first learned about these methods but only 6-7% learned about these as a student. • The first (known) acquisition of knowledge for CL was professional training (32.3%), followed by learning from a colleague (13.4%), experimentation (12.8%), and reading articles (4.3%). • The first (known) acquisition of knowledge for IBL was professional training (42.9%), followed by reading (13.0%), learning from a colleague (8.2%), and experimentation (4.8%).
2. What kinds of professional development (general and context-specific) do community college math faculty participate in?	• Community college math faculty participate in general PD events (68.8%) and math-specific events (53.1%) both on-campus (30.7%) and off-campus (35.4%). • Community college math faculty participate in informal PD activities by reading articles related to teaching math (63%) and engaging in social interactions related to teaching math (67%). • Instructors read articles in both online (49.0%) and paper (47.4%) formats. Instructors participated in social interactions both online (15.6%) and face-to-face (65.1%). Overall, 51% of instructors participated in at least one informal online PD activity. • In the last year, 35.9% of community college math faculty spent less than 2 hours attending presentations, discussions, workshops, or webinars about topics related to math instruction, 45.8% spent between 2 and 20 hours, and 18.2% spent more than 20 hours. • In an average week, 46.1% of community college math faculty spent less than 15 minutes reading about topics related to math instruction, 47.1% spent between 15 minutes and 2 hours, and 6.8% spent more than 2 hours. • In an average week, 30.2% of community college math faculty spent less than 15 minutes interacting with colleagues about topics related to teaching math, 56.3% spent between 15 minutes and 2 hours, and 13.5% spent more than 2 hours.

Table 52 – Continued

Research Questions	Findings
3. What is the influence, if any, of specific demographics (work status, gender, education, experience, or exposure to ideas) on the types of training that community college math faculty receive?	• The participation in PD is vastly different between full-time and part-time faculty (full-time faculty always participate more). Significant differences were found for participation in general PD ($p < .001$), both on and off-campus, math-specific PD ($p < .001$) and off-campus math-specific PD ($p < .001$), reading articles related to teaching math ($p < .001$) in any format, paper format ($p < .01$) and web-based format ($p < .01$), in social interactions related to teaching math ($p < .01$), and specifically in face-to-face social interactions related to teaching math ($p < .01$). • The time invested in PD is vastly different between full-time and part-time faculty (full-time instructors invest more time). Significant differences were found for the annual time invested to attend math-specific PD ($p < .001$), the average time spent reading about teaching math in a week ($p < .01$), and the average time spent interacting with colleagues in a week ($p < .01$). • The longer instructors have been out of school, the more likely they are to participate in general professional development, that is, up to a point about 30 years out. Then their participation in general PD drops off. • Participation in math-specific PD and off-campus math-specific PD was influenced primarily by the work status of the instructor. No other variables were found to influence this behavior within the subgroups of FT or PT instructors. • Females were significantly more likely than males ($p < .001$) to read articles related to teaching math, and this result held up within the part-time subgroup of instructors ($p < .05$). They were also more likely to engage in social interactions ($p < .001$), which held up within the part-time subgroup ($p < .01$). • Those instructors who have taught remedial math were more likely to read articles related to teaching math ($p < .05$), and this result held up within the part-time subgroup of instructors ($p < .05$). They also spent more time during the year participating in math-specific PD than those who had not taught remedial math ($p < .01$). This result was also significant within the subgroup of FT math faculty ($p < .01$). • Those instructors who have taught off-track math courses are more likely to engage in social interactions related to teaching math ($p < .01$), and this result held up within the PT subgroup ($p < .05$). These instructors also spend more time per week (on average) engaged in social interactions ($p < .05$) and this result held up within the FT subgroup ($p < .05$). • Those instructors that possess a math or statistics degree are more likely to engage in social interactions related to teaching math ($p < .05$) and within the FT subgroup this result was more significant ($p < .01$).

Table 52 – Continued

Research Questions	Findings
4. Are there correlations between beliefs held by community college math faculty and their use (or lack of use) of instructional practices?	• The CCSF scale on the ATI correlated positively with use of CL and IBL. When the three use groups (never, infrequent, frequent) were examined for differences in the mean scores on the CCSF, the means were significantly different for CL ($p < .001$) and IBL ($p < .001$). • The CL-AMIP subscales created by the researcher also correlated positively with increased use and the differences between the three use groups were found to be significant ($p < .001$) for the GEN, ENV, ESC, TOOC, Training, and Content scales of CL-AMIP as well as the combined CL-Attitude index ($p < .001$). • The IBL-AMIP subscales created by the researcher also correlated positively with increased use and the differences between the three use groups were found to be significant ($p < .001$) for the GEN, ENV, ESC, TOOC indexes of IBL-AMIP as well as the combined IBL-Attitude index ($p < .001$). • In general, increased positive attitude towards CL or IBL does correlate with increased use of the practice.
5. What is the influence, if any, of specific demographics (work status, gender, education, experience, or exposure to ideas) on whether math faculty chose to adopt (or reinvent) or reject an instructional practice?	• The lecture method is used frequently by 91.4% of community college math faculty. The rates of frequent use for the student-centered instructional practices are much lower: 50.3% of faculty report using CL frequently and 20% report using IBL frequently. • Work status was a significant influence on the use of student-centered instructional practices. FT faculty were more likely than PT to use CL frequently and PT faculty were more likely than FT to never use CL (p = .056). FT faculty were more likely than PT to use IBL frequently and PT faculty were more likely than FT to never use IBL ($p < .05$). • For both CL ($p = .053$) and IBL ($p < .05$), female instructors were more likely than males to frequently use the student-centered instructional practices and males were more likely than females to never use the instructional practices.
6. What is the relationship, if any, of favorable (or unfavorable) attitude towards an instructional practice and actual instructional practice? Is there a KAP Gap?	• Unfavorable attitude towards an instructional practice can be used to predict non-use of that practice. • Favorable attitude towards an instructional practice correlates positively with use, but is not the sole predictor of use. • About 75% of those instructors with knowledge of CL and a favorable attitude towards it choose to use this instructional practice frequently. Only 38% of those instructors with knowledge of IBL and a favorable attitude about it choose to use this instructional practice frequently. This is evidence that knowledge plus attitude does not equal practice, and is solid evidence for the existence of a KAP Gap in the use of inquiry-based learning as an instructional practice. • About 72% of instructors with a non-favorable attitude towards the lecture method use it frequently. This is suggestive that there are contextual issues that cause instructors to favor the lecture method above all else.

Discussion

To investigate the existence of a KAP Gap for collegiate mathematics, the elements of knowledge, attitude, and practice had to first be measured. Almost all of the full-time instructors had knowledge of the instructional practices studied (LEC, CL, and IBL). Part-time instructors reported a lower level of knowledge (which was significant for CL and IBL), but overall the level of knowledge of these practices was still fairly high. The majority of community college math instructors had knowledge of all three instructional practices. Instructors were first exposed to the lecture method when they were students, and this differs greatly from first-exposure to other instructional practices. While a large group of instructors are unsure where they first learned about cooperative learning or inquiry-based learning, many reported that they learned about these student-centered instructional methods through professional training of some sort. Of course, access to and attendance at professional training is highly dependent on work status, with full-time instructors having significantly higher participation rates in both formal and non-formal math-specific professional development (especially off-campus activities).

The level of practice of specific MIPs was self-reported by each instructor participant. Predictably, almost all instructors used the lecture method, while the level of frequent use for cooperative learning and for inquiry-based learning was lower. Full-time instructors used CL and IBL significantly more than part-time instructors, and females used these practices frequently more than males. There were no significant differences on use of MIPs between the levels of math chosen for the survey.

Multiple scales were used to measure beliefs and attitudes. The ATI was used to measure a general attitude towards student-focused (CCSF) or teacher-focused (ITTF) instructional practices. The ITTF scores were fairly consistent across a variety of demographic groups, but the CCSF scores showed significant differences across different groups with respect to the IBL and CL instructional practices. In particular, those with higher CCSF scores were also more likely to use IBL or CL. The beliefs subindexes of the AMIP group of questions also showed the same trend; instructors with more favorable beliefs towards a specific MIP were more likely to use it frequently. This data would seem to predict that favorable attitude and use of a particular instructional practice correlate well. In fact, this was not the case in the prediction models. Unfavorable attitude was a good predictor of non-use, but favorable attitude was not enough to predict use. In general, instructors were favorable towards all aspects of the MIPs with the exception of time and content. Not only were participants vocal in the open-ended comments, lashing out against the lack of time and profusion of content, but these were some of the only belief items where instructors drifted (on average) lower than neutral on the Likert scale.

The main purpose of this study was to search for a KAP Gap in collegiate math. Recall that a KAP Gap would occur when an instructor had knowledge of an instructional practice, and a favorable attitude, but then chooses not to use the instructional practice. For cooperative learning, knowledge of and a favorable attitude towards cooperative learning led to 74.5% frequent use. However, knowledge of and a favorable attitude towards inquiry-based learning only led to 38.3% frequent use, which is strong support for a KAP Gap for IBL. Once a KAP Gap was identified, the analysis turned to determining what would predict use of IBL. Attitude alone is not a very good predictor of use. Combining attitude with other control factors (i.e. desire for training and whether the instructor felt pressed for time) generated a better prediction model for use of IBL or CL, but there is still a lot of room for improvement.

CHAPTER V: CONCLUSIONS

In this study, many characteristics and beliefs of community college math instructors were examined via a quantitative survey sent to the population of community college math instructors in the state of Michigan. The sample consisted of 72% part-time instructors, which is right between the proportion of part-time instructors found in the natural sciences at all colleges (76%) and the proportion found in general at community colleges (66.7%) in the NSOPF Survey in 2003 (Cataldi et al., 2005). Significant differences were found between full-time and part-time instructors on their amount of experience, educational background, and breadth of courses taught.

Research Findings

Source and Knowledge of Math Instructional Practices

Community college math instructors do have knowledge of student-centered instructional practices. For full-time instructors, the knowledge of cooperative learning and inquiry-based learning was very close to 100%. Part-time instructors had less knowledge of these practices (but not a lot less, CL was 88.9% and IBL was 77.4%). Many instructors were unsure (25-30%) how they learned about cooperative learning and inquiry-based learning, but for those who were sure, their knowledge comes from professional training (32-43%), colleagues (8-13%), and experimentation (5-13%). Almost all instructors (90.8%) were sure they learned about the lecture method (used by almost all instructors) experientially as a student. Only 6-7% of instructors reported they were first exposed to the student-centered instructional practices as a student.

There was some evidence that the knowledge of student-centered practices is higher for females, those with an education-related degree (although this did not translate into practice), and those who have been more recently in college. Instructors who have taught remedial math courses were slightly more likely to have knowledge of cooperative learning than those who had not taught these courses. Instructors who have taught Calculus were more likely to have knowledge of inquiry-based learning than those who had not taught calculus, which might be evidence of the impact of the Reform Calculus movement.

Professional Development Activities of Community College Math Faculty

Just over half of the Community College math instructors in the survey reported participating in math-specific professional development (PD) activities in the last year, about evenly split between on- and off-campus PD. Almost two-thirds of math instructors reported reading articles related to teaching math (about equally split between paper-based and online), and about the same proportion reported that they engaged in conversations related to teaching math. While this sounds good, non-engagement levels for math-specific PD were a little disturbing: 35% of participants spent less than two hours a year participating in math-specific PD activities, 45% spent less than 15 minutes a week reading articles related to math instruction, and 30% spent less than 15 minutes per week engaged in social interactions about math instruction.

Demographics and Participation in Professional Development

No characteristic of math instructors made a more significant difference in formal professional development participation than work status. Consider these participation levels comparing full-time and part-time math instructors: general professional development, 96% and 58%; math-specific PD, 87% and 40%; off-campus math-specific PD: 76% and 20%. This mirrors the findings of Cohen and Outcalt (2001), who also found that professional involvement was significantly higher for full-time instructors than part-time. However, this study shows that the difference in involvement is much greater for the community college math population.

The profile of part- and full-time instructors is significantly different for characteristics like the breadth of courses an instructor has taught, the type of degree they have earned, and the highest degree earned. When these same characteristics appear as significant differences for participation levels in professional development, it is difficult to know whether the differences are simply attributable to the characteristic or the work status of the instructor. In most cases, when the subgroups of exclusively full-time or exclusively part-time were examined separately for a variable that might influence participation in PD, the "significance" of the differences disappeared. For example, instructors who had taught remedial math or calculus were significantly more likely to participate in math-specific PD than those who had not, but within the full-time or part-time subgroups, no significant differences were found.

Almost fifty percent of part-time instructors reported spending less than 2 hours per *year* participating in math-specific professional development activities (compare this to 7.4% of full-time instructors). On the other end, 37% of full-time instructors spent more than 20 hours a year on math-specific PD compared with 9% of part-timers. One must be cautious to read too much into this. Part-time instructors generally have less support and access to both formal and non-formal opportunities for professional development. Nonetheless, if we believe professional development is at all related to mathematics classroom practice, these findings cannot be ignored.

Reading articles and engaging in social interactions related to teaching math are both informal professional development activities, and again, there were significant differences between full-time and part-time math instructors: those who participate by reading articles related to teaching math, 85% and 54% respectively; those who engage in social interactions related to teaching math, 83% and 61%. Most full-time instructors (64%) spent between 15 minutes and 2 hours per week reading articles related to teaching math (41% of PT). Just over half of part-time instructors spent less than 15 minute per week reading articles (28% for FT). Full-time instructors also engaged in more social interactions related to teaching math; 74% reported spending between 15 minutes and 2 hours per week on these activities compared to 49% for part-time instructors. Cohen and Outcalt (2001) found that full-time instructors at community colleges spent an average of one hour a day and part time instructors about 45 minutes a day in informal interaction with colleagues. These figures are not discipline-specific, so it is difficult to compare the measures directly. However, it seems likely that part-time instructors spend most of their time engaged in discipline-specific activities, in which case, the Cohen and Outcalt time estimates of informal interactions seem rather high compared to these findings.

For both the general survey sample and within the part-time subgroup, females were more significantly more likely to read articles specifically related to teaching math (72%, versus 55% for males) and more likely to engage in conversations with colleagues about teaching math (78%, versus 56% for males). However, in terms of time spent on informal professional development activities, gender did not make a significant difference.

Instructor Attitudes and Use of Instructional Practices

One of the measurements of attitude was the Approaches to Teaching Inventory (ATI) by Trigwell and Prosser. This inventory has two subscales, information-transfer teacher-focused (ITTF) and concept-centered student-focused (CCSF). The reliability of this inventory was good and the CCSF subscale correlated well with use of both student-centered instructional practices (CL and IBL). This indicates that it would be a good tool to use in future research. The ITTF subscale was fairly uninteresting with regards to subgroups of math instructors, indicating that most math instructors have somewhat uniform views on the ITTF subscale. The Attitudes about Math Instructional Practices (AMIP), which were constructed for this research, also had good reliability, as did the general attitude (GEN), enabling student characteristics (ESC) and time outside-of-class (TOOC) subscales. Favorable attitudes measured on these scales correlated positively with frequent use for both student-centered instructional practices, as did the overall attitude indexes for both CL and IBL.

In general, instructors felt they had much more control about *how* they taught than the design and content of the math courses. While most survey items received neutral to favorable responses, survey items specifically related to the issue of enough time or control of content received non-favorable responses on average. For example, the item "I have control over the content that I teach in these courses." had an average response of 2.29 out of 5 for Algebra instructors. At the end of each MIP question section, there was space provided for open-ended comments; the largest group of the participant comments about why they choose not to use IBL or CL were related to lack of time or too much content to teach in the given time. It is clear that instructors felt they had little control over this issue, and they felt the time/content issue affected how they choose to teach. This corroborates the findings by Henderson and Dancy (2007) that "broad content coverage expectations" are a deterrent to adoption of alternative instructional practices. Not surprisingly, full-time instructors felt they had more say than part-time instructors in how courses were run at the department level.

Demographics and Use of Instructional Practices

Overall, 50.3% of instructors claimed to use cooperative learning frequently, 20% inquiry-based learning, and 91.4% the lecture method. This validates the rates from 2004-2005 HERI Faculty Survey (Lindholm et al, 2005) for level of use for cooperative learning (35-55%). However, use of the lecture method in teaching math found in this study is higher than that reported by department heads in the 2005 CBMS Statistical Abstract (Lutzer et al, 2007). There were two demographics variables with significant differences in use of IBL and CL: work status and gender. Full-time instructors were more likely than part-time to use CL and IBL frequently and less likely to not use them. Likewise, females were more likely than males to use these practices and less likely to not use them.

Knowledge, Attitude, Practice?

About 75% of instructors with knowledge of and favorable attitude towards cooperative learning chose to use cooperative learning frequently. Only 38% of instructors with knowledge of and favorable attitude towards inquiry-based learning choose to use inquiry-based learning. This is sufficient evidence that there is a

Knowledge-Attitude-Practice (KAP) Gap, at least for the instructional practice of inquiry-based learning. For cooperative learning, we could say that knowledge and favorable attitude are a reasonable predictor of 75% of practice.

We would generally believe that attitude leads to practice. And this appears to be true for non-favorable attitudes. That is, a non-favorable attitude will be likely to lead to non- or infrequent-practice. Instructors who never used CL or IBL had average GEN, ENV, ESC, and TOOC scores below 3 (recall that 3 is neutral). While instructors who used CL or IBL frequently did have average scores above 3, this was not enough to predict actual practice. In order to find logistic prediction models for use of CL and IBL instructional practices, other variables had to be considered. When the model included factors like variety of courses taught, engagement in social interactions, desire for training, and whether instructors felt pressed for time, this improved the prediction of the logistic models, but still, these prediction models were only right 50% of the time when predicting *use* of inquiry-based learning (the non-use prediction rate was much higher at 93%). In summary, the research shows that there is a Knowledge-Attitude-Practice (KAP) Gap in the adoption of some instructional practices in collegiate math, however, the cause of the KAP Gap is still a bit of a mystery.

Does the Level of Math Matter?

Instructors were given a choice between three math levels commonly taught at community colleges upon which to base their responses: algebra, precalculus, and calculus. Unfortunately, the survey levels were very unbalanced, with 121 participants choosing algebra, 25 precalculus, and 19 calculus. In most cases, the level of math course did not show a significant difference in instructor responses, but the sample sizes were not large enough to make any kind of definite observation.

Limitations

The sample for this research was community college instructors in the state of Michigan. Although this is a sample of *all* those math instructors, Michigan has some characteristics that may make its teaching population different than other states. Specifically, there are strong teaching unions in Michigan, so full-time instructors have high salaries and the gap between full-time and part-time pay scales is likely to be larger than in other states. Michigan has been in a recession for several years, so the support for professional development (especially out-of-state opportunities) may be less than other states. So, while one should be cautious about generalizing the results on a national level, this is (to my knowledge) the most comprehensive picture we have ever had about a general population of community college math instructors.

There is also a possibility of selection bias in the survey. While the survey was sent to all known community college math instructors in Michigan, it is possible that those who were familiar with the name of the researcher were more likely to respond. Most of my work in Michigan is promoting more student-centered instructional strategies, so bias in the study would cause an overestimation of the attitudes and use of student-centered instructional practices.

Another limitation of this study is the possibility of instructors overestimating their use of student-centered practices. Sometimes instructors perceive that they have knowledge of a practice and are using it when, in fact, they do not actually know what the practice is. In this study, instructors were presented with a description and examples of each practice in an attempt to mitigate this over reporting of use. There is also a natural human tendency to exaggerate behavior in reporting. For both of these reasons, it is likely that if there is bias in reporting use of instructional practices, it is an overestimate of actual practice.

Implications

Faculty Hiring

Full-time instructors teach a larger variety of courses (especially above the Algebra level), they have more years of experience, and they are much more likely to have a degree in mathematics or statistics. Full-time instructors spend considerably more time engaged in professional development activities related to teaching math than part-time instructors. They participate in more general professional development, are almost twice as likely to participate in math-specific professional development, are more likely to read articles related to teaching math, and engage in more social interactions related to teaching math. The differences between full-time and part-time instructors are not surprising. Full-time instructors receive more access to and support for professional development and, by the nature of their full-time status, they are able to focus their energies on their profession (if they choose to do so). If educational institutions believe instructors should be well-informed about teaching and learning within their discipline area, they need to either reconsider their hiring practices or find a way to support the professional development of part-time instructors.

While it is not surprising that there are differences between the full-time and part-time population, the level of “non-participantion” in math-specific professional development for part-time instructors is alarming. For example, 47% of part-time instructors attended less than 2 hours of math-specific professional development in the last year, 53% spent less than 15 minutes a week reading articles related to teaching math, and 37% spent less than 15 minutes a week engaging in social interactions related to teaching math. This non-participating population of part-time math instructors is becoming isolated from exposure to new research and strategies for teaching and learning. This population of instructors is also less likely to frequently use student-centered instructional strategies and more likely to just not use these strategies at all. If educational institutions believe that student-centered instruction is important, they need to reconsider their hiring practices.

Course Redesign

As various national organizations look further into course design, it seems that the content issue needs to be addressed. If there is nearly universal agreement by instructors that there is either too much content or not enough time in these courses, and this is what keeps them from using more student-centered instructional methods, then perhaps something should be done about it. At the community college level, courses must transfer to other colleges and universities, so changing the content of the courses would be difficult, even within well-coordinated state systems. If we want to increase the amount of student-centered instruction, the simplest solution would be to add one credit hour to every math course. With appropriate professional development to support full-time *and* part-time instructors, it would not be unreasonable to ask instructors to spend at least one hour of time per week on student-centered learning practices. Unfortunately, this solution would mean hiring 25-33% more instructors (most math courses are 3 or 4 credits) and budgets are already stretched pretty thin.

Professional Development

Only 6-7% of participants reported experiencing collaborative learning or inquiry based learning as a student. While a large proportion of instructors reported learning about these techniques through professional development activities, this is not enough for these instructional practices to reach classrooms. Since 91% of the participants had earned at least a Masters degree and 61.5% of these were in mathematics or statistics, it would seem that graduate education would be a good place to begin demonstrating the use of student-centered instructional practices or training graduate students (who might become future instructors) on how to use these techniques. For future research, should professional development focus on teaching instructors about these student-centered practices or should the focus be giving the instructors a student-centered instructional experience as students?

Future Research

While this research study has been able to show that there *is* a KAP Gap for some instructional practices in mathematics, it has not been able to adequately explain what is causing the gap. In *Diffusion of Innovations* (2003), Rogers discusses three different types of knowledge: awareness knowledge, how-to knowledge, and principles knowledge. In this study, I only measured awareness-knowledge. For instructional practices, both how-to knowledge and principles-knowledge would be related to the amount of self-learning, professional development, and experimentation about the specific instructional practice. These would all be areas for future research, although measurements of these factors would be difficult unless they take place in a longitudinal study, tracking instructors over many years of practice.

I was only able to show that awareness-knowledge plus favorable attitude is not enough to predict the use of student-centered instructional practices. Further investigation should drill deeper into this ‘knowledge’ piece. There is likely a rich ecosystem of detail in the examining what instructors know about student-centered instructional practices and whether this, combined with a simple attitude measurement (like the ATI-CCSF), makes use of the instructional strategy any more likely.

Further research should also investigate what kind of access to professional development both types of instructors have. In this study, I asked only whether or not they participate, not about the opportunities and/or support to participate. How easy is it to find articles about teaching math? What are the specific resources that are being used? How widely known are these resources? Another potential area of research would be attitudes about professional development. There is at least some evidence from this study that instructors with non-math backgrounds are less likely to participate in math-specific professional development, even when they teach math. Does the work status or degree background of an instructor influence their attitude about participation in math-specific professional development?

Final Thoughts

The purpose of this study was to find out what community college math faculty know and believe about specific instructional practices (especially student-centered practices) and how often they use them. These faculty, a majority of them part-time, teach a highly constrained curriculum to students with the greatest diversity of skills in higher education. Despite national efforts to “reform” the teaching of math instructors, the most widely-used instructional method for these courses remains the lecture method.

In addition to collecting basic demographic information about the participants, the research survey in this study was designed to tease out beliefs and contextual variables that might influence an instructor's decision to use (or not use) the lecture method, cooperative learning, and inquiry-based learning. The study illuminated a considerable difference between full-time and part-time math faculty in both participation in professional development activities and use of student-centered instructional practices. The study also indicated that although knowledge of student-centered math instructional practices may be high and attitudes about these methods may also be favorable, the combination of knowledge and attitude did not predict use.

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Appendix A

Approval Letter From the Human Subjects IRB

WESTERN MICHIGAN UNIVERSITY

Human Subjects Institutional Review Board

Date: February 17, 2010

To: Andrea Beach, Principal Investigator
Maria Andersen, Student Investigator for dissertation

From: Amy Naugle, Ph.D., Chair Amy Naugle

Re: HSIRB Project Number: 10-02-18

This letter will serve as confirmation that your research project titled "Knowledge, Attitudes, and Practices of Community College Math Instructors: The Search for a Kap Gap in Collegiate Math" has been **approved** under the **exempt** category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note that you may **only** conduct this research exactly in the form it was approved. You must seek specific board approval for any changes in this project. You must also seek reapproval if the project extends beyond the termination date noted below. In addition if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: February 17, 2011

Walwood Hall, Kalamazoo, MI 49008-5456
PHONE: (269) 387-8293 FAX: (269) 387-8276

Appendix B

Email to Potential Participants

Subject Line: How do you teach math?

Dear colleague,

How do you teach math? It turns out that researchers don’t actually know much about what goes on in college math classrooms or in the minds of college math instructors, because rarely do they actually **ask** math instructors. This is a situation I’m hoping to remedy with this research survey about instructional practices in mathematics, which has been sent to all part-time and full-time community college math instructors in Michigan.

In this survey you will have a chance to voice your opinions on a variety of instructional practices that instructors often use to teach math, and how effective you think these techniques are. For research purposes, the survey will also ask you some questions about your demographics, professional development, and general attitudes about teaching. Your responses will be confidential.

The survey will take approximately 15-30 minutes to complete. It may help with understanding the reasons why we teach the way we do and illuminate the barriers that might keep us from using a teaching strategy.

This survey is my dissertation research and, while I hope you will consider participating in the survey for purely academic reasons, I am also willing to provide you with an incentive to participate. When the survey is complete, you will have the opportunity to enter your email address into a drawing for one of three $100 Amazon.com Gift Certificates, to be drawn at random from the participants who completed the survey.

If you have any questions or concerns, please contact me at 231-777-0682 or at maria.andersen@muskegoncc.edu. You may also contact my dissertation chair, Andrea Beach at Western Michigan University (269-387-1725 or andrea.beach@wmich.edu).

Thank you, in advance, for your time and insights. You will find a link to the survey below.

Maria H. Andersen
Math Instructor, Muskegon Community College
Doctoral Candidate, Western Michigan University

Appendix C

Survey Instrument

Michigan Community College Math Faculty Survey

You are invited to participate in a research project titled "**Michigan Community College Math Faculty Survey**". This consent form provides an overview of the research project.

This study is being conducted out of the Department of Ed Leadership, Research, and Technology at Western Michigan University. The Principal Investigator is Maria Andersen, under the supervision of Andrea Beach.

Title of Study: Knowledge, Attitudes, and Practices of Community College Math Instructors: The Search for a KAP Gap in Collegiate Mathematics

What are you trying to find out in this study?

Very little is known about why college math instructors choose to teach the way they do. As a math instructor myself, I understand that the situations we face in the classroom are complex and that our problems cannot just be solved by changing the way we teach. I wish to explore and document the many different pressures that face math instructors in the teaching environments at community colleges and how this effects the choices they make. In this study, I hope to examine the knowledge of instructional practices, the attitudes towards these practices and their level of use. More importantly, I also wish to document what makes it difficult or easy for us to implement the adoption of alternative teaching practices.

What will I be asked to do if I choose to participate in this study?

If you choose to participate in this study, you will be asked to complete a 30-minute web survey that will ask about your instructional practices related to teaching at the Algebra, Precalculus, or Calculus level. During the survey you can choose not to answer a question at any time. You can also choose to exit the survey at any time, however, you will **not** be able to return to the survey later once you begin. Please make sure that you have an appropriate window of time to complete the survey.

In this survey you will have the chance to "weigh in" on instructional issues that you may find particularly rewarding or frustrating. While I hope that this is enough incentive to participate, I am offering a little extra incentive. If you complete the survey, you will be entered in a drawing for one of three **$100 Amazon Gift Certificates**.

What are the risks and benefits of participating in the study?

There are no known risks or benefits associated with your participation in this study.

Will my responses be kept confidential?

Yes. Your name will not be maintained with the data set. Any reporting of data collected will include summary data from multiple participants.

What if I want to stop participating in the study?

Once you begin the survey you can choose to stop participating at any time for any reason.

Should you have any questions prior to or during the study, you can contact Maria Andersen (231-744-7838 or Maria.Andersen@muskegoncc.edu) or Andrea Beach (269-387-1725). You may also contact the Chair, Human Subjects Institutional Review Board (269-387-8293) or the Vice President for Research (269-387-8293) if questions arise during the course of the study.

This consent document has been approved for use for one year from (**insert date**) by the Western Michigan University Human Subjects Institutional Review Board (HSIRB). Do not participate in this study if the date is older than one year.

1 **Please click on the appropriate button below to agree or decline to take part in the study.**

- AGREE -- I have read this informed consent document and wish to proceed to the web survey.
- DECLINE -- I do not wish to participate in the survey.

SUBMIT

Survey Page 1

Michigan Community College Math Faculty Survey

2 Which statement best describes your situation as a math instructor:

- I am a full-time instructor, hired to teach mathematics.
- I am a full-time instructor, hired to teach another subject, but I also teach math.
- I am a part-time instructor who desires to teach **only** part-time.
- I am a part-time instructor who wishes to teach full-time in math.
- I am a part-time instructor who wishes to teach full-time in some other subject.

3 What kinds of professional development opportunities have you participated in during the last year? **Choose all that apply.**

- **General** on-campus professional development
- **Math-specific** on-campus professional development
- **General** off-campus professional development
- **Math-specific** off-campus professional development sponsored by a **professional organization** (e.g. AMATYC, MAA, NCTM, MichMATYC)
- **Math-specific** off-campus professional development sponsored by a **commercial organization** (e.g. Pearson, Cengage, Texas Instruments)
- Reading articles in a **paper-based** format (e.g. printed journals, magazines, newsletters, or newspapers)
- Reading articles in a **web-based** format (e.g. online journals, websites, blogs)

- Social interactions in a **face-to-face** environment (e.g. in person discussions with colleagues)
- Social interactions in an **online** environment (e.g. discussion boards, listserv, twitter)
- Other, please specify.

---

4 Approximately **how many hours** of presentations, discussions, workshops, or webinars about topics related to math instruction have you attended **in the past year** either on or off-campus?

- None
- Less than 2 hours
- Between 2 and 10 hours
- Between 10 and 20 hours
- Between 20 and 40 hours
- More than 40 hours

---

5 On average, approximately how often do you spend time reading (either paper-based or online) about topics related to teaching math?

- Never
- Less than 15 minutes per week
- Between 15 and 60 minutes per week
- Between 1 and 2 hours per week
- Between 2 and 4 hours per week
- More than 4 hours per week

---

6 On average, approximately how often did you interact with your colleagues (either face-to-face or online) about topics related to teaching math?

- Never
- Less than 15 minutes per week
- Between 15 and 60 minutes per week
- Between 1 and 2 hours per week
- Between 2 and 4 hours per week
- More than 4 hours per week

Michigan Community College Math Faculty Survey

7 What is your gender?

- Female
- Male

8 Which of the following degrees have you completed? **Choose all that apply.**

- Bachelors in Mathematics
- Bachelors in Math Education
- Bachelors in Statistics
- Bachelors in Education or some other non-math education-related field (e.g. Physics Ed or Ed Tech)
- Bachelors in a math-related science (e.g. Physics, Chemistry, Engineering)
- Bachelors in a math-related business field (e.g. Economics, Finance)
- Bachelors in some field not directly listed here
- Masters in Mathematics
- Masters in Math Education
- Masters in Statistics
- Masters in Education or some other non-math education-related field (e.g. Physics Ed or Ed Tech)
- Masters in a math-related science (e.g. Physics, Chemistry, Engineering)
- Masters in a math-related business field (e.g. Economics, Finance)
- Masters in some field not directly listed here
- Ph.D. in Mathematics
- Ph.D. or Ed.D. in Math Education
- Ph.D. in Statistics
- Ph.D. or Ed.D. in Education or some other non-math education-related field (e.g. Physics Ed or Ed Tech)
- Ph.D. in a math-related science (e.g. Physics, Chemistry, Engineering)

- Ph.D. in a math-related business field (e.g. Economics, Finance)
- Ph.D. or Ed.D. in some field not directly listed here
- Other, please specify

---

9 What **year** did you complete the coursework for your highest earned degree?

(answer as a four-digit year) __ __ __ __

---

10 How many total years of full-time-equivalent teaching experience do you have in teaching mathematics? (for example, two years teaching a half-load would equal one year of full-time equivalent) **Please round to the nearest half-year**.

---

11 At how many different colleges have you taught math?

---

12 Which of the following math courses have you taught before? **Choose all that apply.**

- Arithmetic or Basic Math
- Prealgebra
- Beginning Algebra
- Intermediate Algebra
- College Algebra
- Trigonometry
- College Algebra and Trigonometry (combined)
- Precalculus
- Introduction to Math Modeling
- Math for Liberal Arts
- Math for Elementary Teachers
- Finite Math
- Discrete Math

- Probability and Statistics
- Calculus I
- Calculus II
- Calculus III
- Business Calculus
- Differential Equations
- Linear Algebra

SUBMIT

Survey Page 3

Michigan Community College Math Faculty Survey

Approaches to Teaching Inventory

In the first section of this survey, you will take the 22-question Approaches to Teaching Inventory, developed by Prosser and Trigwell (1999, 2004). The questions may seem a bit repetitive at times, but this is part of the design of the survey instrument.

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

13 In math, students should focus their study on what I provide them.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

14 It is important that math should be completely described in terms of specific objectives that relate to formal assessment items (e.g. exams).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

15 In my interactions with math students, I try to develop a conversation with them about the topics we are studying.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

16 It is important to present a lot of facts to students so that they know what they have to learn in math.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

17 I set aside some teaching time so that the students can discuss, among themselves, key concepts and ideas in math.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

18 I concentrate on covering the information that might be available from key texts and readings.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

19 I encourage students to restructure their existing knowledge in terms of the new ways of thinking about math that they will develop.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

20 In teaching sessions for math, I deliberately provoke debate and discussion.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

21 I structure my teaching in math to help students to pass the formal assessment items (e.g. exams).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

22 I think an important reason for teaching lessons in math is to give students a good set of notes.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

23 In math, I provide the students with the information they will need to pass the formal assessments (e.g. exams).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

24 I should know the answers to any questions that students may put to me during a math class.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

25 I make opportunities available for students in this subject to discuss their changing understanding of math.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

26 It is better for math students to generate their own notes rather than to copy mine.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

27 A lot of teaching time in math should be used to question students' ideas.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

28 In math, my teaching focuses on the good presentation of information to students.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

29 I see teaching math as helping students develop new ways of thinking.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

30 In teaching math, it is important for me to monitor students' changed understanding of the subject matter.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

31 My math teaching focuses on delivering what I know to the students.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

32 Math teaching should help students question their own understanding of the subject matter.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

33 Math teaching should include helping students find their own learning resources.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

34 I present material to enable students to build up an information base in math.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

SUBMIT

Survey Page 4

Michigan Community College Math Faculty Survey

35 For the rest of this survey, please focus on **one level** of math that you have taught during the last year. Please focus on a level in which you teach at least 50% of the time in the classroom.

For the rest of the survey, when you see **Algebra / Precalculus / Calculus**, you will focus on the level that you choose in this question.

- **Algebra** (Beginning Algebra or Intermediate Algebra)
- **Precalculus** (College Algebra, Trigonometry, or Precalculus level courses)
- **Calculus** (Calculus I, Calculus II, Calculus III or Calculus for non-majors courses)
- I don't teach any of these types of courses.

SUBMIT

Survey Page 5

Michigan Community College Math Faculty Survey

Control of Teaching

This section of this survey asks you to respond to questions about the level of control that you have over your teaching environment.

Choose the number that most closely corresponds with what your experiences are when you teach a course at your chosen level (**Algebra / Precalculus / Calculus**).

36 I have very little say in how the courses at this level are run.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

37 The department allows me considerable flexibility in the way I teach courses at this level.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

38 I have control over the **content** that I teach in these courses.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

39 I have control over the **way** I choose to teach in these courses.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

40 I am able to choose my classroom setting for courses at this level (e.g. fixed rows, tables & chairs, type of available technology).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

41 I find it difficult to cover the content of these courses in the allotted time.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

SUBMIT

Michigan Community College Math Faculty Survey

Now you will be presented with three instructional practices that are commonly used in mathematics (one at a time). For each practice, you will be able to read a description of the practice and several examples. After you read about the practice, you will be asked to answer a set of questions that is about that practice.

If you would like to print a copy of the three instructional practices that you are about to read, you can do so by clicking on this link and printing the pages in the window that opens.

At the end of this survey, you will also be given the web link to a site where all the math instructional practices are described in detail, in case you are interested in the research.

CONTINUE WHEN YOU ARE READY

SUBMIT

Survey Page 7

Michigan Community College Math Faculty Survey

Please read the following description and examples of the Mathematics Instructional Practice called **Cooperative Learning**. Again, if you'd like to print these practices to read "off-screen" you may do so by opening a separate window to the document.

Cooperative learning, collaborative learning, and group learning are often used interchangeably in the research literature. For the purpose of this research we consider them to be the interchangeable terms, and define cooperative learning as the practice of including class time for learning that engages students in working and learning together in small groups, typically with two to five members. Cooperative learning strategies are designed to engage students actively in the learning process through inquiry and discussions with their classmates (Rogers et al., 2001; Davidson et al., 2001).

To illustrate this instructional practice in the mathematics context, three examples of cooperative learning are provided:

Example 1: All of the students in the class find a partner and a spot at the whiteboards in the classroom. The instructor reads a factoring problem aloud and the students work together to solve the problem at the board. The students help each other within pairs and between pairs, asking questions and providing hints to each other. The instructor occasionally provides hints to pairs of students, but it is primarily students who are answering each others' questions. Every few minutes, the instructor directs one person from each pair to move to the right, and reads a new question for the new pair of students to solve together.

Example 2: The instructor poses the following question to an algebra class, "How do you find the least common denominator for any set of fractions?" Students are given two minutes to think about the problem on their own, and then they join a group to solve the problem. After 8 minutes, each group presents their solution to the rest of the class.

Example 3: Class is held in a room with eight computer stations. Students work together in groups of three to complete an activity about inverses using a spreadsheet program. One student is designated as the computer-specialist, one student has responsibility for writing the responses to turn in, and the third student will present the results of their experimentation to the rest of the class.

42 Before reading this, were you familiar with cooperative learning as described?

- No.
- Yes, I was taught math this way when I was a student.
- Yes, I first learned about this from a colleague.
- Yes, I first learned about this in some kind of professional training.
- Yes, I first learned about this in something I read.
- Yes, but I don't know how I was first exposed to this idea.
- Yes, but I figured this out on my own through experimentation.

Consider the use of **Collaborative Learning** as an instructional practice.

Even if you have not used this technique, choose the number that most closely corresponds with what you think, based on your experiences with teaching at your chosen level of mathematics for this survey (**Algebra / Precalculus / Calculus**).

43 Cooperative learning is effective for student learning.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

44 Students will enjoy learning with cooperative learning.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

45 Cooperative learning makes good use of class time.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

46 It would be easy for me to use cooperative learning with large class sizes (above 30 students).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

47 I would be able to use cooperative learning in any classroom that I am assigned.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

48 It would be easy for me to use cooperative learning even when some students do not complete their assignments.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

49 It would be easy for me to use cooperative learning even when some students miss a lot of class.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

50 It would be easy for me to use cooperative learning when the students vary a great degree in skill level.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

51 Cooperative learning would be easy for me to use with students who are taking the course for the first time.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

52 Cooperative learning would be easy for me to use with students who are repeating the course.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

53 Cooperative learning would be easy for me to use if my class contained both students who are seeing the math for the first time AND students who are repeating the course.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

54 It would be easy for me to use cooperative learning with students that have poor reading and writing skills.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

55 The amount of time it would take me to prepare for class using cooperative learning would make me hesitant about using it.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

56 The amount of time that I would have to spend grading would make me hesitant to use cooperative learning.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

57 The amount of time that I would spend outside of class interacting with students in order to use cooperative learning would make me hesitant about using it.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

58 If I wanted to, I would be allowed by my department to use cooperative learning at this level of math (Algebra / Precalculus / Calculus).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

59 If I wanted to, I would feel comfortable using cooperative learning without any additional training.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

60 If there were less content to cover in courses at this level of math, I would be more inclined to use cooperative learning (or use it more often).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

61 Please share anything else you'd like to say about cooperative learning.

SUBMIT

Survey Page 8

Michigan Community College Math Faculty Survey

Please read the following description and examples of the Mathematics Instructional Practice called **Inquiry-based Learning** (IBL). Again, if you'd like to print these practices to read "off-screen" you may do so by opening a separate window to the document.

Inquiry-based learning is a student-focused instructional practice defined as designing and using activities where students learn new concepts by actively doing and reflecting on what they have done. The guiding principle is that instructors try not to talk in depth about a concept until students have had an opportunity to think about it first (Hastings, 2006).

Three examples are given to illustrate inquiry-based learning (IBL) for mathematics:

Example 1: Students use colored red and black counters to represent negative and positive integers. Students model the additions of signed numbers by matching up and removing pairs of red & black tiles until there are no more pairs. After several problems, each student proposes a "rule" for how to add integers of various types.

Example 2: Students use spreadsheets or the data table on a graphing calculator to explore how a change in the function equation affects the data it produces. Students propose an explanation for what they see and then devise and conduct tests of their hypotheses.

Example 3: Students use the slider bars on an interactive online model to experiment with the effect of changing a coefficient on the graph of the function. Students work in teams to come up with a precise definition for how the coefficient affects the graph.

62 Before reading this, were you familiar with Inquiry-based Learning as described?

- No.
- Yes, I was taught math this way when I was a student.
- Yes, I first learned about this from a colleague.
- Yes, I first learned about this in some kind of professional training.
- Yes, I first learned about this in something I read.
- Yes, but I don't know how I was first exposed to this idea.
- Yes, but I figured this out on my own through experimentation.

Consider the use of **Inquiry-based Learning (IBL)** as an instructional practice.

Even if you have not used this technique, choose the number that most closely corresponds with what you think, based on your experiences with teaching at your chosen level of mathematics for this survey (**Algebra / Precalculus / Calculus**).

63 Inquiry-based learning is effective for student learning.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

64 Students will enjoy learning with inquiry-based learning.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

65 Inquiry-based learning makes good use of class time.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

66 It would be easy for me to use inquiry-based learning with large class sizes (above 30 students).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

67 I would be able to use inquiry-based learning in any classroom that I am assigned.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

68 It would be easy for me to use inquiry-based learning even when some students do not complete their assignments.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

69 It would be easy for me to use inquiry-based learning even when some students miss a lot of class.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

70 It would be easy for me to use inquiry-based learning when the students vary a great degree in skill level.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

71 Inquiry-based learning would be easy for me to use with students who are taking the course for the first time.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

72 Inquiry-based learning would be easy for me to use with students who are repeating the course.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

73 Inquiry-based learning would be easy for me to use if my class contained both students who are seeing the math for the first time AND students who are repeating the course.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

74 It would be easy for me to use inquiry-based learning with students that have poor reading and writing skills.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

75 The amount of time it would take me to prepare for class using inquiry-based learning would make me hesitant about using it.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

76 The amount of time that I would have to spend grading would make me hesitant to use inquiry-based learning.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

77 The amount of time that I would spend outside of class interacting with students in order to use inquiry-based learning would make me hesitant about using it.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

78 If I wanted to, I would be allowed by my department to use inquiry-based learning at this level of math (Algebra/Precalculus/Calculus).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

79 If I wanted to, I would feel comfortable using inquiry-based learning without any additional training.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

80 If there were less content to cover in courses at this level of math, I would be more inclined to use inquiry-based learning (or use it more often).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

81 Please share anything else you'd like to say about inquiry-based learning.

SUBMIT

Survey Page 9

Michigan Community College Math Faculty Survey

Please read the following description and examples of the Mathematics Instructional Practice called **Lecture**. Again, if you'd like to print these practices to read "off-screen" you may do so by opening a separate window to the document.

Lecture, for the purposes of this research, shall be defined as teaching by giving a presentation on some subject for a time period longer than 20 minutes. This instructional method includes the exchange of questions and answers between the instructor and students. The key characteristic is that the students rarely interact with each other during this learning process (Andersen, 2009).

Three examples are provided to illustrate a range of usage in mathematics:

Example 1: The instructor presents a logical narrative on exponential functions using a whiteboard. The narrative includes definitions, example problems, and application problems. The instructor periodically asks if there are any questions about the material.

Example 2: The instructor presents a lesson on graphing lines using an overhead graphing calculator viewscreen to show students how changes to the algebraic function result in changes to the graph. The students follow along, each using their own graphing calculator and occasionally interject questions when they have a problem with the technology.

Example 3: The instructor uses PowerPoint and video from the Internet to present a lesson showing students how the path followed by a cannonball is modeled by a quadratic equation, and how to find that equation. Students with laptops click through the slides as they listen and watch the presentation.

82 Before reading this, were you familiar with the lecture method as described?

- No.
- Yes, I was taught math this way when I was a student.
- Yes, I first learned about this from a colleague.
- Yes, I first learned about this in some kind of professional training.
- Yes, I first learned about this in something I read.
- Yes, but I don't know how I was first exposed to this idea.
- Yes, but I figured this out on my own through experimentation.

Consider the use of the **lecture method** as an instructional practice.

Even if you have not used this technique, choose the number that most closely corresponds with what you think, based on your experiences with teaching at your chosen level of mathematics for this survey (**Algebra / Precalculus / Calculus**).

83 The lecture method is effective for student learning.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

84 Students will enjoy learning with the lecture method.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

85 The lecture method makes good use of class time.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

86 It would be easy for me to use the lecture method with large class sizes (above 30 students).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

87 I would be able to use the lecture method in any classroom that I am assigned.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

88 It would be easy for me to use the lecture method even when some students do not complete their assignments.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

89 It would be easy for me to use the lecture method even when some students miss a lot of class.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

90 It would be easy for me to use the lecture method when the students vary a great degree in skill level.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

91 The lecture method would be easy for me to use with students who are taking the course for the first time.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

92 The lecture method would be easy for me to use with students who are repeating the course.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

93 The lecture method would be easy for me to use if my class contained both students who are seeing the math for the first time AND students who are repeating the course.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

94 It would be easy for me to use the lecture method with students that have poor reading and writing skills.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

95 The amount of time it would take me to prepare for class using the lecture method would make me hesitant about using it.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

96 The amount of time that I would have to spend grading would make me hesitant to use the lecture method.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

97 The amount of time that I would spend outside of class interacting with students in order to use the lecture method would make me hesitant about using it.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

98 If I wanted to, I would be allowed by my department to use the lecture method at this level of math (Algebra/Precalculus/Calculus).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

99 If I wanted to, I would feel comfortable using the lecture method without any additional training.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

100 If there were less content to cover in courses at this level of math, I would be more inclined to use the lecture method (or use it more often).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

101 Please share anything else you'd like to say about the lecture method.

SUBMIT

Survey Page 10

Michigan Community College Math Faculty Survey

Thank you for getting this far. This is the last page of required questions.

Now I'd like to know how much you actually use these instructional practices when you teach at the level you've chosen for this survey (**Algebra / Precalculus / Calculus**).

It is likely that your teaching is a mix of several practices, some used more frequently than others. There may be some practices that you never use, and that is just fine.

102 During the last year, how frequently did you use **Cooperative Learning** practices in the classroom portion of your course? (answer at the level of math that you've chosen for this survey, Algebra / Precalculus / Calculus)

Never	Once or Twice	Several Times	Weekly	For nearly every class	Multiple times every class
1	2	3	4	5	6

103 During the last year, how frequently did you use **Inquiry-based Learning** practices in the classroom portion of your course? (answer at the level of math that you've chosen for this survey, Algebra / Precalculus / Calculus)

Never	Once or Twice	Several Times	Weekly	For nearly every class	Multiple times every class
1	2	3	4	5	6

104 During the last year, how frequently did you use the **lecture method** in the classroom portion of your course? (answer at the level of math that you've chosen for this survey, Algebra / Precalculus / Calculus)

Never	Once or Twice	Several Times	Weekly	For nearly every class	Multiple times every class
1	2	3	4	5	6

SUBMIT

Survey Page 11

Michigan Community College Math Faculty Survey

At this point, you've completed the required portion of the survey and are eligible for the gift certificate drawing (enter your email address below).

105 Enter your email address to be entered in the drawing for one of three $100 Amazon.com Gift Certificates.

THANK YOU for taking the time to help me complete my dissertation research and contribute to a body of knowledge that we know very little about.

If you have a little more time (15 minutes or so), and are willing to answer more questions, there are three other instructional practices that I'd like to collect data about:

- Mastery learning
- Project-based learning
- Emphasis on communication skills.

This is completely optional.

106 What would you like to do?

- I'm done. I'd like to exit the survey.
- I've got time, I'll answer the extra questions.

SUBMIT

Survey Page 12

Michigan Community College Math Faculty Survey

If you'd like to print this second set of instructional practices to read "off-screen" you may do so by opening a separate window to the document.

Please read the following description and examples of the Mathematics Instructional Practice called **Mastery Learning**.

Mastery Learning is an instructional practice where summative assessment check-points are designed as a crucial part of the instructional program. At each check point, students are tested on their mastery of a single topic (or subtopic). The instructor may coach students during class time or outside of class to help students who struggle with understanding the concepts while they are intensely focused on learning. A key element of mastery learning is that the students do not receive partial credit for partially correct responses on mastery-based assessments (Andersen, 2009).

Four examples illustrate the use of this technique in mathematics instruction:

Example 1: The course is taught in a self-paced lab format. Students cannot continue to the next module in the course until they pass the previous module with an 80% on the end-of-module assessment. The instructor is present during lab time to answer questions, provide coaching, and motivate students to stay on track.

Example 2: Using the course management system Blackboard, an instructor sets up check point quizzes for students to complete after class each day. The quizzes are algorithmically generated, and students may take the quizzes multiple times, but they must answer 80% of the questions correctly before the score is recorded.

Example 3: At the end of the semester, students are each given an oral exam to assess their mastery of the subject. Each question the instructor asks is graded on a pass/fail basis and the oral exam is a major component of the course grade.

Example 4: Midway through the semester, students take a Gateway exam on logarithmic and exponential functions. Problems are graded correct or incorrect. The students must get at least an 80% to have a score recorded for the exam. They may retake the exam five times over a period of two weeks.

107 Before reading this, were you familiar with this technique as described?

- No.
- Yes, I was taught math this way when I was a student.
- Yes, I first learned about this from a colleague.
- Yes, I first learned about this in some kind of professional training.
- Yes, I first learned about this in something I read.
- Yes, but I don’t know how I was first exposed to this idea.
- Yes, but I figured this out on my own through experimentation.

Consider the use of **Mastery Learning** as an instructional practice.

Even if you have not used this technique, choose the number that most closely corresponds with what you think, based on your experiences with teaching at your chosen level of mathematics for this survey (**Algebra / Precalculus / Calculus**).

108 Mastery learning is effective for student learning.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

109 Students will enjoy learning with mastery learning.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

110 Mastery learning makes good use of class time.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

111 It would be easy for me to use mastery learning with large class sizes (above 30 students).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

112 I would be able to use mastery learning in any classroom that I am assigned.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

113 It would be easy for me to use mastery learning even when some students do not complete their assignments.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

114 It would be easy for me to use mastery learning even when some students miss a lot of class.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

115 It would be easy for me to use mastery learning when the students vary a great degree in skill level.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

116 Mastery learning would be easy for me to use with students who are taking the course for the first time.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

117 Mastery learning would be easy for me to use with students who are repeating the course.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

118 Mastery learning would be easy for me to use if my class contained both students who are seeing the math for the first time AND students who are repeating the course.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

119 It would be easy for me to use mastery learning with students that have poor reading and writing skills.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

120 The amount of time it would take me to prepare for class using mastery learning would make me hesitant about using it.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

121 The amount of time that I would have to spend grading would make me hesitant to use mastery learning.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

122 The amount of time that I would spend outside of class interacting with students in order to use mastery learning would make me hesitant about using it.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

123 If I wanted to, I would be allowed by my department to use mastery learning at this level of math (Algebra/Precalculus /Calculus).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

124 If I wanted to, I would feel comfortable using mastery learning without any additional training.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

125 If there were less content to cover in courses at this level of math, I would be more inclined to use mastery learning (or use it more often).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

126

Please share anything else you'd like to say about mastery learning.

SUBMIT

Survey Page 13

Michigan Community College Math Faculty Survey

Please read the following description and examples of the Mathematics Instructional Practice called **Emphasis on Communication Skills**. If you'd like to print this to read "off-screen" you may do so by opening a separate window to the document.

An instructor who chooses to emphasize communication skills as an instructional practice provides opportunities for students to practice their ability to communicate mathematical and quantitative ideas using both written and oral communications (Andersen, 2009).

Five examples follow to illustrate the emphasis on communication skills in mathematics instruction:

Example 1: At the beginning of each class, the instructor chooses two students to each present a selected homework problem. Each student presents their answer to the class, explaining each step to the class as they go.

Example 2: Ten minutes before the end of class, the instructor has the students write one paragraph about what they have learned in class that day. The writing assignments are turned in to the instructor, who chooses several paragraphs to copy (without student names), and then corrects the mathematical language, spelling, and grammar. The next day in class, each student receives a copy of the uncorrected student paragraphs to correct themselves. Then they compare their corrections with the instructors' corrections to learn from what they missed.

Example 3: In an algebra class, students are required to answer every application problem in a complete sentence that summarizes both the problem statement and solution.

Example 4: Students in a trigonometry class have to write their own application problem (and solution) based on some situation in their own life. The assignment is graded on the clarity and quality of the writing, and the accuracy of the mathematics.

Example 5: Students take a mathematical version of a "spelling test" where the instructor reads five problems aloud and the student writes the problems down. Then the instructor shows the students the answers, and students correct their own work to learn from their mistakes.

127 Before reading this, were you familiar with this technique as described?

- No.
- Yes, I was taught math this way when I was a student.

- Yes, I first learned about this from a colleague.
- Yes, I first learned about this in some kind of professional training.
- Yes, I first learned about this in something I read.
- Yes, but I don't know how I was first exposed to this idea.
- Yes, but I figured this out on my own through experimentation.

Consider the **emphasis on communication skills** as an instructional practice.

Even if you have not used this technique, choose the number that most closely corresponds with what you think, based on your experiences with teaching at your chosen level of mathematics for this survey (**Algebra / Precalculus / Calculus**).

128 Emphasizing communication skills is effective for student learning.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

129 Students will enjoy learning with an emphasis on communication skills.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

130 Emphasizing communication skills makes good use of class time.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

131 It would be easy for me to use an emphasis on communication skills with large class sizes (above 30 students).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

132 I would be able to use an emphasis on communication skills in any classroom that I am assigned.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

133 It would be easy for me to use an emphasis on communication skills even when some students do not complete their assignments.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

134 It would be easy for me to use an emphasis on communication skills even when some students miss a lot of class.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

135 It would be easy for me to use an emphasis on communication skills when the students vary a great degree in skill level.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

136 An emphasis on communication skills would be easy for me to use with students who are taking the course for the first time.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

137 An emphasis on communication skills would be easy for me to use with students who are repeating the course.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

138 An emphasis on communication skills would be easy for me to use if my class contained both students who are seeing the math for the first time AND students who are repeating the course.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

139 It would be easy for me to use an emphasis on communication skills with students that have poor reading and writing skills.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

140 The amount of time it would take me to prepare for class using an emphasis on communication skills would make me hesitant about using it.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

141 The amount of time that I would have to spend grading would make me hesitant to use an emphasis on communication skills.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

142 The amount of time that I would spend outside of class interacting with students in order to use an emphasis on communication skills would make me hesitant about using it.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

143 If I wanted to, I would be allowed by my department to use an emphasis on communication skills at this level of math (Algebra/Precalculus/Calculus).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

144 If I wanted to, I would feel comfortable using an emphasis on communication skills without any additional training.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

145 If there were less content to cover in courses at this level of math, I would be more inclined to use an emphasis on communication skills (or use it more often).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

146 Please share anything else you'd like to say about teaching with an emphasis on communication skills.

SUBMIT

Survey Page 14

Michigan Community College Math Faculty Survey

Please read the following description and examples of the Mathematics Instructional Practice called **Project-based Learning**. If you'd like to print this to read "off-screen" you may do so by opening a separate window to the document.

Project-based learning is defined as designing and assigning project work that requires students to solve a non-standard problem that requires a longer period of time than problems that would typically be assigned for homework or in class. There is often a research component where students must actively seek data, background knowledge, or formulas. Often the students work on projects in pairs or small groups. The final result of a project might include a written paper or a presentation on the findings (Andersen, 2009).

Three examples are given to illustrate project-based learning in mathematics:

Example 1: In an assignment that takes several weeks to complete, students are required to compile data from three different government databases, find functions to model the data, and then use the functions to make predictions about the future. The instructor reserves two days of class time for the students to present their findings to the class.

Example 2: Students in an algebra class are asked to design an experiment to test the assertion that the circumference of a circle is pi times the diameter. After writing a paragraph to describe how they are going to test the rule, and getting approval from the instructor, the student carries out several trials, records the data, analyzes it, and then writes up the results.

Example 3: Students work in groups to analyze statistics on the energy efficiency of one of the buildings on campus. Students have to determine (on their own) how to measure energy efficiency, gather the data, and analyze it. To present their findings, each group prepares a poster and then presents the results to the Supervisor of Buildings & Grounds.

147 Before reading this, were you familiar with this technique as described?

- No.
- Yes, I was taught math this way when I was a student.
- Yes, I first learned about this from a colleague.
- Yes, I first learned about this in some kind of professional training.
- Yes, I first learned about this in something I read.
- Yes, but I don’t know how I was first exposed to this idea.

- Yes, but I figured this out on my own through experimentation.

Consider the use of **Project-based Learning** as an instructional practice.

Even if you have not used this technique, choose the number that most closely corresponds with what you think, based on your experiences with teaching at your chosen level of mathematics for this survey (**Algebra / Precalculus / Calculus**).

148 Project-based learning is effective for student learning.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

149 Students will enjoy learning with project-based learning.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

150 Project-based learning makes good use of class time.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

151 It would be easy for me to use project-based learning with large class sizes (above 30 students).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

152 I would be able to use project-based learning in any classroom that I am assigned.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

153 It would be easy for me to use project-based learning even when some students do not complete their assignments.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

154 It would be easy for me to use project-based learning even when some students miss a lot of class.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

155 It would be easy for me to use project-based learning when the students vary a great degree in skill level.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

156 Project-based learning would be easy for me to use with students who are taking the course for the first time.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

157 Project-based learning would be easy for me to use with students who are repeating the course.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

158 Project-based learning would be easy for me to use if my class contained both students who are seeing the math for the first time AND students who are repeating the course.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

159 It would be easy for me to use project-based learning with students that have poor reading and writing skills.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

160 The amount of time it would take me to prepare for class using project-based learning would make me hesitant about using it.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

161 The amount of time that I would have to spend grading would make me hesitant to use project-based learning.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

162 The amount of time that I would spend outside of class interacting with students in order to use project-based learning would make me hesitant about using it.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

163 If I wanted to, I would be allowed by my department to use project-based learning at this level of math (Algebra/Precalculus/Calculus).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

164 If I wanted to, I would feel comfortable using project-based learning without any additional training.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

165 If there were less content to cover in courses at this level of math, I would be more inclined to use project-based learning (or use it more often).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

166 Please share anything else you'd like to say about project-based learning.

SUBMIT

Michigan Community College Math Faculty Survey

This is the last page of optional questions. Thank you so much for getting this far!

I'd like to know how much you actually use these instructional practices when you teach at the level you've chosen for this survey (**Algebra / Precalculus / Calculus**). Again, if you'd like to print these practices to read "off-screen" you may do so by opening a separate window to the document.

It is likely that your teaching is a mix of several practices, some used more frequently than others. There may be some practices that you never use, and that is just fine.

167 During the last year, how frequently did you use **Mastery Learning** practices in your course? (answer at the level of math that you've chosen for this survey, Algebra / Precalculus / Calculus)

Never	Once or Twice	Several Times	Weekly	For nearly every class	Multiple times every class
1	2	3	4	5	6

168 During the last year, how frequently did you **emphasize the use of communication skills** in the classroom portion of your course? (answer at the level of math that you've chosen for this survey, Algebra / Precalculus / Calculus)

Never	Once or Twice	Several Times	Weekly	For nearly every class	Multiple times every class
1	2	3	4	5	6

169 During the last year, how frequently did you use **project-based learning** practices in the classroom portion of your course? (answer at the level of math that you've chosen for this survey, Algebra / Precalculus / Calculus)

Never	Once or Twice	Several Times	Weekly	For nearly every class	Multiple times every class
1	2	3	4	5	6

SUBMIT