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FACULTY DEFINITIONS OF AND BELIEFS ABOUT STUDENT ABILITY: ARE THEY RELATED TO CLASSROOM STRUCTURES, STUDENT RETENTION, AND STUDENT PASS RATES?

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FACULTY DEFINITIONS OF AND BELIEFS ABOUT STUDENT ABILITY: ARE THEY RELATED TO CLASSROOM STRUCTURES, STUDENT RETENTION, AND STUDENT PASS RATES?

A Dissertation APPROVED FOR THE DEPARTMENT OF EDUCATIONAL PSYCHOLOGY

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After completing a Masters, I pondered whether to apply to a doctoral program. My education and training and development experiences had opened the door for many questions about how people learn, how do instructors effectively facilitate learning, and what motivates students to participate in the process. My concern was the length of time it would take me to complete the degree and my age at graduation. A friend responded to my thoughts with, "Well, pretend you are five years down the road and how would you feel if you did not do this?" The answer was instant, "I'd have missed the boat!" Although I do not know where this "boat" will lead, I am so grateful I made the decision to pursue a Ph.D. in Education, Instructional Psychology and Technology at University of Oklahoma. The work has been both challenging and rewarding and provided the framework to continue the quest for answers to more and more questions.

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ABSTRACT

Due to community college faculty and staff concerns about low adult student retention and pass rates, an exploratory study of mathematics faculty definitions of mathematical ability, their beliefs about the nature of mathematical ability, and the classroom structures implemented was conducted. The purpose of the study was to explore the possibility that faculty definitions, beliefs, and usage of classroom structures may contribute to having higher or lower retention and pass rates.

Four fulltime mathematics faculty from two different community colleges in a southwestern metropolitan city were selected based on either high or low retention and pass rates. Eight faculty were interviewed and their replies were compared and investigated.

Analysis of the interviews indicated that faculty do not have a common definition of mathematical ability and while all believed that students could learn, a few voiced the belief that students have ceilings or limits to their ability. Faculty with high retention and pass rates reported use of more activities and more active learning structures in the classroom. Cooperative group activities and boardwork were reported actively used by them. Those with low rates selected primarily lecture and imbedded problem questions. Control was referenced by the 3 younger males and the attitude of students was often mentioned as a concern limiting achievement. Faculty attitude may be another consideration.

Implications include inservice professional development programs focused on learning theories, active learning strategies, task involvement vs ego involvement, and

students' perception of task meaning as related to learning and ability level change. Another important consideration would be a comparison of the reasons faculty choose the classroom structures and the reasons community college students choose to engage in or not engage in those structures. Both faculty and student beliefs and perceptions will continue to be an important consideration for research and discussion.

DISSERTATION

CHAPTER 1

INTRODUCTION

One of the problems facing community colleges is that courses intended to teach pre-college level mathematics are often not successful in terms of retention and pass rates. In other words, students who come to the community college with hopes of transferring to a four-year college or university, or of building a career path, are often thwarted early on if they are deficient in mathematics knowledge and skills. Since the mission of the community college is to foster student academic success, beginning at whatever level of competence each student evidences, the lack of success with mathematics is a major concern.

Public two year colleges in 1991 numbered almost 1,400 and enrolled approximately 5.4 million students or about 48 percent of the students in higher education (Voorhees, 1997). In 1996 the federal government reported that most two-year community colleges offered from one to four pre-college level mathematics courses (US Department of Ed., 1996) for the purpose of enhancing students' opportunities to be successful in later college level mathematics courses. Overall, 41 percent of the first-time public community college students enrolled in one or more remedial classes and 34 percent enrolled in pre-college mathematics according to 1995 data (US Department of Ed., 1996). In Fall 1995, 16,380 new freshmen entered Oklahoma community colleges. Of these, 7,609 (46%) enrolled in remediation and 6,155 (81% of 7,609) of them enrolled in remedial mathematics. Of the students enrolled in remedial mathematics classes at the two public community colleges investigated in this study, approximately 40 to 90 percent passed the courses. The other 60 percent at one community college 10 percent at the other either failed or withdrew.

These statistics reveal that a significant proportion of students, who enrolled in community colleges, lacked the needed skills and knowledge to be successful in college level mathematics courses. Of those enrolled in remedial courses largest proportion enrolled in remedial mathematics classes. Although the proportion of students needing remedial mathematics is disappointing, it is the lack of success, as evidenced by the low pass and retention rates, within the course that is of greater concern for the present study.[1]

Although there are numerous factors that probably influence the low pass and retention rates associated with remedial mathematics classes, the present study is based on the theory and research that suggests that teacher beliefs about student ability can indirectly impact student success through the impact on the learning environment and on student beliefs. Classroom research has shown that teacher beliefs influence the nature of the learning environment (e.g., Good and Weinstein, 1986; Good and Brophy, 1994). Good and Weinstein (1986) noted that the classroom experiences of students whom the teacher thought were less capable were sometimes both quantatively and qualitatively different from the experiences of students whom the teacher thought were more capable of learning. For example, the students thought to be less capable

1.Although retention and pass rates may not be the best indicators of student understanding, they are indicators institutions monitor carefully as part of their assessment and institutional effectiveness evaluations. Also, the North Central Association accreditation body has ruled that G.P.A. is not a suitable measure of student learning. (NCA, 1994) Therefore, faculty and staff will continue to monitor pass and retention rates as indicators of student academic success and the institution's success in meeting its mission.

were found to experience the following when compared to the students thought to be less capable: Less opportunity to engage in meaningful learning tasks, less opportunity to engage in learning tasks that require higher level cognition (e.g., comprehension, analysis, and synthesis), fewer choices of learning activities, less autonomy in the classroom, and less honest, more gratuitous, feedback on performance. Such differences in the learning environment can result in different opportunities for learning which will lead to differential performance.

Research has shown that teacher beliefs about student ability can affect students' beliefs about their abilities. Information about teacher expectations for student learning is conveyed to students through their interpretations of the teaching-learning situation (e.g., Maehr, 1984) and can be internalized as evidence for either low or high ability (e.g., Eccles and Wigfield, 1985). There is a large body of research on the relationship between self-efficacy, or confidence in one's ability to be successful, and achievement (e.g., Bandura, 1993; Greene and Miller, 1996).

In addition to the theory and research regarding the effects of teacher beliefs on student learning and motivation, some of my professional experiences encouraged my focus on teacher beliefs. As Director of Institutional Assessment and Planning at a community college, I have heard faculty and administrators express concern about this problem. I have also heard faculty and staff here and across the country discuss concern that some students are repeating mathematics classes two and three times before passing and worry that others may be dropping out of college as a result of continued failure. Some have expressed concern about whether all students are capable of learning mathematics. As they considered the reasons for the low pass and retention rates, they made comments like the following: "These students just are not good at math," "If they have not learned mathematics in twelve years of schooling, why would anyone suppose they could learn it in college?" and "Statistically speaking, I know that only one out of three in my class will complete the course with a passing grade."

It seems that some faculty may hold the belief that students are born with an innate mathematical ability, intelligence, or capacity; if they do not have the capacity, they are not likely to obtain it in a college mathematics class. Other faculty may hold the belief that students who did not learn mathematics during twelve years of prior schooling cannot be expected to learn it just because they are in college classes. Still others may be supposing that by the time students reach college whatever change in mathematical ability that has taken place is fixed and cannot change significantly. According to these beliefs, attempting to gain competency in a college-level mathematics class for many students will be futile.

Although such limiting beliefs about student ability may exist, not all faculty have these concerns about ability. In discussion on college campuses and at conferences some faculty have reported their belief that student attitudes towards mathematics limit their initial willingness to engage in mathematics learning. Fortunately, some of these faculty indicate they have found ways to help students reframe attitudes and successfully engage in the learning activities. They also recognize students' lack of basic mathematics skills and talk about how they present skills and concepts to encourage students' knowledge construction. They model the thinking patterns for students, want students to work through the process themselves, encourage mastery of the needed skills and concepts, and watch for ownership of the mathematical relationships. Faculty talk about strategies and effort on their part to facilitate student learning. Underlying this, they voice and act on a confidence or belief in students' ability to achieve expected mathematical levels of thinking and performing. They assume mathematical knowledge and ability can improve.

As I thought about faculty comments and considered the statistical data, I wondered where a community college study could lend help in solving the problem. I considered a study of students as well as faculty. Because faculty are concerned about their students and having heard faculty discuss their beliefs about students, I chose as a beginning point to conduct a formal examination of the role of faculty beliefs. In the remainder of this chapter, I will review the theoretical foundations for the study and conclude with the proposed research questions. Nicholls' (1984) theory will be used to lay the research framework for the research problem; and the work of Maehr (1992), Epstein (1988), and Ames (1984) provides structures for how to explore the problem. In Chapter II, I describe methodology used, the results are presented in Chapter III, and finally, Chapter IV includes a discussion of the results as they relate to the theoretical framework, the limitations, implications and recommendations, and final comments.

THEORETICAL FOUNDATIONS

Nicholls' (1984) Theory on the Nature of Student Ability

In this section, Nicholls' (1984) theory of beliefs about ability will be described because research has shown that beliefs about ability are related to achievement behaviors such as effort and persistence (e.g., Bandura, 1993; Wigfield and Harold, 1992). According to Nicholls (1984), there are two general beliefs about ability. For some, ability is believed to be an acquirable human trait that is increased by gaining knowledge and competencies. Others believe it is an inherent capacity where performance is indicative of ability level. Students are believed to engage in learning at varying levels of effort due to their beliefs about their own ability. Each of these beliefs may have implications for instructional planning and student academic achievement in the community college classroom. Therefore, it is appropriate to consider Nicholls (1984) theory in more detail.

Nicholls (1984) defined achievement behavior as "developing or demonstrating higher rather than lower ability." As ability becomes more clearly defined as capacity, and related closer to either effort and strategies or social comparison, the beliefs about ability drive student motivations to perform in certain ways. Belief about the nature of ability is key to his theory and he posits how the two specific conceptions of ability are tied to achievement-related behavior. One he labeled task involvement and the second, ego involvement. In task involvement, ability covaries with effort and usage of appropriate strategies. In other words, if a student wants to learn and improve, he/she needs to exert effort and try various strategies to be successful. Learning is the goal and grades are a measure of accomplishment toward that learning goal.

For those with an ego involvement focus, ability is related to a comparison of one's ability or performance to that of others. In other words, the ability level of others is the focus rather than one's own perceived ability and task achievement. Ego involvement and high ability produces moderate expectations of success on moderate to difficult tasks. Ego involvement and low perceived ability produces three tracks. One is a commitment to demonstrating high ability with low expectations for success on the selected high-moderate to high ability tasks. A second group perceives their ability as not high and a third know their ability level to be low. These last two perceptions result in a preference for tasks where they feel very confident of their success and choose easy tasks.

Although students may have developed beliefs about their own mathematical abilities, it would seem logical that faculty also make assumptions about the nature of their students' ability levels. Their assumptions are probably influenced by their general beliefs about ability. Based on those assumptions or beliefs, they plan their teaching design and activities (Thompson, 1992). It is also possible that some faculty do not consider student ability levels in their teaching design, but base their design choices on something totally separate from students' ability levels such as teaching the way they were taught. This, too, would be important to know and determine whether the outcomes are better or worse than those related to beliefs about their students' abilities.

It is possible, using Nicholls' (1984) theory, to derive various assumptions faculty might make about students' mathematical ability. For instance, if faculty make the assumption that student ability is fixed by the time the student reaches college, then they might conclude that at whatever level student ability is, it will not change no matter what activity the instructor chooses for the classroom. If ability level is believed to be fixed or limited by the time students reach the community college, then they might feel that students' mathematical ability cannot be expected to improve, and faculty will feel unable to teach them. When faculty wonder whether some students are capable of learning mathematics and reference those students as "not good at mathematics," these may be some of the issues they are consciously or unconsciously considering. The assumption is that faculty beliefs about the nature of student ability, that is, beliefs about the limits of student knowledge construction, are strong contributors to student achievement outcomes in the classroom. There may be other contributing beliefs as well. Until more research is reported, these are only assumptions or conjectures.

Both Nicholls (1984) and Bandura (1993) have argued that ability level changes as a result of effort. Some faculty may believe change in ability is possible and therefore, their teaching behaviors would be set on encouraging improvement of ability level through the use of effort and appropriate strategies. In other words, their efforts at teaching may also be influenced by their general view of ability. For example, some faculty may believe that students placed into remedial courses may be unprepared for college level mathematics because their high school mathematics curriculum was not rigorous enough or because they have forgotten much of what they knew. In this case, faculty may believe that teaching needed skills and concepts could be the solution for higher levels of pass and retention mediated through increased effort and increased ability. Student efforts to learn the skills and concepts would be expected to impact a positive change in ability level.

On the other hand, if faculty hold the view that ability is fixed, they may question the value of trying to teach remedial classes. They are more likely to hold negative attitudes toward teaching remedial or precollege mathematics courses because they do not think their students will benefit much since their low ability levels are thought to be fixed. They are not likely to believe their efforts in teaching will result in the increased ability needed for passing the course. Therefore, it seems likely that instructors' beliefs about the nature of student ability influence their approach to teaching. Instructors choose activities for the classroom environment based on those beliefs. Classroom activities include teaching formats (lecture, cooperative learning, boardwork, seatwork, etc.), homework activities, grading, and exams. In fact, there is support for the proposition that instructor beliefs about student ability help explain how teachers construct classroom environments (Good & Brophy, 1994; Good & Weinstein, 1986) and are related to the level of student engagement in learning (Bandura, 1989; Cabella & Burnstein, 1995; Pajares, 1992).

The present study was intended to provide information on what faculty believe about adult student mathematical ability and on the nature of the classroom activities chosen to promote knowledge construction and ability change. The purpose of the present study is to explore the following three aspects of faculty beliefs: how faculty define and state their beliefs about the mathematical ability of their students, how faculty describe their remedial mathematics classes and instructional activities,and whether there are patterns of beliefs and classroom activities that correspond to patterns of pass and retention rates.

Importance of Faculty Beliefs: Beliefs and Teaching Practices

In this section I will describe the research on how faculty beliefs impact their classroom activities. First of all, faculty beliefs are important because they are reflected in teaching practices (Bandura, 1989; Cabello & Burstein, 1995; Fishbein & Ajzen, 1975; Pajares, 1992). Although not a mathematics example, Cabello and Burstein, (1995) reported a study of two cohorts of ten female teachers each from elementary through high school with from less than one year to more than ten years teaching experience, and found that beliefs about teaching culturally diverse students were reflected in their choices of classroom activities. Data sources included portfolio analysis using an application letter on background, professional experience, interests, questionnaire on beliefs about culture, teacher-written logs, case study on a student, and exit interviews. The teachers began the class with one set of beliefs and as they proceeded through a special class on cultural diversity, their beliefs changed somewhat and so did their selection of classroom activities. The authors suggested experiential activities for engaging pre-service teachers in examining their beliefs in relation to their students' achievement results. This may be an important structure for consideration for planning learning for instructors as well as community college students.

As another illustration of the use of beliefs in teaching practices, Raymond and Santos (1995) found that preservice teacher beliefs affected their choices of classroom activities. In their study, preservice teachers were challenged to examine their beliefs about mathematics and mathematics pedagogy in an innovative mathematics class.

They chose to engage in the tasks and experienced disequilibrium with the cooperative groups, problem solving, journaling, and other activities which contrasted the traditional lecture format. Toward the conclusion of the course they reported feeling more positive about the class activities and began to relate their classroom experiences to their future teaching roles and activities (Raymond & Santos, 1995). The tasks had meaning that engaged them in learning, challenged them to examine their beliefs, resulted in changed behaviors such as choice of future classroom instructional activities and would be reflected in teaching practices. As their beliefs changed so did their choices of classroom activities.

The Shavelson and Borko (1979) research review on teacher's decisions in planning instruction provided several examples of instructor beliefs affecting faculty behaviors. Their proposed model for instructional planning includes perceptions about student aptitudes, different teacher educational beliefs, and the nature of the task. "Teachers beliefs about education are expected to affect their decisions directly by limiting the types of instructional strategies they will consider. These beliefs also may affect decisions indirectly by influencing the types of information about students to which teachers attend when forming estimates of students aptitudes" (p. 185). They found that instructors' beliefs about students' current performance levels suggested that ability was assumed to be a fixed entity. Such a belief has been noted to limit the data and observations faculty attend to when evaluating students and setting expectations. In other words, instructor beliefs influenced instructor behavior; instructor perception of student aptitude for learning resulted in choices of instructional strategies.

Students are also reported to be affected by instructor beliefs. Eccles and Wigfield (1985) in their literature review of the relationship between teacher expectations and student motivations argued that instructor beliefs or expectations about future performance and skill levels impact student achievement more directly than students' current levels of achievement. Students were more affected by their instructors' beliefs that they could improve than they were by their current inability to perform. If their instructor believed they could successfully complete the task, students believed in their ability to do so. Eccles and Wigfield (1985) proposed that interventions be developed to help students disassociate themselves from their current achievement levels as totally indicative of their future achievement. "What seems to be critical is that teachers not interpret the students' failures as stable and predictive of continued failure and incompetence. Instead, it is important that teachers believe they can intervene to stop the failure cycle" (p. 201).

We know that instructor beliefs affect the teaching learning environment and affect student motivation. Therefore, faculty beliefs about the nature of adult student ability to achieve successfully are likely to be reflected in teaching practices or classroom environment and instructional activities. Very little research has been reported on instructor beliefs about students' abilities as part of the reasoning for their instructional decisions. In an earlier qualitative study (Baker-Lopp, 1994), I interviewed three high school instructors and four community college faculty abouttheir beliefs in the relationship between ability and effort. They often struggled for words on the topics, but overall were more comfortable talking about effort than ability. They were not clear about their beliefs about the nature of student ability or about the specific effortful activities needed to change ability levels. Their statements emphasized a need for examination of faculty beliefs and ensuing patterns in the mathematics classroom. The present research will probe for a clearer definition of faculty beliefs about adult student mathematical ability and the types of activities selected by instructors for creating a learning environment supportive of engaging students in learning.

Maehr's (1984) Theory: Task Meanings and Environments as Keys to Students Investment in Learning Tasks

Research reports that students derive meaning from the tasks and environments that often determine the likelihood of their engaging time and effort in learning (Ames & Archer, 1988; Epstein, 1988; Maehr, 1984). The following passages will describe Maehr's (1984) Personal Investment Theory which suggests instructors build a teaching and learning environment, but students find some activities within the environment more motivating than others. According to Maehr's (1984) theory, activities communicate messages to students that they may or may not find engaging (Ames, 1988; Epstein, 1988; Maehr, 1984). Following the teacher's choice of activities, students recognize messages within the structure and choose whether to involve themselves in the activity or not. As Maehr (1984) pointed out, activities build the environment that students find engaging or not engaging. Maehr's theory of personal investment can be used to explain the possible link from faculty beliefs to student behaviors. In Maehr's model, student investment is shown as influenced by both external and internal factors. The factors external to the students are called the Antecedents of Meaning and are composed of past personal experiences, the socio-cultural context, and the teacher/learning context. The internal factors are called the Components of Meaning, which directly influence student investment, and consist of the student's self-efficacy, goals, and action possibilities. The Components of Meaning are affected by the Antecedents of Meaning, as the student interprets the contextual and experiential factors. Teachers, then, influence student investment indirectly via the teaching/learning situation or instructional activities. It is likely that the teaching/learning situation reflects the beliefs of the teacher or faculty member responsible for a particular course. A major goal of the present study will be to examine, through faculty interviews, the connections, if any, between faculty beliefs and the activities they implement in their classrooms.

The learning environment and the specific tasks have meaning to students (Epstein, 1988; Maehr, 1984). Faculty may have sound reasons or beliefs for choosing activities, but students' perceptions of the meaning within the activity may be discouraging to them. By using discouraging instructional activities, faculty would be missing the opportunity to obtain student investment in the activities. An example concerning student perceptions is the policy of placing students in remedial classes. Faculty may believe students' mathematical ability levels can improve if they are grouped according to knowledge and skill level. Students placed in remedial courses may not perceive the placement as helping them achieve, but as exposing their inadequacy to achieve at college level. The placement to them is not about a better environment for learning but about being labeled as "dumb". This relates back to students' reluctance to have themselves exposed as having low ability (Nicholls, 1984). What was conceived with sound reasoning by faculty to help students learn and improve may be perceived by students as tasks affecting their self image. If ability grouping does increase pass and retention rates, then students need to be convinced of it.

Support for the usefulness of Maehr's model can be found in Thompson's (1992) review of research literature on the beliefs of public schools teachers about mathematics learning, which is separate from their beliefs about student ability and how that fits into learning. The author suggested that teachers' "unexamined assumptions or beliefs about what children are capable or not capable of learning can render them impervious to matters of children's cognition" (p. 142). For instance, teachers who teach as they were taught may not be in tune with the knowledge and skill levels of their students or with the meaning of the task as perceived by their students. He also suggested a need to "develop sensitivity for the many subtle ways in which unintended messages and meanings might be communicated to students" (p. 142).

If, as Nicholls (1984) proposed, risk of exposure of their ability level as low is relevant to students' motivation to invest in the activity, then both faculty beliefs about the nature of their adult students' abilities and recognition of students' interpretations of the task would seem important for engagement of students in learning. Engagement should then affect retention and pass rates. In summary, if faculty construct an environment for learning and have beliefs about the nature of adult students' ability, and students read meaning from the tasks in the environment related to exposure of their ability, then careful consideration of the task and environment should be included in the design of instruction.

This study examines the possible links between faculty beliefs and classroom activities. Rather than include student interpretations of the activities, I used the literature on motivating classroom instructional activities to evaluate the choices described by faculty. In the next section, I describe that literature and the findings on the types of activities found to be inviting to students.

Epstein's TARGET Theoretical Links Between Instructional Activities and Effective Student Behaviors

This section described Epstein's Theory for development of a classroom with students focused on effective learning. Choice of classroom activities by faculty is included because such choices are reported to reflect faculty beliefs and how students respond to the activities. Maehr (1984) suggested that tasks have meaning to students and some may have meaning that is more engaging than others. In a literature review, Ames and Ames (1991) found demotivating factors to be competition and social comparison, public evaluation, reinforcing ability and not effort, communicating low expectation, permitting students to be uninvolved in learning, reinforcing performance instead of learning, excessive emphasis on success and grades, lack of recognition, and poor working/learning conditions due to noise level, overcrowding, etc. (p. 255).

Ames (1992a; 1992b) and Epstein (1988) suggested that change in student ability levels can be facilitated through teachers' use of global classroom structures that support student cognition and motivation. Certain classroom structures provide teachers with strategies for creating an environment that encourage positive motivation and student use of cognitive strategies. Epstein called them TARGET strategies with each letter of the word target standing for a specific group of strategies. The groups are task, authority, reward, grouping, evaluation, and time. Each of these will be discussed along with supporting evidence.

Task Structures

Task structures or task activities within the global classroom structures are the actual instructional activities. Within the tasks is information students use to make decisions about their ability, whether to persist, how much effort to exert, and the level of task satisfaction. (Ames, 1992a). In a study by Ames and Archer (1988) 176 randomly selected high school students responded to a questionnaire "on their perceptions of the classroom goal orientation, use of effective learning strategies, task choices, attitudes, and causal attributions" (p.260). When mastery goals were emphasized in the classroom, students reported using more effective strategies, preferred challenge within the task, and believed that effort impacts the level of success.

Whereas Maehr (1984) emphasized meaning, evaluation, choice, and freedom, as important elements in task design, Ames and Blumenfeld (1992, p. 272) emphasized "variety, diversity, challenge, control, and meaningfulness " as affecting students' responses in class. Epstein (1988, p. 99) suggested activities providing "appropriate levels of instruction increasing to abstract and challenging levels." Activities emphasizing effortful engagement include themes of authority/autonomy, recognition and rewards, grouping, evaluation, and timeliness. One of the unspoken objectives of task design is for instructors to select activities the student will also select.

Authority/Autonomy Structures

Authority/autonomy structures or instructor authority and student autonomy structures are important to task design and general classroom climate because students prefer opportunities to make choices within the task in order to develop self-direction, responsibility, and independence (Epstein, 1988). Maehr's (1984) theory suggested that choice and freedom in performance were related to persistence. Giving students opportunities to make decisions about classroom projects, establishing task priorities, initiating the pace of learning, establishing responsibility, planning projects, selecting and applying appropriate strategies (Ames, 1992b; Corno & Rohrkemper, 1985; Ryan & Grolnick, 1985) are examples of instructional activities promoting student choice and autonomy.

Several studies indicated that instructional activities promoting student autonomy are at a minimum in the classroom (Ames, 1992; Meece, 1991; Ryan, Connell, & Deci, 1985; Ryan & Grolnick, 1986). Why are instructors reluctant to give students more autonomy? Part of the answer may be found in a study of instructors where a need for control was reported related to the level of thinking. The instructors teaching at an abstract level were found to be "less overtly controlling, more encouraging of individual responsibility, more creative in presenting learning activities, and more encouraging of student theorizing and search behaviors" (Nicholls, 1983, p. 231, 1989). Instructors teaching at the concrete level apparently saw themselves as the authority and had identified no reason to involve students and attempt to change ability levels. Faculty beliefs about the nature of ability may reflect a belief about whether students can perform the task and whether they should be active or inactive participants in the learning process.

Reward Structures are a third group of strategies from which faculty select activities for motivating students to engage in learning activities in order to improve their knowledge, skills, and ability levels. According to Maehr's theory (1984) goals have meaning for students. For instance, rewards may have demotivating effects on students if they are perceived as efforts to bribe or control. They can encourage achievement when related to student effort, making progress for short-term goals, or relevant to performance. Instructional strategies that encourage, evaluate, and recognize improvement support mastery learning. Some evidence exists that task persistence may be increased by rewards that shift student focus from ability to mastery (Ames, 1992). Cameron and Pierce's (1994) meta-analysis suggested that if an expected reward is given without addressing level of performance, students will spend less time-on-task after the reward is removed. Rewards promoting improvement and mastery reinforce the value of effort and strategies and suggest to students that ability can improve.

Grouping Structures

Group structures are also characteristic of the classroom. Social skills that include "tolerance, acceptance, understanding and appreciation of people who are different from themselves" are encouraged by Epstein (1988, p. 101). Some instructors organize the class for single group activities as in discussion during lecture and others initiate cooperative learning groups. Instructor and student interaction in faculty offices may be an example of a very basic small group activity. The social interaction within the group provides opportunity for learning. Maehr (1984) suggested that groups set expectations for themselves. For instance, when faculty and students discuss mathematical performance differences of ethnic groups, they may be aware that performance deficiencies among Asians are credited to issues of effort rather than ability as in the U. S (Chen & Stevenson, 1995). Together group discussion of this observation within the class or group develops both the expectation that taking a more effort-based approach to learning mathematics is productive and promotes social group skills of "tolerance, acceptance, understanding and appreciation of people who are different" (Epstein, 1988, p. 101).

Evaluation Structures

Evaluation structures as a component of task design with imbedded meaning for students, can take several forms such as assessment and grading procedures. Evaluation is normally about performance appraisal. According to Maehr, it is the way performance appraisal is carried out that is important to students. An emphasis on tests and instructor evaluation has been reported to have a negative effect and he recommends promoting and "continuing an independent interest in the subject matter" (Maehr, 1984, p. 138). Additionally, while instructors may design assessment and evaluation activities to determine if students mastered certain goals, students may have an entirely different perception of the meaning of those activities. As with rewards and recognitions, if evaluations are made public, students relate the outcomes to ability perceptions of themselves, of others, of others' judgments about their ability levels, and of their future in that environment (Ames 1992a, 1992b). Comparative evaluation may take the form of grades, competitive win/lose activities, normative standards, displaying papers/projects, and other perceived public reportings of measurements. If the classroom environment supports their efforts at effective learning strategies and mastery outcomes, then students are more likely to use the strategies that have been found to enhance learning (Ames & Archer, 1988; Garner, 1990; McCombs, 1984). Grades perceived as an opportunity to evidence improvement impact effort rather than ability perception (Covington & Omelich, 1984). The key component is evaluation for progress, improvement, and mastery (Ames, 1992).

Time Dimension Structures

Time dimension structures within the task include deliberation about the size of the assignment, pace of instruction, and time assigned to complete tasks. Tasks may be designed to be adjusted should students have difficulty with a task, broken into reasonable segments for completion, and built on a reasonable time schedule (Ames, 1992). Attention spans and styles and rates of learning change as students age. "Speed or finishing within a fixed time frame are not always the most important criteria for gaining or demonstrating knowledge" (Epstein, 1988, p. 102). While Maehr (1984) made no mention of time constraints, their inclusion fits within the Epstein's overall TARGET task design (Epstein, 1988).

Summary and Overview of Study

Bandura (1993) and Wigfield and Harold (1992) suggested that students' beliefs about ability are related to students achievement behaviors like effort and persistence. It is probably safe to assume that faculty have beliefs about the nature of their students' mathematics ability. Ames (1992) recognized the use of classroom structures to activitate different types of effort related achievement goals, Nicholls (1989) emphasized belief in the nature of ability to improve through effort, Maehr (1984) supported a teaching/learning environment where the meaning of the task according to students determined whether students put forth the effort, and Epstein (1988) argued for the inclusion of the TARGET strategies for the purpose of including students perspectives about the classroom tasks in which they were more likely to invest effort. Therefore, in order to successfully engage students in learning and ultimately improve the retention and pass rates, it would seem important for faculty to select those classroom tasks students will more readily engage in to construct knowledge. The underlying question is, "What do faculty believe about the nature of student academic ability and does their belief impact their choice of instructional activities?" If instructional activities are motivating or demotivating to students and therefore, encouraging or discouraging to students' use of effort and investment in the learning task, then faculty belief and ensuing choices may be key to retention and achievement levels.

In considering the faculty and staff concerns about the large number of students enrolling in remedial mathematics courses, the low student pass and retention rates, the possibility that different beliefs and activities may produce different environments and different results, and the lack of community college research in these areas, I conducted a qualitative study. The study included definitions and beliefs about the nature of mathematical ability and choices of classroom instructional activities of eight community college mathematics faculty from two community colleges in the metropolitan area. Of the faculty invited to participate, four had high pass and retention rates and four had low rates. The study explored faculty views in two areas: faculty beliefs about the nature of adult student mathematical ability; and faculty use of classroom structures (e.g., teaching methods, student activities, choices of evaluation techniques) to construct an environment supportive of expected learning outcomes.

Research Questions

The purpose of this study is to investigate the following research questions:

1. How do some community college mathematics faculty define mathematical

ability?

2. What do they believe about the nature of adult students' mathematical ability in their classes?

3. Can we infer from their descriptions, patterns in the areas of beliefs and selected classroom structures that may contribute to some instructors having higher pass and retention rates?

CHAPTER 2

METHODOLOGY

Overview of Procedures

A qualitative research design was used to explore what some community college mathematics faculty believed about the nature of students' mathematical abilities and whether patterns existed in the areas of beliefs. Additionally, the data were examined to see if patterns of classroom structures would reveal differences between instructors having higher pass and retention rates. The interview questions and processes were piloted prior to three contacts with eight mathematics faculty from two metropolitan community colleges in a southwestern state. Initial analysis of the data began during each interview, was followed by further examination immediately following the interview, and culminated in a short summary paper of initial impressions of the participants' viewpoints. Coding and analysis for patterns within and among the participants in relation to the research questions was accomplished prior to writing the final report.

Piloting of Questions and Process

The semi-structured interview questions were piloted with two university tenured faculty and one high school mathematics teacher. The two faculty members were from the Educational Psychology Department and the other was from the state's high school for the academically gifted mathematics and science students. The entire interview process was practiced and refined using a semistructured list of questions designed to guide the interview and probe for answers to the research questions. The appropriateness of the vocabulary, of the questions, of their flow in the interview, and of the replies to anticipated responses was critiqued by the two tenured faculty, high school mathematics teacher, and myself.

Participants

Two Vice Presidents of Academic Affairs and two Academic Division Deans at two different community colleges were contacted about the study. All four had indicated interest in participating and suggested participants. The participants were full-time mathematics faculty. Each of the two institutions had a pool of twelve full-time mathematics faculty. Two faculty with the highest retention and pass rates and two with the lowest retention and pass rates were requested from each institution. A total of eight faculty contributed to the study. There were two females with high rates at one community college and two males with high rates at the other college. There were also two males with low at one community college and two females with low at the other college. Therefore, there were two men and two women with high rates and two men and two women with low rates.

In order to ensure a more unbiased interview, I was *not* told the pass and retention ratings of the instructors until after the interviews were completed at each community college. Once all the interviews at a college were completed, the Vice President for Academic Affairs at one community college and the mathematics coordinator at the other provided me with the retention and pass rates for each instructor.

Materials

For the purpose of keeping the interview focused, I arrived with a list of interview questions (See Table 1). These questions were used to guide the discussion, but the dialogue was not limited by them. A tape recorder was used to accurately record the conversations and free the interviewer for thoughtful probing. I had a tablet available to note thoughts and observations during the interview as well as log in thoughts afterward.

Interview

The interview took place in an informal atmosphere, in the instructor's office or in the faculty lounge. My perspective was that of a learner. Careful attention was made to listen to and explore faculty replies. The first question, "Let's begin by talking about you and what drew you to teaching, i.e., particularly, what drew you to teaching mathematics?" was designed to set the stage for a comfortable, quality discourse inquiring about what led each to become a college math instructor. Following the opening question, the interview questions began probing for information about the classroom structures used and a definition of mathematical ability as well as beliefs about the nature of adult student mathematical ability (See Table 1).

The interview concluded with a few background questions (See Table 2) on the instructor's number of credit hours in math education courses, learning theory, instructional design, and motivation, number of credit hours in math content courses, number of years teaching in elementary, middle school, high school, and/or college, postgraduate degree(s), and frequency of attendance at mathematics professional conferences. The data from these questions was used to compare responses and analyze patterns.

Coding, Analysis, and Interpretation

Analysis began by listening for patterns and themes, repetitions of ideas, words, and attitudes during the interview. Once the interviews were completed and written as transcripts, I will wrote a summary profile of what I understood the participant to say. The summaries were sent to each participant with a thank you note.

The next step was to code the transcripted responses. Coding is the process to "organize, manage, and retrieve the most meaningful bits of data" (Coffey & Atkinson, 1996, p. 26) for the purpose of identifying patterns and concepts. The coding was accomplished by labeling the responses in the transcript, i.e. change, fixed, other, expectation, activity, etc. Each participant's replies were examined for consistent and inconsistent patterns within the interview as well as compared to other replies.

Once the coding was complete, I began to analyze the data within groups. The replies were systematically divided into units determined by the research questions. Each group of replies based on the questions was examined for patterns. Units were also established to examine similarities and dissimilarities between groups, i.e., high pass vs low pass, or professional meetings vs no professional meetings.

To preserve confidentiality, each participant received a fictitious name and each reply was labeled accordingly. At least one coded copy was developed on the computer. for all the groupings. By grouping relevant replies and discussions the patterns were more evident. Summary sentences and paragraphs were then composed. As the summaries were developed, much thought went in to the creative exploration and interpretation of the data before the final writing began.

In coding, some data may have been lost, but every effort was made to use the data related to the research questions. The data gleaned from interviews with eight mathematics faculty may or may not generalize to other mathematics faculty. The purpose was to creditably begin an exploratory research, study the research, and expand to a generalizable stance in the future.

Establishing Confidence, Validity, and Reliability

The questions were designed to establish confidence in the findings. They were used to check the perceptions of the interviewer and convince the reader that the conclusions are accurate. Whereas some authors use a qualitative phraseology and others use the quantitative words, the underlying constructs are similar --- establishment of confidence, validity, and reliability. Rubin and Rubin (1995) recognize that both quantitative and qualitative research must evidence creditability. According to them, quantitative research accomplishes this through evidence of *validity and reliability* and qualitative research emphasizes *transparency, consistency-coherence, and communicability.* As they suggest, *transparency* will be established by declaring the researcher's biases and careful documentation of what is seen, heard, and felt through the use of tapes, transcripts, participant interview summaries, and journaling. *Consistency-coherence* will be established by checking and rechecking the themes as they develop both within a participant's interview and between the interviews. If inconsistencies become apparent, an attempt will be made to explore them. *Communicability* or bringing the reader into the research setting is also included in the design through attention to the writing. Accurate descriptions, first hand retelling of experiences, and an attempt at gaining a "glimpse backstage" will be presented in the narrative.

The other approach to establishing creditability was in the use of *validity* and *reliability* concepts. "Validity refers to the appropriateness, meaningfulness, and usefulness of the inferences researchers make based on the data they collect, while reliability refers to the consistency of these inferences over time" (Fraenkel & Wallen, 1993). Using these frameworks, the following techniques were used:

- The pilot study helped establish an understanding of mathematical vocabulary for the researcher that may apply to beliefs about the nature of student mathematics ability and usage of classroom structures. Probing the understandings of mathematics faculty and understanding their perspective implies using a common vocabulary. The pilot contributed to the assurance that what was being asked would be understood and responded to in kind. A common vocabulary contributes to the consistency of understanding which may impact the replies.
- Since the interview was semistructured, the initial questions and thrust of the questions were similar at each interview. Faculty replies were compared looking for similar replies within the interview process as well as comparing replies for patterns and trends among faculty.
- Use of a tape recorder documented the conversation, and resulted in accurate transcripts of the interview for analysis purposes.
- By visiting with each faculty member before the interview, an initial sense of trust was attempted. Knowledge that they will have the opportunity to read the profile and make suggestions to preserve their anonymity hopefully contributed to the authenticity of their statements during the interview.
- The codes or categories established were checked against the transcripts by a

doctoral candidate in the Department of Education at the university. The Chair of the doctoral committee also skimmed and read the interviews, profiles, and chapters. Their purpose was to double check the codes and categories against the transcripts. The Chairperson also compared them with the later analysis.

- Finally, my bias was addressed in the final report. This bias involved several perspectives, i.e., believing that with intellectual capacity, effort, strategies, and supportive environments, students' mathematical ability can improve.

CHAPTER 3

RESULTS

The purpose of Chapter 3 is to report the analyzed data in order to answer the three research questions. The chapter is organized as follows. First, I begin by describing my personal perspectives that may have influenced my analysis of the data. Next I introduce the eight participants by describing their backgrounds and their pass and retention rates. I then begin the results summary with the data related to the research questions, "How do some community college mathematics faculty define mathematical ability?" and "What do they believe about the nature of adult students' mathematical ability in their classes?" This section reports case data addressing those questions. A fourth section follows identifying the trends and patterns across those cases. The fifth section reports on classroom structures used by faculty and will be followed by examination of the trends and patterns addressing the question "Can we infer from their descriptions, patterns in the areas of beliefs and selected classroom structures that may contribute to some instructors having higher pass and retention rates? " It will identify the definitions, beliefs and classroom structures used by each instructor with high and low retention and pass rates. The sixth section is on trustworthiness of the results.

Researcher Perspectives

The goal of this section is to describe myself in order to explain any biases that may have been referenced in this research. The research began as I heard faculty voice concern about whether students with low mathematical ability should have to take college level math. Their statements made me wonder if faculty beliefs about their students mathematical ability or inability helped or hindered students' retention rates and academic success rates in their classrooms. I believe faculty beliefs about their students abilities to be successful in their classroom do affect students, but tried not to voice that opinion.

Both my professional work and life interests include tracking success patterns and, in this case, student success patterns. It is my basic assumption that students' ability levels improve with effort and appropriate strategies. Because of this, I tried to avoid statements revealing my bias.

Four of the faculty interviewed work at the same college where I work. I have spent time visiting with them during the past five years. I hope it is evident that they were asked the same questions as the other four and the additional probes were logical from their responses. As I expected, each interview and ensuing analysis produced thoughts about more questions that could have been asked.

Both faculty and the professional literature report that students often arrive in the classroom with a math attitude of anxiety and lack of self-confidence. These students believe they can not be successful in mathematics. The literature supports the thesis that attitude and belief affect outcomes (Bandura, 1989; Cabello & Burnstein, 1995; Fishbein & Ajzen, 1975; Pajares, 1992). If this is so for students, would it not also be characteristic for faculty? What if faculty believe their students will or will not be successful? What are the beliefs about students that might increase or limit the retention and achievement outcomes? Since the literature did not report on it, my quest was to probe faculty definitions and beliefs about their students' mathematical abilities and about the classroom activities they selected while not letting them know my concerns about the possible negative effects of faculty beliefs.

Participant Backgrounds

The demographic information reported was obtained from the Educational and Professional Background sheet (Appendix 2) given each participant. The eight community college instructors were given fictitious code names. Two syllable names were given instructors with high retention and pass rates and one syllable names were given instructors with low retention and pass rates. The instructors with high retention

TABLE 1: Retention and Pass Rates Comparison

	Fall 1996		Fall 1996	
	High Retention	High Pass	Low Retention	Low Pass
Danielle	92%	67%		
Christy	92%	63%		
Edward	64%	89%		
Andrew	45%	86%		
Rob			74%	24%
Mark			74%	15%
Liz			42%	56%
Jan			36%	58%

and pass rates are grouped together in the narrative and tables as are those with low rates. The retention and pass rates for each participant are shown above. It is my perspective that meaningful learning is tied to effort. I also recognize that just because students pass a course, their level of learning is not necessarily indicated. In other words, a passing grade does not mean they are prepared for the next course in the sequence and will pass it.

The retention and pass rates were of immediate interest following the interviews and receipt of the retention and pass rates. A table for study and reference was developed (Table 1). The patterns within the group of instructors with high retention and high pass rates as well as that within the group of low retention and pass rates requires background to understand. Danielle and Christy teach at one community college and Edward and Andrew instruct at the other one. During the interview Edward and Andrew indicated a college policy of classroom testing that may have quickly weeded out the lower ability and more weakly prepared and motivated students. If they did not pass the first test they were counseled to move to the prerequisite course, participate in tutoring, or withdraw and re-enroll the next semester. Therefore, those that remained were more likely to pass. On the other hand, Danielle and Christy retained students at a higher rate, but had lower pass rates than Edward and Andrew. Their college's policy was not as strict on administrative withdrawal for sparse attendance or counseling students to withdraw following the first test. Even if low grades resulted on the first test, students who would not be able to achieve a passing grade were retained. A similar comparison holds true for the low retention and pass rates foursome. From a pool of twelve mathematics instructors, the colleges contacted chose and labeled the participants as high retention and high pass rate faculty from that institution. One college emphasized retention and the other pass rates, but within their institution they were either high retention and high pass rate or low retention and low pass rate.

When reading about mathematics courses, developmental courses or pre college courses are articulated as Arithmetic Skills, Pre Algebra, Elementary Algebra, and Intermediate Algebra. College level courses are College Algebra and Contemporary Math.

Danielle

Danielle began her college education in her middle thirties in a community college and graduated with an Associate of Arts degree in Liberal Arts. She then continued her education and earned B.S. and M.S. degrees in mathematics. Danielle taught 3 years in middle school, 2 years in high school, and 5 years at the college level for a total of 10 years. As an undergraduate she received 3 hours credit in learning theory, cognition, and instructional design, but no mathematics education courses as part of her 36 hours of graduate work. At her community college she teaches pre college or developmental mathematics courses, Pre Algebra and Intermediate Algebra. She reported having attended three professional conferences in the past three years and regularly reads one mathematics related professional journal. As referenced in Table 1, page 32, Danielle's Fall 1996 student retention and pass rates placed her in the high group.

Christy

Christy teaches only developmental level courses, Arithmetic Skills and Elementary Algebra at the community college. She holds a B.S. and M.A. in mathematics including 21 undergraduate hours in mathematics education, 6 undergraduate hours in instructional design, and several learning theory workshops. Of her 26 total years teaching, 5 were in middle school, 9 in high school, and 12 at the college level. Christy reported attending 6 professional conferences in the past 3 years and reading 2 professional journals regularly. Her student retention and pass rates placed her in the high group from her community college (Table 1).

Edward

Edward is the second most experienced of the eight participants in the study as well as of the high retention and pass group. He is a veteran mathematics professor with 34 years experience of which 5 were at a middle school, 4 in a high school, and the remaining 25 at the college level. He was awarded a Bachelor of Science in mathematics and a Master of Natural Science, Mathematics Option. He also reported one math education graduate level course. Edward attended 2 professional mathematics education conferences during the past 3 years, numerous workshops and seminars on both technology in the classroom and calculus reform, and regularly reads one professional journal. Of the five mathematics sections, he teaches four college level and one developmental level course.. His retention and pass rates were in the high group (Table 1).

Andrew

Andrew reported a Bachelor of Arts and a Master of Science in mathematics. He received no undergraduate or graduate hours in mathematics education and has taught 15 years at the college level. Andrew reported attendance at 2 conferences during the past 3 years and regularly reads 3 professional journals. He was teaching more developmental level courses this semester. He is the youngest of the high retention and high pass rate group (Table 1). Andrew teaches five college level and three developmental level courses.

Rob

Rob has a Bachelor of Science and Master of Science degrees in mathematics. Since graduation, he has taught mathematics for 12 years. Five of those years were at the middle school level, 1 was at the high school level, and 6 were at a community college. He reported having 22 graduate mathematics hours and 11 in math education courses in preparation for teaching. Included were 3 in learning theory and 2 were in instructional design. He listed no conferences attended during the past 3 years or professional journals as regular reading. For Fall 1996 his students' retention and pass rates placed him in the low group (Table 1). Rob teaches only developmental level courses this semester.

Mark

Mark has both a Bachelor of Science in meteorology and a Master of Science degree in mathematics as well as additional hours toward a Ph.D. All together he has taught college mathematics courses for the past 16 years. He mentioned no math education conferences attended in the past three years, but regularly reads two professional journals. Mark's retention and pass rates placed him in the low outcomes group (Table 1). Mark taught three college level and two developmental courses.

Liz

Liz has a Bachelor of Science and Master's in mathematics and has taught college level mathematics for almost 22 years. She has three graduate hours in mathematics education, has attended one professional conference in the past three years, and regularly reads one professional journal. Liz's ratings placed her in the low retention and low pass rates group (Table 1). Liz taught one college level and six developmental level classes.

Jan

Jan holds the most degrees with 2 masters and a Ph.D. and has the most teaching experience. One of the master's degrees is in English. Of her 37 years teaching, 30 were at the college level and 7 were in middle school. She reported three hours in learning theory, has attended two math conferences in the past three years, and regularly reads one professional journal. As is reported in Table 1, Jan's retention and pass rates placed her in the low group. Jan taught two college level and three developmental level classes.

Definitions and Beliefs about Adult Student Mathematical Ability

Although the Introduction Question, "Let's begin by talking about you and what drew you to teaching mathematics," plus Question 1 were designed to begin the interview with questions instructors would find comfortable discussing, instructors' responses to the Introduction Question often related to Question 2 and faculty definitions and beliefs about mathematical ability. Therefore, the Introduction Question, Question 1, and Question 2 will be discussed together. Note that when quoting the interview statements are italicized and that key words or phrases related to stated themes are in bold type.

Danielle's Definition of and Beliefs about Mathematical Ability

For Danielle math ability characteristics include a **knack** for mathematics evidenced by being able to problem solve by **being very careful, precise, checking everything, and asking appropriate questions**. She also ties in **student attitude and**

self-confidence as factors limiting ability development.

Danielle is unique to the study for two reasons. The first one is because she started her college studies at a community college when she was about 34 years old, and secondly, because she truly did not seem to realize she was good at math until her college instructor pointed it out to her. Apparently after a couple of semesters of mathematics, her instructor asked her if she had thought about teaching mathematics. She admitted to me she had thought about it, "but didn't think" that financially she would be able to do it. Her instructor pointed out that she had the **knack for mathematics**. By that he meant she was **very careful, precise, checked everything, and made it a point to ask questions for understanding**. Danielle also pointed out that math was not always easy for her, but she kept asking the questions and working at it. She admitted that **her struggles help her understand her students' struggles with mathematics now.**

One of the strong themes within Danielle's interview is a belief that pre college level or low ability level students often arrive in the classroom needing more self-confidence. Danielle and Christy teach only pre college level classes. When probing for a definition of why students were not willing to expose their lack of knowledge and skill, Danielle referenced her own experience and commented:

> I feel like it's not that they don't have it, (but) a lot of it has not been used in a while. And they just need to fill their **self-confidence**. It's not that they don't have it because I started in a prealgebra class. It's not that it's not there; it's just that they don't have the confidence yet to know that it's there and they've just forgotten some things. Or they just . . . it could be that it's not there, but they can learn it. And they all can learn it; it's just a matter of time and they've got to pull out and understand that they've got to ask questions.

When talking about boardwork, Danielle referenced **student anxiety** in performing tasks where others would see their work. She recognized that "they just do not have good feelings about their math . . . It's their attitude and they think they don't have the ability. They do well and they like it once they go, but they like having everybody up there. They don't want to be singled out. (*Because this would expose their ---?*) It exposes their insecurity as far as math is concerned."

Later on we visited about motivation and ability levels. Danielle thought it took "work to pull those in that have a very low ability . . . to get them to come through and get them to participate in class." From an instructor's point of view she has often found it difficult to teach at a level that challenges both those with high and those with low ability levels in the same classroom. She acknowledged different ability levels were evident to her and that by teaching to the middle she may lose the high and low students.

> Sometimes you bore the ones with high ability and the ones with lower ability. You may lose them, but you really have to come down to that level. You have to get down there and understand exactly where these students are coming from.

I asked Danielle about the comments I had heard about students lack of preparation, e.g. "What makes people think that students who have been in public schools for 12 or more years and have not been able to understand mathematics all those years, think they are going to walk into a college level math class and pass it this semester?" At first she responded as though defending the students and their many activities and responsibilities outside class, but my question was about faculty, their beliefs and expectations. The conversation that followed was strongly reflective of her definitions and beliefs: Note, too, her careful avoidance of a statement that some students may not be able to learn mathematics at a rigorous college level.

But what are they saying about their expectations of those students?
It's like they've already got their minds set that those students can't learn. Although they should have enough experience to know that there are several students who don't do well in school that do well in college. But it just . . . if they've already determined that, then probably their success rate will not be as good because they've already got that determined.

Danielle's expectations that her students will succeed is congruent with the achievements of her students. She was one of two out of twelve mathematics instructors at her community college with the highest retention and pass rates.

So, as an instructor, their success is determined, is that what you're saying?
I feel like it is already determined and they're saying their students can't learn it.

And you've talked with math faculty and listened to them more than I have about what they think about their students. Mathematical ability, what is it? What is it you're looking for?
Well, I . . .

That's all right. Think about it. . . . . . .
I have lots of students who don't have mathematical ability. I mean, they're not geared to, you know, they're not going to be totally successful in math, but it depends on what they're . . . if this is the best they can do, a 70, and they're really trying hard to do that, then that's success. That's success; that's not failure. That doesn't mean they don't have the ability to do calculus; some students don't have the ability to do calculus, I don't have the ability to be a medical doctor. They've each got their own . . . they have their abilities to do things and do things well. Sometimes math is not it. I just want them to know they can be successful as long as they don't set their success rate to be an A.

We're talking about passing tests. What about the kind of behaviors you look for in the room . . . the students who have ability and those who don't have it? What are the contrasts?
I don't know. I know the difference, but I guess I don't see the student in the class acting any different.

Your professor said you seemed to have the knack for math. Use that phrase — those students in your classroom who have a knack for math, as opposed to those that don't. What's happening?. . what I'm hearing you say, you're doing the same thing and expecting the same from them, but are you seeing anything different?

I see sometimes that if they had the **knack for math**. I see the ones that don't.

What do they not have?
Some of them just don't have the **ability to ask questions**. Some of them don't know even how to get started on anything. They just don't have the approach and I think a lot of times the ones that don't have it are the ones that are just passive in class.

Do they have a belief system about their performance. . . their ability or their ability to perform?
Oh, some of them have it already built in. Yeah. Unfortunately there are some that have already been told that they aren't going to be very good at that. And some of them have told themselves that they're not going to be any good at it or they've had a failure so they think they can't succeed.

So some students, their attitude may be impacting them every bit as strongly as whatever capacity or ability they have?
If they've already told themselves they can't do it, it's real hard to break that barrier.

Danielle saw the knack for asking questions as characteristic of mathematical ability. The conversation continued and moved into beliefs about mathematical ability rather than characteristics and definitions. In fact, as I reread the transcripts, the conversations focusing on definition of mathematical ability and beliefs about mathematical ability often blended and overlapped.

Danielle's belief about the nature of mathematical ability was first evidenced when she said, "And I think that most of them can do very well if they are willing to put the time and the effort in it." Even more clearly stated was her belief in response to, "Is mathematical ability something you're born with, can it change, is it fixed, or is it something else?" Her reply was,

I feel like it can be changed. I try to think back in my math experience. . . I was just a basic. . . I went through the regular math core as far as high school. I wasn't

> behind or anything. As far as being in an exceptional class, I wasn't. And probably still wouldn't be. At the same time I don't think . . . maybe it is born in some people, but I don't think that has anything to do with it. I think it is a **matter of work**. It doesn't come naturally for me and it still wouldn't come naturally for me. I see other people that mathematics comes naturally to. They can talk it and talk the talk and walk the walk whatever! I can't do that. I struggle with it.

Here she was saying that she had changed her own mathematical ability level through hard work. Math did not come easy to her as she revealed when we talked in terms of a mathematical ability belief. Undergirding Danielle's comments was also the consistent belief that students have different abilities of value. "They've each got their own. . . they have their abilities to do things and do things well. Sometimes math is not it." Earlier Danielle seemed to avoid saying some did not have the *knack* or could not learn mathematics, "if this is the best they can do, a 70, and they're really trying hard to do that, then that's success. That's success; that's not failure." She supports students' efforts to change by being available for conferencing and constantly refining her instruction. For instance, she referenced office hours in her syllabus and adjusting her responses to students with test anxiety and different ability levels. As noted earlier, Danielle also felt strongly that students may have the ability to succeed in math, but it is their *attitude* about mathematics that may be limiting their performance.

Christy's Definitions of and Beliefs about Mathematical Ability

Christy's reasons for teaching mathematics centered around being a good student and tutoring others frequently in mathematics. In college she started off in calculus, established herself in a study group, and continued to tutor dorm friends and others. Although she achieved an A in her first college English course, she preferred the mathematics and kept working at it.

Christy's definition of mathematical ability focuses around a **maturity level** to recognize what is understood and not understood, and **ask appropriate questions** to get at the gaps in understanding. This, too, follows Christy's growth as a mathematician and instructor. . . that sense of self knowledge and wanting to understand.

Christy liked "(high)school, had a good time, and tutored an awful lot." She had a "good experience" with teaching mathematics in college, too. Rather than giving her peer group credit for helping her recognize her mathematical ability, she said, "Sometimes you do things well and you do well at what you like. . . and if you like it you do WELL." When asked "Why did you like math?" both honesty and a sense of humor popped forth, "Did you see all those boys in that math class?" She then followed with a sense of self knowledge and let that knowledge drive her decisions. She explained herself by saying,

> I was good in English and math and I was leaning toward both of them. I got to XXXX and in the first English course I got an A and that was OK. And then we took one of these where you read one of these and then you write an essay and you had to read and say this rock was queen of England and this tree was the king of Spain and I was going, it's not, and I wasn't good at that at all. . . Well, I always stayed with the math and I just kept on. And I did a lot of tutoring in the dorm or I had a girl the street or down the hall, and I'd tutor them. And it was just a natural thing. I think I knew, I had always leaned toward teaching math. . . teaching and then math.

Apparently in college she had a take charge attitude and if you met her today you would recognize that that pattern continues. She participated in a study group that proved instructive to her growth as a mathematician as well as instructor for she emphasizes group work in the class, outside class, and at the board. In the passage below Christy talks fast and jumps around a bit, but reiterates how the study group's system worked for her and she continues to promote it in her classes:

> There was a sophomore, myself, two freshman and I, and we took our classes so we would meet together in the student union and after we had tried it either together or even sometimes after class we would go and work together and if we did not get part of it we would explain. **And I found that to be a successful way to be successful in math. . .** And then if one of us had trouble then if you didn't have trouble then I'd explain it to you and if you didn't, you'd explain it to me and we made it a part of our system. And you would say, if, from what I learned, and didn't learn it then, I knew I was doing it, I didn't know the languages, as you read something, or if you hear something you only have 20 percent, if you write it down, it's 30 percent. And if you tell it to someone else, then it is retained to 65 to 70 percent. So it is important for students to make it a part of theirs. And even if you're reading a paragraph in poli sci, you read that and if you read it, that's nothing. You've got to read it and explain what you've read so that it becomes a part of your system. **So I think that's what I try to do in my classes.**

Thus, Christy recognized that she was good at mathematics, developed a system for understanding mathematics for her classes, practiced explaining the understandings and skills, and today uses all this in her classes to help students be successful. This was the way she matured as a mathematician and teacher and just as Danielle did, she shares her mathematical ways of knowing and growing with her students. While Christy's recognition of her mathematical ability and development as a mathematician was something that may have been self driven, we assume she also received feedback through tutoring about her ability because she continued doing it and perceived herself as successful as a tutor.

At one point I used a rather long question about what I had heard professors say regarding poorly prepared mathematics students, "I go to conferences and am on different campuses and I hear conversations, staff and faculty, talking about math students. And sometimes it seems they are saying, "'If they haven't learned math in 12 years in public school, what in the world makes you think they're going to pass a college level math course here, this year?' What are they really saying about students and math?" Christy replied with, "I don't believe that." Her next statements are mixed with beliefs, but she does include a definition of mathematical ability that is interesting.

> There is a **maturity level** and I find that also in my own child. She took prealgebra and made a C and a D. She took Algebra I a year later, just a year later maturity, and she took it late. She took ninth grade prealgebra and tenth grade Algebra I and in Algebra I she had 2 B's or a B and a C (She couldn't quite remember.) It was much more comprehensive for her. And I think sometimes it is just a **maturity level**. And I think sometimes it is just a **maturity level**. I think mathematicians are making a mistake of putting kids in math before their **maturity level** is ready. I don't like to see seventh grade algebra. I think . . . they may be smart enough but **maturity**, they're not ready. They're just doing the steps. . . . There's just a **maturity focus** on what they want to do.

Among the behaviors she looks for in students with high ability is being able to "catch on quickly." For students with low ability, she finds it necessary to say things "three or four different ways." She hears students say, "This takes me so long to process," or "I don't see what you did." Her point was that the student who will speak up and in essence say, "I don't understand," may be both smart enough to and mature enough to understand. Again, her earlier idea of an appropriate **maturity level** for mathematical understanding undergirds her definition of mathematical ability.

Christy combined her thoughts on mathematical ability with stories about her own journey in understanding herself as a student and in understanding her students. She had worked as a student to improve her mathematical ability and today is constantly trying to improve her teaching of mathematics. She likes to tease the students, share relevant scenarios illustrating the mathematical understandings, encourage students' independent thinking at their seat and at the board and is constantly monitoring the students' progress as well as her own. From what I heard Christy saying, she believed students could understand the mathematics and hounded them with examples, scenarios, teasing questions, and opportunities to succeed. Her attitude and expectation was that if they engaged in the activities, their knowledge and skill level in the pre college courses she teaches would improve. Just as she worked on her mathematics as a student independently and with others, she works on her teaching methodology independently and through discussion with other professors. From the looks of her retention and pass rates, she is successful.

Edward's Definitions of and Beliefs about Mathematical Ability

Edward grew up in a small rural agricultural community and recognized a career path in either farming or education was ahead. He enjoyed mathematics at an early age and credited some of his ability to his inquisitive mind, enjoying seeing patterns, and fitting the patterns together into mathematical language. He was careful to differentiate between learning the basics with memorization and regurgitation, using the basic tools, and seeing underlying principles and patterns to think about a second more mature level or think mathematically.

Edward's definition of mathematical ability began with his own inquisitive ability to see underlying patterns and principles and use them to think and solve new problems. Early in his life he enjoyed mathematics and "tended to do more of it than some of (his) other subjects and of course, got better at it." He said he was better at mathematics "comparatively speaking, with all the other students in my classes, you know, my grades were always better than their grades." He apparently compared himself to achievements of other students in order to determine his comparative standing. By having better grades than others he said, "I'm better than this person is at it and better than all the persons in my class, so that must mean you're good at it." Additionally, a another observation on his past was his teachers recognition of his mathematical.ability which further reinforced his mathematical self confidence.

> So being better at it and all the people, all the teachers at the school all kept saying that I had contact with kept saying, 'You ought to be a teacher because you're good at this.' And so that just evolved and that's kinda how I got into the field of teaching.

Discussion of what led him to become a professor of mathematics led to questions about why he thought he was good at it. This was also a way of having him define his understanding of mathematical ability. His replies were rich with thoughtful examples:

> I think the main reason I was good at it was because I had an *inquisitive* mind. When I was a small child before I ever went to school and elementary school, I loved to take things apart and put them back together just to see how they worked. And I was real good at that, too. I took a lawn mower apart when I was 11 or 12 years old. . . the whole engine and put it back together and I didn't know anything about engines and it worked fine after I put it back together. But I was just curious. I was a curious kid. I was a mischievous kid. I liked to get into things and do things and I think that's why I enjoyed mathematics because it was kinda like a puzzle, you know, where you could put things together and all of a sudden a picture emerged even though it wasn't like a picture on a picture puzzle, there was a picture emerging. And I think that was one reason I enjoyed mathematics. . . I could see this picture in front of me. It was a mathematical picture.

When asked why he thought taking things apart and putting them back together related to mathematics, he replied,

> I think that taking something apart is easy because there's no pattern to taking things apart. You just start tearing things apart, but to get it to fit back together there has to be a **pattern**, a system of the way things fit together so your ability to

> recognize the **pattern** of fitting things back together is one of the primary premises on which mathematics is founded. That's the ability to recognize **patterns** and then put these **patterns** down in mathematical language so that other people can understand the same pattern. So I think that's one of the reasons I enjoyed that and was fairly good at it.

Interestingly enough, Edward also uses this knowledge about patterns in mathematics in his classroom today. When asked about how he pointed out mathematical patterns to students, he replied,

> In developmental classes, you can't point that out. In developmental level classes you're too busy learning basic skills to worry about learning mathematics and I don't equate those two. Learning that x + x is 2x isn't mathematics; that's learning what I call a basic skill in mathematics. But that's not learning mathematics.
>
> Mathematics is **learning those patterns** that we're talking about and you can't learn mathematics in developmental math classes; you're too busy trying to survive basically, but as you get to higher levels, and especially when you get to your first course in calculus is where I believe the students start learning mathematics. Up to that point, a lot of what students do, I call, for a better name is regurgitation. And the fact that somebody has shown you how to do this and you turn around and show me you can do that, that's not learning, that's regurgitation.
>
> Learning is where you have obtained some basic skills and you've been in some situations that allow you to use those skills, but now you're in a completely new environment with a new problem and learning is how to take this body of knowledge I currently have and apply it to a new environment and come out with some type of conclusion in that new environment is somewhat intimidating at times. That's what I call learning mathematics and developmental mathematics is not really learning mathematics; it's just learning the tools that you need to do the learning mathematics.. . . Without that foundation you cannot learn or develop mathematically.

Following another probing question about defining mathematical ability and being good at math, he continued,

> OK, **being good at mathematics, in my opinion, is seeing some underlying principles and patterns that occur in a problem situation and then being able**

to pick the right mathematical tool that is applicable for solving that particular problem. That's what I call being good at mathematics. But learning X times X is equal to X squared is not being good at mathematics. That's just like adding 2 + 3 and getting 5; that's just a skill you need to do mathematics. Mathematics is a nebulous idea; it's not a real quantifiable idea, but it's one of those deals that eventually at some point in time you can judge a person as being good at mathematics or not being good at mathematics. It's not a defined thing. It's somewhat a subjective thing.

Whereas Danielle and Christy teach only pre college level mathematics courses, Edward teaches four college level and one pre college level. He finds the pre-college level classes more challenging; one day it would be interesting compare the two levels and explore his reasons for making that statement. Edward defined mathematical ability in terms of an inquisitive mind, seeing underlying **patterns** and **mathematical maturity**. When asked whether ability was genetic, fixed, or changeable, he responded in terms of the effect of one's environment on mathematical development, he said,

> I think there are people that have more ability to do mathematics than other people, but I don't always call it genetic. I think a lot of it comes from your environment. It comes from your environment with your parents, your environment with your peers. Like I told you, I think a lot of my mathematical ability came from my environment; I liked to tear things down, put them back together, see how they work, look for patterns. Whatever interests I had, whatever ability in mathematics wasn't at least genetic. I think it was more of an environmental situation than genetic.
>
> I think you can nurture the ability and if that nurturing care is given in the right forum we might all become Albert Einsteins, but I think we can become mathematicians at some level whatever that level is we can become mathematicians. But I don't think it's genetic. Hey, I can learn to plan a violin and I can learn to play it at some level, but I probably will never be a concert violinist, OK, because there is an ability inherent in you to do that, but that ability can be enhanced to a level higher than it currently is. . . the old Peter Principle, you know, you're going to get to a certain place where the next level is too high, whatever that level happens to be.

Later we talked about motivating students through relevant examples. Edward was more interested in "giving them the **mathematical maturity**" than in the number of specific how-to-do examples, "By doing more and more applied problems they're going to be gaining a greater **mathematical maturity** than they've had in the past." Edward's belief about the importance of **mathematical maturity** development was evidenced again when he talked about the mandated college level algebra course:

> **Mathematical maturity** is something that we can use in the world without doing mathematics. We can problem solve without using mathematics, using the concepts of mathematics, without using mathematics. That's **mathematical maturity**. And the other thing is that so much of what do now a days involves number crunching and statistical analysis and whatever. You have to be exposed to some mathematics to be able to even read some of the articles in the newspaper and, you know, and have them make sense to you.

Another underlying belief according to Edward is that "learning mathematics is a process that is continual." He tells his students that they must "keep working at it."

> I tell them over and over that when I was doing mathematics at XXXX of XXXX, I could work on a problem so long and then that was it. I couldn't handle it after that. It was stressful, so I had to have a break. So I'd go ride my motorcycle for a couple of hours, you know, and then come back and start again. But there comes a point where just spending time trying to do something is not productive. There's a time where it's non productive, and you've got to be able to recognize it as that. And so, what you need to encourage students to do is think about this awhile and when you get stuck, put it up a little bit, do something else and believe it or not, you mind has that capability of kinda like a Windows program, of having an active window in front and another window in the background working at the same time and you may not realize it, but all of a sudden while you're working on something else, that problem you were working on in mathematics, all of a sudden something can come up. But if you continue to think about it a bit at a time, it's not ever going to come up again. . . . I try to impress upon them that learning mathematics is not an overnight thing; it is a continual thing they have to keep working at and working at. And the worst thing they can do is when the going gets touch, quit. And that's what a lot of developmental students do.

Andrew's Definitions of and Beliefs about Mathematical Ability

In response to the question, "What led you to teaching mathematics?" Andrew quickly replied, "I am good at it for whatever reason." On the other hand he thought that his early teachers might not share in his confidence about his mathematical ability. By the time he was a sophomore in high school, he was not interested in or good at doing "100 problems the same way," but challenging math problems were of interest. He likes teaching because it gives him flexibility to do other things in the summer and holidays. Strong feedback on his mathematical ability and teaching ability did not arrive until he was in the military.

> They said I was good at it. . . . So it's the combination of well, OK, you're good at teaching math, you like math, and teaching gives you the flexibility to do other things as well.

More questions about being "good in math" followed and Andrew related,

> I do things in my head better than I do them on paper often. I day dream. . . I daydream and math comes into my thoughts. I will be . . . working on something, or doing something and the problem I've been working on pops in to my head and I'll be thinking about it for awhile.

Key to his thinking about the development of mathematical ability was having a **keen interest** in it. He did not know why he became a mathematician except that mathematics just interested him and effort and practice took him to higher levels of mathematical ability..

> I took an interest in solving certain kinds of problems in mathematics. . . I took an interest in it and so I started to study in it. I studied and I got better. If you're not going to take an interest in it, you're not going to study it and you're not going to get better.

Andrew pointed out that students'attitudes or motivations are probably affected by their perceived ability level.

And if they perceive they are not good in math, then they're not real motivated to do the class whether they're not good in math or not. And they put themselves at whatever wheel and they keep spinning around because they've told themselves they're not good in math or somebody's told them they're not good in math.

Andrew told a story to illustrate the point that faculty impact students' perception of themselves.

I had a student who'd been recruited because he was a wrestler, not because they felt he was going to be an aerospace engineer. And he was sitting in my CAL 2 class and I'd talked to his previous instructor and his previous instructor said, "Now I want you to understand, this guy works real hard, but the only reason why he passed my class was that he got a C on the final." I thought, Well, I don't really want to know this, but thank you anyway." And we're in class one day and I was asking questions and he answered the question. He'd taken the first test and not done real well; wasn't doing his homework. We were talking about something in the class and I asked the question and he answered it. And I looked at him and I said, "Mr. Smith, you know, you really do know this stuff. You just demonstrated to me you know this stuff. And one of these days you're going to show me on a piece of paper that you know this stuff." And he looked at me and he looked thoughtful. He got B's and A's for the rest of the semester.

Andrew recognized that if he took the time to relate to students, his attitude and confidence in them could make a positive difference in their effort and achievement. He thought another component of **student attitude** to be considered was their own expectations of themselves. "They come into a math class and they think they have to be a nerd or a math person to do well in a math class. And that's not true. He recognizes that because he has been working mathematics problems for a long time, he sees the problems and solutions quicker than they will and discusses that with his students. Additionally, he references a belief that there are some people who have a **talent or interest** in mathematics and those individuals may become mathematicians. His beliefs about the genetic propensity of mathematical ability followed

Is it genetic? I don't know. I know there are different philosophies on whether or

> not people, you know, . . . I will claim that not every student can. . . I for one, not everybody is going to be a mathematician, if only because of interest. Everybody can have a certain basic level of mathematics, now what that level is going to be will vary from person to person. Genetic? I don't think so.
>
> *So how do they get it? Some come in with more than others.*
> I don't know. For me, it was a particular. . . I took a particular interest in solving certain kinds of problems in mathematics. . . I took an interest in it and so I started to study in it. I studied and I got better. If you're not going to take an interest in it, you're not going to study it and you're not going to get better.

As I have read and reread the interviews, faculty sometimes seemed to separate skills or tools and thinking behaviors. Andrew held that the way of thinking is different in the college level courses and yet he also suggested that mathematical ability and reading and writing ability were the same.

> *How is mathematical ability different from reading and writing ability?*
> Well, good question! From the standpoint of how people pick it up, at a certain basic level (unless) you've got something physically wrong with you or some sort of genetic malfunction, can do, can learn to read well enough to get around without getting lost, going to the wrong place, can write well enough to be understood, learn to do enough math not to get in trouble with the IRS. So at that level, there is no difference. At basic day to day level doing things, there's really no difference. At the level you operate if you decide you're going to be a math major, there is a big difference. I wouldn't put myself on this level, but for example, Stanisslof Ulam in mathematics and William Faulkner in writing. . . not everybody is going to write like William Faulkner. We can all write at a nice basic survival level. Not everybody is going to do mathematics like Stanisslof Ulam. As far as ability, there are certain people for whatever reason have an ability that is understood to be well and above. I think more people in society around us have an understanding of William Faulkner than maybe of Stanisslof Ulam.

When Andrew talked about testing and mastery he again referenced two levels of understanding.

> The basic idea is that there are certain skills they need to have before they start a college level course. It doesn't matter how many tests it takes them to get the skills down, so long as they get the skills down.

Rob's Definitions of and Beliefs about Mathematical Ability

Rob found mathematics easy and gravitated toward it as a result. He spoke about mathematical ability in terms of **talent and knack**. Another phrase he hinted at was **hereditary ability** versus **self-developed ability**.

Rob's discovery of his skill in mathematics was recognized as a child. During the interview he indicated that he always enjoyed math, enjoyed helping others with their mathematics, and was reinforced by his teachers who thought that he was "excellent in mathematics." Apparently they also felt that since he excelled in it he would not be able to be an effective teacher because he would not be able to think as his students would be thinking and effectively guide or instruct them through the difficult concepts.

> *Excelled in ___________?*
> Excelled in mathematics and they felt that because I excelled in it I couldn't relate to my students and I couldn't get where they were and help them through something difficult. And I felt that I've always been able to do that.

Although Rob felt he has "always been able to do that," his retention and pass rates at his community college fell in the lower group.

When asked what led him into the study of mathematics, he replied, "Well, I think that's pretty much where my **talent** lies. I have a pretty good grasp of the basics." Further probing for a definition of **talent** led to the statement:

> I think everybody has **talents**. And certainly we all tend to gravitate towards things that are easy for us. For instance, my mom does crafts work. She has a **knack**. . . she usually has a creative way of sewing or putting things together. My dad's found wood working. People tend to do things repetively. . . they either like doing or find easy for them, or you know, I think that's just natural. I think we all search for those **areas**.

In order to further define the nature of mathematical ability, I asked, "The talent— is that something you acquired, that just came with the package, that you developed. . . ?" and he replied,

> Well, it's a combination of all those. I mean it's kinda of like saying, you know, are we born with our ability to understand or is it hereditary or is it something that we can develop. I think it's 50-50. I think that's one of the things I was given, that God gave me. At the same time I chose to develop it. If I didn't develop it, I think it probably, you know, I could probably develop it further. I think we all have maybe certain limitations. I don't know exactly where that limitation is. I think we might all have certain limitations, but **we can develop what we have**. And again, I think it comes back. Is this a priority? Do we want to spend a lot of time with it. Turns out that I enjoy school work. I enjoy mostly mathematics, philosophical types of things. And I did develop, I spent a lot of time working. . . . I struggled more in graduate school than undergraduate school. I think most people would say that. Most people experience more challenge then. I felt I reached my **ceiling**. And I may have been able to go a little further, but I would have had to have devoted 12 hours a day to nothing but mathematics. I enjoy it and I love it and I see a lot of things. It wasn't as fun anymore. . . . I didn't want to do it after I reached that point.

I found myself wondering about choosing areas that were easy and whether that would not become boring. Was there a need for challenge? Rob agreed and thought that was why he enjoyed teaching. For him teaching is a challenging way to "help people. . . at least at some level to see some things I see about mathematics." This later phrase related to his emphasis on "different ways of approaching certain problems," and trying to help students "visualize what's going on."

As referenced earlier, Rob professed to believe that students' mathematical ability could change or improve with effort, but that there was also a ceiling. He used his own experience in graduate work to illustrate his point on limit.

Rob also believes a lot of mathematical ability is about paying attention to detail, that is, being able to copy a problem in the text onto a piece of paper correctly. The value of mathematics lies in thinking abstractly and organizing "information to help justify conclusions based upon things that you know to be true." Another component is hereditary or genetic and thus he held to a ceiling or limits to capacity premise.

Mark's Definitions of and Beliefs about Mathematical Ability

Mark traveled a somewhat different path into the community college faculty offices. He was not fascinated with mathematics early in his life. Apparently high school was boring; repetitious, and rote and drill mathematics activities were of no interest. He commented, "I was horrible in high school math, at least the math that was presented to me." When asked what he meant by "horrible in math", he replied,

> Well, a D. . . I came from a high school with unexceptional results—a high school that was considered fairly good. And my quote-unquote assessment scores were not all that good.

He was placed into a 1000 level Intermediate Algebra class in college and felt that was due to his poor preparation, but he blossomed in the college environment. Although he never quite said it, it was in this environment that he recognized his mathematical ability.

> There was a great difference in atmosphere and presentation in college versus high school and I guess I fed on the college environment. . . I just felt like it was exciting. It was very good for me to be in that kind of environment. . . big school, a lot of people from all over the place. It was just different. . . And I felt like I could achieve excellence on my own. . . whereas I don't think that kind of environment exists in high school. . . what I can remember of it. I think you're stigmatized if you try to achieve excellence in high school. And I guess I was stupid, I didn't realize that what I did was so exceptional, but now it would be considered exceptional . . . taking 19 hours and working 40 hours a week, driving 60 miles a day. . . and still maintaining a very high GPA.

When asked why he chose to teach mathematics, he replied, "Because I wanted a stipend to help me live." During high school, mathematics was not challenging and his first college mathematics course was Intermediate Algebra, a 1000 level or developmental course at that time. During his undergraduate assistantship at the state university, he discovered and fell in love with mathematics. Excellence was not expected or encouraged in his high school, but in the college environment excellence was supported. He remembered high school mathematics as only problems from a book without explanations.

Mark's definition of mathematical ability in basic math courses centered around mathematical vocabulary, attention to detail, logical patterns, and an autonomous nature. Although thoughtful in many areas of mathematics, his definition of student's mathematical ability was often not clear and probably something he had not considered.

Mark's definition of mathematical ability began with what it was not. Mathematical ability was not working problems from a textbook by rote and without explanation or understanding. In fact he set a very high level for mathematical ability or mathematical ways of thinking for himself. He considers himself a technical person rather than "an excellent creator and an excellent technician" in the mathematical world. According to Mark, he is a "great technician---can sweat the details."

Mark's definition of mathematical ability was not clear. He felt students were not coming to the community college prepared for college level mathematics. They may have passed the math courses, but were not prepared to solve problems at the level of rigor expected. It is interesting to note that his own experience was similar. In college he was placed in a 1000 level Intermediate Algebra course which today would be a developmental or pre college level course.

> *You're saying the students in high school get a lot of practice on doing a problem over and over, but they're not getting the concepts. They can't transfer it to new problems.*
> Right. In other words, it should be deductive reasoning that goes on. And that should distinguish what we do and in particular, I'm not a person who has a lot of the knowledge to speak of about what goes on in high school. . . other than my experience there and which I ran like hell to get out of there and I was happy to leave. I don't know what goes on there, but clearly if you understand the general, you can apply it to the specific. But just because you can do specific kinds of things, doesn't mean you understand the general and I think that's what characterized higher education. At least that's I understood to be all those 11 years I went to school. . .
>
> *The knack for math?*
> Well, it's *pattern*. OK, I was looking for what is mathematics and this author said it is the **science of pattern**. That's very simple and I don't want to say that's what it is because at higher levels it certainly is not. . . not a science of pattern. But certainly for what we do here, a lot of what we try to convey to the students is there is a **pattern to. . . a logical pattern** to what we do

Mark also thought that students needed a basic mathematical vocabulary in order to read the text, understand the lectures, and think within the mathematical discipline. He emphasized vocabulary with each chapter and unit.

> A lecture is basically definition, to make sure we have the vocabulary defined, then any concepts will be labeled in real course facts without the dreaded theorem and then we want to apply those facts in an example or two or three. . . . I'd push on the vocabulary part. I don't think there is a single more important thing. . . . And secondly, I would encourage them, if anything, to try to integrate the vocabulary use, use a lot of English in their explanation, try to use less mathematical symbols and when you use mathematical symbols make sure you use the connections to the English, because students come into remedial courses with thin vocabulary in math and you need to use that English and try to get them to think about mathematics in those terms. . . . I think I use more words. I think I recognize that reading comprehension is based on vocabulary and vocabulary is based on exposure to words, both spoken and read. The larger the vocabulary you have, the higher the reading level.

He also emphasized reading and **attention to detail** and felt that they were not emphasized in the public or higher education domains as much as they should be.

Mark enjoyed sharing his ideas about mathematics teaching and his role in that, but much of his commentary diverged from the topic to his own agenda. Mark distinguishes higher education and its role from that of public education.

> I mean, how do we distinguish what we do as an institution of higher education from common education? If someone comes and works on your air conditioner, do they understand thermodynamic principles? Probably not. But because I understand thermodynamic principles, I can go fix the air conditioner. I think that's part. . . you go into a classroom, a math classroom, and you say, "OK, if you understand these concepts, every problem that illustrates these concepts can be solved, but because you can do the first 25 problems on the board, me standing over you or with your tutor, doesn't mean you can do the 26th. And that's where we're screwing up, big time. It's not concept and practice, its's practice back to concept. I don't think it works. . . In other words, it should be deductive reasoning that goes on. And that should distinguish what we do and in particular. . . but clearly if you understand the general, you can apply it to the specific. But just because you can do specific kinds of things, doesn't mean you understand the general and I think that's what characterized higher education.

Mark was trying to say that just because students get a lot of practice on a specific type of problem does not mean he/she will be able to transfer the concept to new problems. He was also trying to point out that public education emphasizes practice, rote, and memory rather than concept building and transfer.

Pre-college courses are filled with skills and concepts that should have been learned in public schools. His community college offers three pre-college level mandatory placement mathematics courses. Mark emphasizes vocabulary development in his pre-college or developmental courses. His belief is that students think in words and pictures and they need the mathematical language to communicate about mathematics.

In response to the inevitable question about his beliefs about mathematical ability, he talked about patterns. He believed that at the lower levels mathematics is a science of patterns, "logical patterns to what we do."

So we're talking maybe a capacity, a range that within. . . what makes them hit that ceiling? . . helps them hit that ceiling?
I don't know what you mean. . . oh, achieve their maximum potential. Well, I would think, again, that's their ambition.

Motivation?
Yeah, sure. They have to have some courage to try to find that ceiling. That's kinda frightening for some people to say. . .

The ceiling is the same for everybody?
No, I don't believe that. Goodness, no. We wouldn't have an Einstein. And to be quite honest, I don't want a student to say, "Look at Mr. Smith or look at Ms. Jones, they're so far ahead of me and I think that's good." I want them to say, "I think that's good." I want them to say, "Look at Michael Jordan play basketball." When I watch him play basketball, that sheer joy because of who he is, not what he does. . . Bloom wrote there . . . his wish for students is to become autonomous. That's my wish, too. I think that after a good length of study, not two years, not four years, maybe six years, maybe eight, maybe ten years, maybe, you know, that when you're all said and done and got your degrees and everything is done and you've got your books on the shelf in the library at OU, what do you hope your experience has gotten you? Do you want to be to the point that you are autonomous? That you go there to the library and do anything you want to do? You know, can you take a book and fix a car? Can I take a book and study mathematics? Take a book and study history? And read about thinking and higher education and what not? That takes a long time and that's what I want my students to be able to do, but very few people can do that.

. . . *What motivates students to change their ability level?*
I think that with some individuals, if they perceive that they are capable, they may be more motivated. That is not true for everyone. I think there are those individuals who have that glimmer in their eyes, that sheer spark of enjoyment of being in the process of learning and understanding that there are people or books or ideas that are to be learned and that they transcend nations and languages and culture. Those who feel like they are going to be successful, achieve that feeling of achievement motivates them. But then, there are those who do it just for, I would say "joy of learning." Even though they are not good at it, they try to achieve and try to motivate themselves. And I think that that's not very fashionable any more.

Liz's Definitions of and Beliefs about Mathematical Ability

Apparently Liz recognized her mathematical intuition early for she commented that she was "always good at doing mathematics." Intuition, logic, and practice were key to Liz's understanding of the nature of mathematical ability. She thought everyone has intuition and students must learn how to use it in mathematical thinking.

When asked what drew her to teaching mathematics, Liz recognized that teaching allowed her to fulfill her interest in helping people. She also knew that she was good at mathematics, "I was always good at doing mathematics when I was in school." The phrase "good at mathematics" was interesting and when queried about its meaning, her quick and enthusiastic reply was, "I could do it!" As Christy, Rob, and Edward suggested earlier, Liz also expressed the idea that "whenever you can do it well, you enjoy doing it." She enjoyed mathematics, chose to study mathematics, achieved two mathematics degrees, and began teaching.

In trying to query her for a definition of mathematical ability I used the word "intuition" and she picked up on it, but her statements describing mathematical ability were interesting. The conversation flowed as follows:

You were GOOD at math. It came easy to you. You had good skills or good intuition or good _________ what?

First of all, I think the most important thing in studying mathematics or learning it is *intuition.* You've got to just be able to use your **intuition** in doing math; you've got to be able to look at a problem and just think about what the answer should be or think about a method for solving the problem. And sometimes these ideas just come to you.

Is that like driving the car and you just intuitively know which way is north? Something that some people have and some don't have as much of?

I think everybody has that, but you have to learn how to use it. You have to learn how to use your **intuition** in doing mathematics. Some people don't trust their **intuition**. They just don't learn how to use it. *Logic* is involved, too. After you get through the process of just thinking about what the answer should be or the method should be for determining the answer, then you've got to present your results and that's got to be presented in a **logical way**.

In a later discussion of how students learn mathematics the word **ability** was used. The question related to some students needing more and some less practice. I asked about practice and students with low and high abilities.

If they have the ability to learn math at all, I mean, some may have to put in more time, more time practicing than others, but they can also learn the material. They can also achieve, too. Those that don't learn it quickly, that don't have the **ability** to learn it as fast, they just have to work harder. Those that can do it quickly, they don't have to work as hard.

In other words, if students can learn other academic subjects, Liz felt they should be able to use intuition and logic with effort to learn mathematics.

Liz firmly believes that students' mathematical ability is not a matter of genetics. She thinks that if they can learn other subject content, then they can learn mathematics. The problem is that "a lot of students don't learn how to learn math. They don't know how to learn the concepts and there's a certain way in which you have to proceed." This was key to her thoughts in response to an earlier question when I had asked her about what she did when she hit a "brick wall" and was having major difficulty understanding a mathematical concept. She replied,

I would just never be defeated. I just figured I can do this. I kept thinking I can do this. And in solving math problems, in addition to just working intensely, you gotta have some rest periods in there, too, and if I would hit the brick wall, I would just let it go because I would end up getting frustrated if I just kept working and working. I would just have to rest for awhile and I would go away and maybe think about it for awhile and during the time I was away from the problem then some ideas would

> come. Maybe intuition got to working again and some ideas would just come and, you know, it would be the solution I was looking for.

In this response Liz related to her own experiences in order to reinforce her belief that mathematical ability can improve through effort.

Later we discussed the importance of attendance and practice. Liz thinks attendance and practice are important in the development of mathematical ability because they help students "stay on top of things" and because

> mathematics is an accumulative subject. You cannot one day not do homework problems and come back the next time we meet and expect to pick up from there and go on because there is a hole in their knowledge and they won't be successful unless they stay on top of things. They need to consistently do the homework problems and they need to do them to gain the practice necessary to learn.

Twice Liz mentioned "the ability to learn math." The first time she was answering a question about the reason for some students needing more practice than others. She thought that if they had ability to learn math some will be able to learn faster than others. The second instance was when she was asked to elaborate on how students should "know how to learn the concepts and there's a certain way in which you have to proceed." Her explanation was,

> Well, I just think about how I learned math and I think about how I did. First of all, they've got to believe that they can do it. Some students say, "Well, I can't do this. There's no point in even trying." They have to believe they can do it and they have to put forth effort to do it. They have to really be actively involved in learning; they have to do whatever it takes to learn it. If it takes going to the math lab everyday, coming to see me in my office everyday, that's what they have to do if they want to learn the math. And, basically, I used to think that some students have a math mind, and some don't. I really don't believe that any more. The motivation has a lot to do with it. . . self-motivation. There's just something that they have to work with. . . I believe that if a student has the ability to learn, then they can learn the math.

When asked if ability level could change, she replied, "Just having the ability, I don't think it's . . . just being able to learn, having the ability to learn. I think it can change." She believes that students need skills, the ability to learn, and to be actively involved in the learning process. One of her beliefs about mathematical ability is that some of the younger students with lower ability levels have shorter attention spans whereas the "normal adult attention span is about an hour." She has observed that the younger ones have trouble focusing on the class activities.

Jan's Definitions of and Beliefs about Mathematical Ability

Jan commented that she had always liked mathematics, been good at it, and decided to pursue a career in teaching while in elementary school. Mathematical ability is about "curiosity and a way of looking at things. . . Curiosity to see how things work and willingness to analyze and try things and explore what would happen if you did such and such" according to Jan. She wanted to be a mathematics teacher when she was about ten years old. At that point in time she had been tutoring and recognized she liked to work with people. When asked about why she was good at mathematics, she replied, "I think it's the **way I look at things. I think things through and analyze and consider alternatives. I think logically**. . . just have a natural **curiosity and way of looking at things**."

My next question related to how one develops mathematical ability and she replied, "In the way you teach it, the way you ask questions." Jan did not believe in requiring the memorization of math facts, but liked to play games with students to make them think. For instance, when teaching the multiplication tables she would ask them, "I'm thinking of two numbers whose product is something. Can you think of some numbers that do that? And if they answer it, you say, 'Now that's good, can you think of another way?' Try to get them to think of alternatives. . . I try to ask them questions to make them think about things rather than just memorizing how to do problems."

According to Jan, an inhibiting problem for students in her mathematics classes was not lack of motivation or ability, but of just not being prepared. "Their background is so poor and they've been told they're stupid or than can't do this and that; math is hard; so they come in a little afraid of what they're getting into." In essence, she was saying that their own attitudes set their limits, not actual ability.

Her thoughts on mathematical ability were interlaced with an understanding of how learning takes place.

> Everything in math requires that they understand the material from the previous courses. So you try to relate what they're learning now with what they know and perhaps so they can start with that knowledge and try to build on it and expand it. You try to get them to look for patterns, to think about what they need to . . what it is they're trying to answer and what they already know and kinda figure what the route they would have to take to get from what they already know to where they want to go and try to figure it. . . try to analyze the situation and make a plan of action.

She was trying to set the stage for students to do as she had done and drive their own learning. Jan herself continues to be curious, analytical, logical, and aware of the *patterns*. She is concerned about the number of students passing and felt that if only one third of the students were passing then there may be one of two problems occurring. "Nothing is being taught decently in the course or the students don't have the background to be able to handle it. If they don't have the background, they should be in a lower course to build up that background before they come in to that class." Jan continued to define curiosity, and background skills and knowledge as mathematical ability. Later on when asking her about the difference between behaviors of low ability and high ability math students, she said,

> I've been counseling with the ones that don't want to be there or are just there because they have to. I try to find out what they're interested in and why they're there and encourage them. It's not a matter of being as curious as other people. They still have the . . . if they're interested they can be just as *curious* as an A student. They may not have the *background* to explore that.

Of the eight participants Jan has achieved the most education with two masters degrees and a Ph.D. She takes pride in her ability to "think things through and analyze and consider alternatives." She thinks logically and believes that those who are not mathematically minded have not learned to think logically. She believes that part of the problem is that they were not taught how to think logically in high school but were only expected to memorize. She believes that a strong component of mathematical ability is curiosity. "Curiosity to see how things work and willingness to analyze and try things and explore what would happen if you did such and such. . . " Students may even be curious but without an adequate background of skills and concepts they do not have the needed ability level and are not prepared for the rigor of college level mathematics. She reiterated the need for analysis when discussing mathematical ability and reading and writing ability. Jan believes there is not very much difference in how students must learn the three.

> In either case, you take some given information, you analyze it, you think about what it's telling you and you draw conclusions. . . In our Basic Math we encourage word problems as a way of learning to analyze English which should help them somewhat in their reading.

Trends and Patterns Across Responses: Definitions and Beliefs

The purpose of beginning the interview with the question, "Let's begin by talking about you and what drew you to teaching mathematics?" was to dissolve interview anxiety by having faculty talk about something they were comfortable with and that was related to their interest and development in mathematics. As it turned out, the question provided informative insights into their definition of what it took to develop mathematical ability.

The first section will review patterns from the participants' stories about what drew them to teaching mathematics and discuss their definitions and beliefs as a reflection from their earlier experiences. Other topics include their references to practice, and processes; observations of students' attitudes; comments about faculty attitudes; and beliefs about the limits and ceilings of mathematical ability.

Definitions of and Beliefs about Mathematical Ability as Reflected from Personal Mathematical Journeys

Six of the eight participants, Christy, Edward, Andrew, Rob, Liz, and Jan, reported remembering that they were always good at mathematics. Danielle and Mark did not recognize their strengths in mathematics until they were in college. Danielle, Edward, Andrew and Rob also reported positive feedback on their mathematical ability from their instructors. The timing of the encouragement was not consistent for Danielle received it when she went to college and Andrew while he was in the military. Although Rob received positive feedback from his public school teachers, they did not encourage him to consider teaching as a career. Edward received positive feedback initially from his elementary teachers. Still another form of feedback occurred for Christy and Jan who received positive feedback from their tutoring experiences. Thus, Danielle, Christy, Edward, Andrew, Rob and Jan received positive feedback either from their instructors or their tutoring experiences. Only Mark and Liz made no mention of instructor feedback from tutoring . In addition to being good at mathematics, outside affirmation was a theme in faculty mathematical ability development of this group.

Another way to look at this phenomena was to consider intrinsic and extrinsic encouragement. For some, recognition of their ability was intrinsic and self-driven. Others knew they were good at mathematics and had prods from others along the way. These prods helped them define their high level of mathematical ability and encouraged them to consider teaching mathematics. Danielle, Edward, Andrew, and Rob received extrinsic encouragement from instructors and Christy and Jan received extrinsic encouragement from their tutoring experiences. Mark did not report encouragement except to note that his doctoral faculty advisors were very disappointed when he decided to withdraw from the program. Thus, Mark appears to have been intrinsically driven and without outside encouragement. Liz also made no mention of extrinsic encouragement.

As might be expected and had been identified in earlier research (Lopp, 1996), their definitions of mathematical ability were often echoes of their own mathematical journeys. For instance, Danielle's college instructor suggested that she had the "knack for math" which she said meant

> I was precise, I checked everything and then when I didn't understand I went back and questioned. I was, I did, . . . something that I didn't understand, I was always in there asking questions about what, why was something like it was. And what was I

doing wrong and so he felt like I knew what I was asking, I just didn't know the answer to it, but I knew how to ask the questions.

Later in the interview I probed further about Danielle's definition of mathematical ability and asked what those with *low* mathematical ability did *not* have. She replied

> Some of them just don't have the ability to ask questions. Some of them don't know even how to get started on anything. They just don't have the approach and I think a lot of times the ones that don't have it are the ones that are just passive in class. . . .
>
> *Is mathematical ability something you're born with, can it change, is it fixed, is it something else?*
> I feel like it can be changed. *I try to think back in my math experience*. . . I was just a basic. . . I went through regular math core as far as high school. . . .
>
> *Why do some people have more than others?*
> Have the ability?
>
> *Have more knack or more ability than others?*
> I. . . to be honest with you, I don't know. I can't say why somebody else on our faculty can be more. . . it's not, I don't know what the word is I want to use. . . intellectual about the mathematics. They really have the **gift** about the mathematics. I don't have that **gift** as much.

Danielle related mathematical ability to a **knack** that she had and a **gift** she saw in other faculty. These characteristics related to questioning and understanding as her professor defined **knack**.

Christy tutored while in high school and college and then developed study groups in college. These are active ways of learning and as an instructor she advocates study groups and emphasizes active learning techniques, i.e. lots of board work, attendance.

Edward delighted as a child in taking things apart and putting them back together. Edward defined mathematical maturity as the second of two levels of mathematical development. The first was the development of tools or basic skills and the second used the tools for mathematical thinking and problem solving. He believes that a strong component of mathematical ability is contributed by the environment -- through parents, peers, interests, and activities. Mathematical maturity is the ability to solve applied problems using the "concepts of mathematics."

Edward has an inquisitive mind and is constantly studying his classroom environment. For instance, when asked about active teaching strategies designed for students to discover mathematical patterns, he replied,

> I don't know whether discovery added to what they had as children has been squashed during the time before we get them, but most of the students we have at the developmental level classes just aren't discovery type of students. They are not active students themselves; they are somewhat passive students and it's very difficult to get them to be active learners. And I've tried some things years ago and it's just one of those deals where you work your butt off and tried different things and you look at your completion ratio and its the same no matter how you do it. It seems to be, and in fact it's getting lower now, that's not just me, that's everybody, and you think, "Why do I go to all this extra trouble of doing all these extra things?" For instance, one of the things that is recommended is feedback of some kind like homework and things of that nature. So one semester I decided, actually for a whole year, I had more than one section of elementary algebra, so I said just for my own non-statistical data or anything, I'm going to take up homework everyday in this class, grade it, and return it the next day and not take up homework in this other class. No difference in the completion rates whatsoever! OK, they were both bad, but no difference in the completion rate. Just didn't have any effect. And I thought why am I spending all my personal time grading all these papers to get them back to students the next day when it's really not having any net effect. It may be helping one student individually finish the class that wouldn't have finished it, but as a group, I'm not increasing the percentage, so to me it wasn't worth it, I guess.
>
> *Did you find anything that made a difference on retention?*
> I haven't found anything yet. And I've gone to meetings, I've talked to people, and it's a common, nation-wide problem of developmental mathematics. For awhile, you think it's you, then you get to talking to other faculty in your area and, no, they're having the same problem and then you go to local meetings and then state meetings and then national meetings and it's a common topic. So it's not just us, it's everyone.

Thus, early patterns and understandings continued to echo in their mathematical journey.

Patterns, Practice and Process

Looking for mathematical patterns, the use of practice as a part of mathematical development, and mathematical thinking as an evolving process were suggested by several faculty. The importance of patterns was mentioned by Edward, Mark and Jan. According to Jan,

> You try to get them to look for patterns, to think about what they need to . . what it is they're trying to answer and what they already know and kinda figure what the route they would have to take to get from what they already know to where they want to go and try to figure it. Try to analyze the situation and make a plan of action.

Practice was specifically mentioned by Christy, Edward, Andrew, Mark, and Liz. In response to a question about why use practice, Christy said, "It becomes a part of them." In fact, all eight faculty used homework, examples, and classwork to promote practice.

That development of mathematics is a continuous process requiring practice was suggested by Danielle, Christy, Edward, Rob, Mark, and Liz. Whereas, Christy stated the value of practicing as, "It becomes a part of them," Liz said it even more clearly:

> Well, you learn by practicing, I think. You get better at doing anything by just practicing. The more you practice, the better you get. So they have to practice and if they stay on top of things, they have to stay on top of things. **Mathematics is an accumulative subject**. You cannot one day not do homework problems and come back and the next time we meet and expect to pick up from there and go on because there is a hole in their knowledge and they won't be successful unless they stay on top of things. They'll consistently do the homework problems and they need to do them to gain the practice necessary to learn.

Edward's statement about the process was both thoughtful and lengthy,

> Learning mathematics is a **process that is continual**. It's not, "I've learned it and

I'm through." It's a **continual process** and it's like the old country and western dance. It's two steps forward and one step back. You learn a little bit and then you lose a little bit and you lose a little bit. And you've got to realize that since it's a **continual learning** situation, that you have to continually pursue that and every person . . . and students never believe. . . they think that all of us were straight A students in mathematics. . . they couldn't possibly believe that some of us could have made a C in a math class. There's no way we could have made a C. So when we tell them and try to identify with them that we've been in the same places they've been, we've done the same things they have, and that if you work at this **continually**, and we nurture a little bit, that crack opens a little, and a little light starts to come through at the end of the tunnel, and for some students, there just may be one particular thing that tends to open up the whole picture to them. And you have to keep working at that and you've got to let students know to keep working at it. I tell them over and over that when I was doing mathematics at XXXX, I could work on a problem so long and then that was it. I couldn't handle it after that. It was stressful, so I had to have a break. So what'd I do, I'd go ride my motorcycle for a couple of hours, you know, and then come back and start again. But there comes a point where just pending time trying to do something is not productive. There's a time where its not productive, and you've got to be able to recognize it as that. And so, what you need to encourage students to do is think about this awhile and when you get stuck, put it up a little bit, do something else and believe it or not, you mind has that capability of kinda like a Windows program, of having an active window in front and another window in the background is working at the same time and you may not realize it, but all of a sudden while you're working on something else, that problem you were working on in mathematics, all of a sudden something can come up. But if you **continue** to think about it a little bit at a time, it's not ever going to come up again. . .

And when they start explaining things, I try to impress upon them that **learning mathematics is not an overnight thing; it is a continual thing they have to keep working at it and working at it.** And the worst thing they can do is when the going gets tough, quit. And that's what a lot of developmental students do.

Although Mark recognized learning as a process, his comment also spoke to his own attitude toward the process as well.

I notice that people progress at different speeds through the course, and I don't feel like I should have someone who is progressing quicker slow themselves to help someone who is progressing slow. Now if they wish to do that on their own, I would certainly encourage it.

Faculty recognized a need for students to actively practice the computing and thinking skills in order to understand the process and move forward into the mathematical way of thinking.

<u>**Student Attitude**</u>

Student attitude was referenced by all participants. Sometimes faculty injected thoughts about student attitude or their students' perception of their ability as being the limiting factor rather than actual ability. It was as though student attitude toward mathematics set limits. For instance, Danielle mentioned student attitude as student self-confidence and said,

> I feel like it's not that they don't have it, a lot of it has not been used in a while. And they just need to fill their **self-confidence**. It's not that they don't have it because I started in a prealgebra class. It's not that it's not there, it's just that they don't have the **confidence** yet to know that it's there and they've just forgotten some things. Or they just. . . it could be that it's not there, but they can learn it. And they all can learn it; it's just a matter of time and they've got to pull out and understand that they've got to ask questions.

Later when asked about their anxiety about being at the board for board work, Danielle said,

> Well, I think if they're in that prealgebra class, they just do not have good feelings about their math. . . .
>
> *So you're saying attitude or ability?*
> It's their **attitude** and they think they don't have the **ability**. They do well and they like it once they go, but they like having everybody up there. They don't want to be singled out
>
> *Because this would expose their ---*
> . . . . exposes their insecurity as far as math is concerned.

And when asked what inhibits her being able to do achieve her classroom role of teacher, instructor and helper, Danielle added more about student attitude.

> Well, sometimes it's just students on themselves that are an inhibitor. They think they can't do it or they don't want to do it, or don't want to be . . . sometimes it's just

breaking that barrier down to tell them they can. You tell them, "You can do it, you can do it, you can do it."

Edward's response to the question on what inhibits them in accomplishing their perceived role in the classroom was

> I think the most frustrating, inhibiting, intimidating factor is when you've gone in and you've put everything you know into this particular class and the class has no reaction whatsoever . . . I mean the class is like HOHUM. I mean, we as instructors, kinda want to get our warm fuzzies by seeing some positive response from the class and I think the most frustrating thing in the world is to have a classroom that has a . . . and each class has its own personality, I think. . . but to have a class that has no single individual that seems to have some kind of positive response. In other words, you could come in there and set off a bomb and the attitude would be the same everyday no matter what you did. And there are some classes like that and I think that is the most frustrating thing in the world. And you don't have many of those, but you do have some classes like that.

Edward also commented that his students seldom attended the math lab during his hours to tutor.

> Very few of mine come at that time. Whether it's, "I don't want to come and show my ignorance," or whether it's not convenient at that time because of my schedule or what, but I usually find that very few of my students come during my math lab hours.
>
> *You said, "Don't want to show ignorance."*
> Well, what they mean is when they can't do something, they think it's their fault that they can't do it. . . But there are some people, I think, that are real reluctant to ask questions and now when they're in there with this person that is their instructor and they're working with them everyday, they feel like if they ask these questions, that just shows they just don't understand the material and therefore they feel like they'd rather ask another instructor because that other instructor, the only time they're going to see is in the math lab. If they ask me, then I'm going to see them in class; so I'm going to say, "Well, this student doesn't know what they're doing," or at least that's what they think I say. And so I think they're more reluctant to ask questions of the instructor working in the math lab than they would a different person working in the math lab.
>
> *So they don't want to expose their inability to do the problem and to you in particular?*
> I think that's the primary reason they don't because I talk to students and they say,

yes, they use the math lab, but they don't use it while I'm in there. So I think, it may not be a conscious decision on their part, maybe an unconscious decision, they don't tend to use is... now my calculus students will. OK. But my developmental level students won't. It's the difference in their confidence in themselves and so as to whether they'll come in when I'm working in the math lab or not.

Andrew referenced an incident in which he found the attitude and actions of a controlling student as inhibiting. By that he meant a student who tries to control the class makes it difficult for the instructor to maintain control and teach and for students to learn. He also told a story about Mr. Smith in which he addresses **faculty attitude impacting student attitude and performance.**

"Mr. Smith, you know, you really do know this stuff. You just demonstrated to me you know this stuff. And one of these days you're going to show me on a piece of paper you know this stuff." And he looked at me and he looked thoughtful. He got B's and A's for the rest of the semester. If we identify, if we have time, and that's the biggest thing with big classes and a lot of them, you don't always have time, but a lot of times you can identify that a person really . . . you can find out why the person is not doing well in class, and if it is psychological... well, not psychological, but if it is for a whatever reason they've just never thought they'd do good in math, then you can usually do something that without having to . .

You're talking about self-confidence, self-efficacy. . . ?
Self-confidence or whatever. Yeah...

Mark and Rob also referenced student attitudes as being problematic. Rob said,

One thing is student perception of me as their teacher. I know as a student, it didn't happen too often, if I had a teacher that I didn't care for for whatever reason, it was difficult to accept what they said without thinking first and going back to and spending 90 percent of your time and effort saying, "Why do I have to be here?" Instead of spending 90 percent of your time being open about this. So a lot of it is student attitude. Part of what I try to work on is student attitude. I try to work on it. It's part of what I do what I do. Allow students to correct their tests. Encourage them to ask questions. I do tend to try to joke around a little bit in class and I try to be less formal, although my nature is to be fairly formal. I try to be less... to try to reword things in terms of understanding. I try to help their attitudes toward me.

When probed for more about student motivation, Jan said,

> One of the problems is they are not prepared to be in the courses which is why we have so many go back into Elementary Algebra and Basic Math. Their background is so poor and they've been told they're stupid or they can't do this and that math is hard so they come in a little afraid of what they're getting into.

Faculty Attitude

As Rob talked about students' attitudes, he revealed his own attitude. His attitude and those of the other participants are a reflection of beliefs about self and others. Danielle, Christy, Edward, and Andrew voiced a determined attitude that students could learn mathematics if they would just spend the time and effort. They saw themselves as actively involved in fanning the thinking and processing fires. Liz verbalized some of that same attitude, but on the whole, Rob, Mark, Liz, and Jan seemed to have a more distanced manner as though learning was up to the students and their faculty role was not as an active shoulder-to-shoulder player in the process. For instance, Danielle and Christy reported a sensitivity to student's dismay or anger at being placed in pre-college level mathematics courses and determination that part of their role was to **care** about students. The resulting responses by students may have been students **caring** about their own performances in class. Danielle used phrases like, "You have to get down there and understand exactly where these students are coming from," and "I try not to put them on the spot. Board work does that and I put everybody at the board and have them working with someone else that doesn't intimidate them so much. They don't like to be intimidated. . . . They're scared enough. I would have died to have had to go to the board by myself in prealgebra. Working with other people, it's a lot less intimidating."

Christy's thoughts on her own performance as to what inhibits her role accomplishment were unique among the group of eight. She focused on her role rather than student attitude or something outside her control. She recognized her thoughts, feelings, and attitudes and that she could and needed to respond to those of students.

> I always get nervous the first day of class. I wake up early in the morning or wake up in the night of something. You worry about what you're going to get and I think you do.
>
> . . . And the other thing I do I think is real important. It's not a college situation thing. I think this is coming out somewhere else. I think you have to treat them as that they have problems, too. "Gee, you've had a bad day! Your kid has been throwing up all weekend." That's on their mind more than learning math. And if you don['t take an interest in some of the personal problems they have, they're not going to listen to you for math either. . . . I think that I know a lot. . . I know more about them than I want to hear. I have an awful lot of students that call and tell me, one's having a baby, one's, you know, . . .

Edward's comments about how he had changed as an instructor reflected a change in attitude toward his role in the classroom. He moved from the telling mode to a getting into their thinking, strategizing, and conclusion development mode.

> *How has your teaching changed since you first started? In what ways? Did you use more lecture, did you use. . .*
> Let me put it this way, when I first started teaching I thought I was a teacher. After I taught about ten years, I realized I wasn't a teacher. And so, I think I matured in my ability to teach after a period of time and I've really only become what I would consider a good teacher in the last 5, 6, or 7 years.
>
> *What is a "good teacher now" as opposed to that beginning teacher?*
> I think, in my opinion, I'm a better teacher, at least, I don't know what a "good teacher" is, but a better teacher is a teacher that can lead students to come to conclusions rather than providing the conclusions for them. Now when I first started teaching, I provided the conclusions for them without letting them get there by themselves so I think I'm better now at giving them direction to get where they need to go without telling them what the end is going to look like when they get there. I think I'm a lot better at that than I used to be.

Andrew indicated an interest in "why the person is not doing well in class." He thought that if the instructor took the time to find out, he/she could make a difference, e.g. Naval Academy student story.

Rob recognized students' attitude toward their instructor impacted attendance and effort, but whereas, Danielle and Christy talked in terms of "caring" about the students and their problems, Rob's response was to reach out on the professional academic level to them.

> Part of what I try to work on is student attitude. I try to work on it. It's part of what I do. Allow students to correct their tests. Encourage them to ask questions. I do tend to try to joke around a little bit in class and I try to be less formal, although my nature is to be fairly formal. I try to be less. . . to try to reword things in terms of understanding. I try to help their attitudes toward me.

Rob and Mark's attitude toward students included a need to control the activities. At one time Mark had developed a matrix for roll taking which he has since stopped because "it has really rubbed the students raw. I don't know why." He does not use board work activities because he perceives college "as being very independent and learning" whereas "going to the board kinda seems high school." Although he did not say it, board work activities do not offer him the same level of classroom control as having students remain in their seats. Twice he referenced the lack of questions from students. His interaction with students as he reported was limited.

> *You have a question and answer time at the beginning?*
> They can certainly interject at any time and I prefer that they just start speaking because often my back is to them and raising their hands is kinda ridiculous in that environment. The amount of interaction that I have from any crew here with rare exception is pretty slim. I don't have a lot of questions. I don't care if it's the first day, last day, middle, and if it is it's always those students making relatively good grades.

Mark thought that students lacked the fertile soil in which to cultivate mathematics.

He remembered a big difference in the students at his alma mater and those at the community college when he first started teaching. He also commented that "Those (first community college students) were darling angels compared to what I have now."

Liz reported confidence that if students had the ability to learn other subjects they could learn mathematics. Her attitude was one of confidence in students if they were "willing to get in there and work at it and try." She encouraged students to work intensely, rest, and come back and work some more. Her role in the classroom is to impart knowledge, motivate, and make them understand both the importance of the course and the importance of trying to learn the material. "They have to be willing to do what is necessary to learn. . . "

Jan's attitude was thoughtful, but consistently distant. It was someone else's job. Her thoughts about getting around the "brick wall" were to "Just encourage them to keep at it. Compare them to runners. . . Stay with it, don't give up. At some time the flood is going to break!" She suggested there was a need for better assessment and placement, but had not been to the Testing Center to use and evaluate the computerized placement test instrument. Her role in the classroom was one of guide, counselor and sometimes expounder of knowledge.

Beliefs About Limits and Ceilings of Mathematical Ability

In probing for answers to questions about beliefs and mathematical ability I asked questions about genetic determination and fixed versus maleable characteristics. I also listened for information about effort and strategies promoting change in ability level.

No one said they believed that some people are born with a genetic propensity for mathematics and others have little or none. Some thought there are limits to the levels of understanding an individual could reach, but all seemed to think mathematical ability level could change. What was interesting was their thoughtfulness or lack thereof about how that takes place.

Who said mathematical ability can change and who said there were ceilings limiting change? Danielle said, "I feel like it can be changed," Christy believed there was a **maturity level** students had to develop. This would imply change, too. Christy believed that she cannot take "morons and turn them into mathematical geniuses," but if a student can learn other subjects, the student can learn mathematics. Edward divided development of mathematical maturity into a tool level and a thinking mathematically level. He thought being inquisitive and learning to see patterns was part of the development. According to Edward, without the tool level you cannot learn mathematics, "Without that foundation you cannot learn or develop mathematically." Edward believed that the environment nurtures ability changes and that it's important to consider "learning mathematics a process that is continual." Andrew did not think mathematical ability was genetic, but he thought, "Everybody can have a certain basic level of mathematics; now what that level is going to be will vary from person to person. Genetic? I don't think so." Andrew also thought there were two levels of understanding to be achieved and the underlying assumption was that the basic skill level had to be mastered before the mathematical thinking level could be achieved. "The basic idea is that there are certain skills they need to have before they start a college level course." Again, Andrew assumed change in mathematical ability.

Rob's thoughts seemed stronger toward a genetic component .

> I mean it's kinda of like saying, you know, are we born with our ability to understand or is it hereditary or is it something that we can develop. I think it's a 50-50. I think that's one of the things I was given, that God gave me. At the same time I chose to develop it. If I didn't develop it, I think it probably, you know, I could probably develop it further. I think we all have may be certain limitations. I don't know exactly where that limitation is. I think we might all have certain limitations, but **we can develop what we have.**

Although Rob professed a belief that ability level was not totally predetermined, he obviously struggled with how much is genetically determined.

> **It can change. It can be developed.** You know, it's really funny, because I hear the body of education saying a different thing than when I took education classes at XXXX. And I don't know if they still say the same thing to students there or not. I was. . . it was always accepted that certain students, certain people, would never reach true abstract level of thinking. And certainly there would be things to do to develop that level people had and elevate them to a higher level of thinking. But still, I was always taught, I accept it to be true, that a certain percentage of our population just will never reach that level of thinking. And in order to understand some of the concepts we teach in our math courses, students need to be at the abstract level of thinking unless we change what we are teaching and if we require students to have what we call a college level math class, then that's going to cut 30 percent, 40 percent, I don't know, 50 percent of the population out of it. . . probably not 50 percent, but that's probably going to cut 25 percent out of the classes.

The dialogue with Rob continued when asked about how students learn or

> *How do they get the information, what do they do with it, how do they get. .*
> A person learns by . . . certainly they have to have some motivation to begin. Whether it's well, ok, I'm . . . I tell my students that at the very least they just need to accept the fact that they're in the course and if you don't want to be in here for any other reason, what you don't want to spend 90 percent of your energy saying you don't want to be here. You'd rather spend 10 percent of your energy saying, "I don't want to be here," and 90 percent, "I'm here and what am I going to do?" And certainly. . . openess is probably the first thing. And then you pretty much you take in information and some people are visual learners and some people are kinesthetic learners and some people like to simply. . .they can pretty much do it mentally. You have to organize the information somehow. It's kinda like the process of solving the word problem. You pretty much take the information in and you organize it somehow and put it into a language you can understand. That's why I don't tend to

write a lot of formulas on the board. I more or less organize things in pretty much common terms. Here's the formula, I just explained it, but I think everybody's going to be confused at some point or they're going to have some discomfort with the information they take in. If they didn't have any discomfort, they didn't learn anything. And so they're either going to be confused or uncomfortable about something . . whether it's for five seconds, a minute or two days. Then they're going to work through to a certain point, but I had to have the drive to continue to pursue.

> *So you were at that frustration level. Say why you think that frustration level is important in learning. Because if you haven't learned anything new . . . Do you watch for it in your classroom?*
> Yes, and when I spot it happening, I try to ask questions. . . clarifying questions to find out exactly where they're having trouble. Well, ok, this other example . . . what do we do over here that's similar to this. See the thing in algebra and mathematics, a lot of students have trouble with is how certain problems are similar and not similar. Every student will see 30 problems that have no relationship. And part of the learning process is seeing how those problems are related and how they are different. And so, I think that frustration level or that frustration is . . . so I've got this information, how does it relate to this problem. Once they see the relationship, that's when, once they see that relationship, that's when the frustration goes down.

Mark was also a proponent of the different ceiling theory, "Everybody has a ceiling. **Is the ceiling the same for everybody?** No, I don't believe that. Goodness, no. We wouldn't have an Einstein." He also did not believe a person's ability level is based on genetics.

> . . . there are individuals who have great capacity who never cultivate. And cultivation is mostly done by the individual. So clearly it is affected by what goes on around and the people you choose to engage in helping the person cultivate it.

Liz believed that if students can learn other subject content and concepts, then can learn mathematics. The limits are set by whether they know how to learn the concepts, "I believe that if a student has the ability to learn, then they can learn the math." She believed there is a method to learning mathematics and that a component of mathematical ability is curiosity and the ability to think logically. From her observations, it was evident that students have not been taught to think logically before arrival at the community college. She attributed much of adult mathematical ability to "cultural aspects . . . whether they've been encouraged as young children to try things or they've just been told to sit there and memorize this. . . A lot of it is their own attitude." Her assumption is that ability level change can take place and it is the student's job to do so.

How does change in limit take place? In order to bring about change in ability level Jan distanced posture was evidenced as she referenced the community college policy,

> If they're in a certain class, there are certain standards set for that class, and they are expected to come up to those standards. If they don't have enough background, we need to get them moved back to a lower level course or else if they insist on staying in there, they need to be willing to put out the extra work and do some reviewing and maybe watch some videos from the earlier courses on their own.

Liz felt strongly that the

> problem with math is that a lot of students don't learn how to learn math. They don't know how to learn the concepts and there's a certain way in which you have to proceed. . . . First of all, they have got to believe that they can do it. Some students say, "Well, I can't do this. There's no point in even trying." They have to believe they can do it and they have to put forth **effort** to do it. They have to really be actively involved in learning; they have to do whatever it takes to learn it. If it takes going to the math lab everyday, coming to see me in my office everyday, that's what they have to do if they want to learn the math.

At another point in the interview she suggested working on the mathematics, then walking away and doing something else and then coming back to it.

> Because if you keep working, you get frustrated, anxious, and I have got to be able to think clearly. So you have to walk away from it for a while. Just don't even think about it. Because like I said, in problem solving, I think, working intensely on a problem and resting are all a part of it. And so they go away and rest for awhile and then come back to it. Things come to them.

Classroom Structures Used by Instructors

The purpose of the third research question was to describe the classroom structures reported by faculty and identify patterns of use within the high retention and pass rate faculty and the low retention and pass rate faculty. This section will report faculty comments about classroom structures or activities and faculty's perceived classroom roles. As an aid, Table 2, page 87, was developed to briefly list the structures and more frequent comments related to classroom learning events and Table 3, page 88 was developed to remap the TARGET structures onto the list of classroom strategies. The term classroom *structures* is the more global term for groups of activities used.

Danielle's Classroom Structures

On a typical day Danielle begins class with a "brief recap" of what was covered on the previous class. She tries to review rather than give a complete lecture and then invites questions about the homework. She continues with an introduction or overview of what is to be covered next and sometimes includes how the concepts will apply in the next course. As she discusses the content for that class she integrates examples, questions, and activities. For instance, she may have students work on problems at the board together as partners or alone. Danielle's unspoken theme is to keep them actively involved and she methodically uses selected activities to do that:

> I think it takes a lot of work to pull those in that have a very low ability . . . to get them to come through and get them to participate in class. Either they're wanting to sleep, and some of them do, and usually the ones that are wanting to sleep are the ones that are the lower level ones. You have to really pull to get them **actively involved**. And one of the things that does that is by making them work with partners or work at the board. Then they are given no choice but to be **actively involved**.

Structures such as recapping what happened in the previous class, asking for any questions about homework, setting the focus on the current day's objectives, introducing and lecturing the content, and continuing with relevant examples and varied activities are typical classroom activities for her classes. She also commented on student attendance, mastery and understanding of skills and concepts, student effort and practice, motivation, peer or study groups, and attitudes and perceived ability levels of students. Danielle was also thoughtfully reflective of her teaching and referenced experimentation with structures through the years.

Instructors' roles and and inhibiting activities to those roles may also be important classroom activities, too. Danielle reported her classroom role as that of teacher, instructor, and helper in preparing students for the next mathematics courses. Her role was student focused, but inhibiting to her accomplishment of those roles was student attitude.

> They think they can't do it or they don't want to do it, or don't want to be . . . sometimes it's just breaking that barrier down to tell them that they can. You tell them, "You can do it, you can do it, you can do it."

Danielle spoke about student attitude, but her own positive attitude may be a significant factor in determining student retention and achievement.

Christy's Classroom Structures

Christy begins each class with roll call, lists the objectives for the class, and then begins her lecture and uses many relevant examples. Although the structures may vary, she includes board work, calculators, cooperative group work, class work, and homework. During the interview she also commented on attendance, effort, office hours, motivation, peer support or study groups, practice and student attitude. She was reflective of her teaching, actively experiments with new strategies and structures, and explained that she sees mathematics as having two levels of thinking, a skill or tool level and a mathematical maturity level.

Tell me a little about your classroom. . . the typical day.

> I generally . . if I take the roll, then I like to write down on the board, particularly the arithmetic, that we're going to this, . We're going to talk about ratio, we're gonna talk about rate, and we're going to this, this, thus. We're going to talk about ratio, we're gonna talk about rate, and we're gonna talk about proportion. And this is what we're going to cover today. Actually, I do it in almost all my classes because it keeps me straight. . . that's part of the reason. . . I forget what I'm supposed to do. I rarely. . . in arithmetic take a note in. I just have done it and I'm so familiar with it I can do it. In elementary algebra, I have to take notes so that I don't forget something. I have so much material in there that if I forget some of it, I hate to do that. A lot of times I write that up there as well to keep me straight so I don't forget things. I don't use notes in arithmetic, but I do in elementary so that I, like I said, don't forget some of the things. And I teach out of the book as well. After I have made a presentation, then I always go to examples of the book or we go to examples on the board. If it's an oral thing then we can go around the room, then we do that. I have an activity where they have a worksheet two different times in the classroom where they work with a partner. . . and I don't do that a lot because I haven't found a lot of materials
>
> yet that I like. Now I know that there's some that use that and I think it's a good idea, but I think you have to lean toward. . . I have to find the right stuff before I'll feel comfortable with it. I do like to do going to the board, and I do that because after I have shown then how to do. . . . one of the things in math you need to practice before you leave the class or as quickly. . . and a good way to do it is to put them at the board and let them practice. And they like that, too.

Sometimes I probed about specific activities and this time inquired about her reasons for using practice.

> **It becomes a part of them.** You know, if they tried one, I tell them it's like you can watch me swim all day, but you aren't going to swim until you get wet so I gotta get them wet before they leave the classroom and, you know, people will sit back and say, "Oh yeah, oh, that's the way I do it, that's good, you know they can watch me, that's good, that's good, she's doing good, and they get home and, "AHHHHH. What's she say?"

TABLE 2: CLASSROOM STRUCTURES

	Danielle	Christy	Edward	Andrew	Rob	Mark	Liz	Jan
Instructional Activities								
Recap Earlier Class	X		X	X				
Homework	X		X	X	X	X	X	X
Questions	X	X	X				X	
Objectives	X	X	NO	X	NO	NO	Some	NO
Board Work	X	X	X*	X	X	X	Some*	X
Calculators	NO	NO	NO	NO	NO	NO	NO	NO
Competitions	X	X	X*	X	NO	NO	NO	NO
Group Work/Project	X	X	X	X	X	X	X	X
Lecture	X	X	X	X	X	X	X	X
Classwrk/Homewrk	X	X	X	X	X	X	X	X
Examples								
Other Comments	X	X	X	X			X	X
Attendance	X		X	X		X	X	
Concepts	X	X	X	X				
ID Experiments	X	X	X		X		X	X
Effort Expected	X	X	X		X		X	
Faculty Help	X			X				
Mastery	X	X	X	X	X	X	X	X
Motivation	X	X	X					X
Peer Support	X			X		X		
Perceived Ability			X		X			X
Patterns	X	X	X	X	X	X	X	X
Practice/Process	X	X	X	X	X	X	X	X
Reflect on Teaching		X	X	X		X	X	
Two Level Theory	X	X	X	X	X	X		X
Student Attitude								

*Used in college level courses, not developmental

TABLE 3: TARGET CLASSROOM STRUCTURES

Task Recap Earlier Class, Hmework Questions, Objectives, Board Work, Calculators, Lecture, Examples Classwork/Homework, ID Experimentation, Effort Expected, Patterns/Relationships, Practice/Process
Authority/Autonomy Attendance Expected, Homework Questions, Objectives, Board Work, Calculators, Competitive, Activities, Group Work/Project, Lecture, Attendance Expected, ID Experimentation, Effort Expected, Faculty Help/Office
Reward/Recognition Non mentioned
Grouping Group Work/ Project, Peer Support
Evaluation Competitive Activities, Concept Understanding, Mastery Expected
Timing Longer class periods - from 50 or 60 minutes to 1.5 hours
Other Comments Perceived Ability of Students, Reflects on Teaching, Two Level Theory, Student Attitude

Language, vocabulary, and instructor attitude were important to Christy. She said, "You have to talk language they're going to understand, teach them new language, and you have to care about them. And I think that's the most important thing. If you don't care about your students, then you're not going to be a good teacher." Christy openly suggested *instructor attitude* as an important factor for student success.

Christy's perceived roles in the classroom were as coach and score keeper.

> Coach. I teach how to do them (tasks) and I tell them I'm the score keeper. You can't get mad about the score keeper. . . .
>
> *But as a coach your job is to be smart about the success of the student.*
> Yes, and to make sure that they do their best. You have to feed them and teach them the skills to do that and then you be a good score keeper.

When asked about inhibitors, she focused on her own limitations like her nervousness on the first day of a semester. Christy also pondered carefully effective management of student anger and frustration when placed in pre college level mathematics classes. She also seemed to be saying that **student attitude** and **how she responded to those attitudes** were key to student progress.

<u>Edward's Classroom Structures</u>

Edward begins class before entering the classroom. Although he has taught for over thirty years and is quite confident of his mathematical knowledge and ability, immediately before each class he makes it a point to spend twenty to thirty minutes reviewing the objectives and activities for the class. He begins writing the objectives on the board, recapping the earlier class, asking for homework questions, discuss the objectives for that day's lesson, and then lecture on the content. He does not require calculators in developmental classes and does not implement group work in them either. His lecture includes relevant examples and classwork and homework are assigned. Edward commented on attendance, varying instructional structures, student effort, office availability, motivation, study groups, reflection on teaching strategies, and student attitude. He referenced two levels of mathematical thinking, a tool level and a mathematical maturity level. He thought it important for students to be able to see numerical patterns and relationships, to practice their skills and thinking about mathematics, and recognize that thinking is a process which takes time and effort in order to develop mathematical maturity. Below are his comments about a typical class:

A typical classroom day will be me getting to class about 5 minutes before class.

OK, as I walk in there'll be a handfull of students there. I'll generally say, "Hi," Or whatever. Now with all the technology involved, I always walk in with something hanging on my shoulder and so there's a little bit of setup time there. If I'm not using the graphing calculator that part won't be in that class, but the next thing I will do is I will walk to the board and on the upper right hand side of the board I will write down any announcements for the day. I will specifically write the objectives from the syllabus that we're going to be covering that day and if there are any exceptions to our time line that we've developed earlier, I'll make note of those exceptions, etc., etc. It's kinda like an announcement thing and students know to look at that when they come to class. If I just make those announcements verbally, and students come in late, they've missed all that. But if it's still up on the board, I leave it there the whole class period. If it's up on the board, then they can read it. The second thing I do is I review very briefly what we've covered in the previous class period or two and I usually, not always, say after the brief review, "Are there any questions you'd like to ask about the material that you've been working on that we've just reviewed?" I'm sad to say that most of the time there are no questions either from two reasons -- #1 that students haven't done their homework or #2 that students feel intimidated about asking questions just because, I don't know, mathematics seems to be more an intimidating subject than other subjects happen to be and I don't think it should be because I've been in physics classrooms or biology classrooms that can be just as intimidating as mathematics classrooms, but students just seems to be more intimidated. So they don't usually tend to ask questions. So if I feel we need to talk more about the topic, I will pick a problem out of the homework assignment a lot of times to work as a demonstration problem. That's a review. And then I give an overview of the topic for them to be talking about that day to kinda let students know where we're at, where we're going, and when we get there what it's going to look like. And then I start the serious stuff. And in this case the serious stuff is mainly lecture.

Edward was confident of his own ability as an instructor and felt that with one-on-one work with a student across sixteen weeks, he could "get them through developmental classes." When asked about what would be an ideal teaching situation, he replied,

Well, the ideal is me working one on one with a student. I don't honestly think there are many students that I couldn't take one on one for sixteen weeks and have them not complete elementary or intermediate algebra if I could do it one on one with them and meet three hours a week for sixteen weeks. Because I think they could be successful because so much of the basic skills is not an understanding of mathematics, it's just a memorization of rote over and over. . . do this and the next time you see the same thing, do it again. And I think I could get almost any student. . .there'd be afew I couldn't. . . but if they showed the interest and inclination, I think I

> could get them through the developmental classes. But you start getting the class size larger and larger, that reduces the amount of time you can spend individually with students and because of that your success ratio is going to start going down also and that's the primary reason the math lab was established because, the school, the College, and the math department felt a need for more one on one attention with students which the faculty members couldn't five in a classroom environment. So that's the primary reason the math lab was established.

Edward's class load is primarily college level. In those classes he does use calculators and cooperative group work as is appropriate. He does not use boardwork in developmental classes because of the large class load of students and emphasis on skill development. He encourages study groups for developmental students as part of the math lab.

Edward thought of himself as interpreter, motivator, actor/performer, and coach. The major inhibitor to his roles was student attitude. He did not define his role in terms of information source or giver of the information Neither did Danielle or Christy.

<u>Andrew's Classroom Structures</u>

Activites in Andrew's classes include greeting students when he arrives in the classroom, roll call, announcing housekeeping or administrative items, and then inviting questions related to the homework assignment and reviewing the last class topics.

> I start off by walking in and saying, "Hello," and taking roll because we have to take rollhere. If there's some administrative stuff to be taken care of in terms of an assignment is due in a reasonable time, or I'm going to be missing class on a given day, or something like that, I take care of that. Then I ask the students if they have any questions. And it depends on the class. If I teach a calculus class, I'll get lots of questions. Developmental classes don't ask so many questions. College algebra classes can go either way.

Lecture, discussion, and selected activities follow. The activities include use of calculators, examples, ocassional group activities, test or quiz, reading assignment discussion, or demonstration. He varies the activities depending on their appropriateness for the concepts. In the passage below Andrew mentions activities in two college level courses, Contemporary Math and College Algebra, and one developmental course, Intermediate Algebra.

So after they ask questions, then what do you do?
Well, it depends on what I'll be doing that day. And again, it depends on the subject. In a contemporary math class, I have a wide range of things I do. There might be a lecture, there might be an example, there might be a group activity that I have them doing. If it's college algebra, it might be a lecture, it might be a test, it might be a quiz, it might be a reading assignment that I've given them. Intermediate algebra, I probably use a little more lecture format in that after they've asked any questions, I'll start out with a lecture, but somewhere along the line after I've covered a certain block of material, instead of me doing an example, I'll stop and I'll write the example on the board and then I'll give them five or so minutes to work the problem out themselves and then we'll talk about the problem. So it depends on the level of the course and what I happen to be doing that day. . .what material we're talking about, what's appropriate. I might bring in a piece of computer software to demonstrate something that we're talking about. In contemporary math, if we're talking about truth tables or we're talking about linear programming, I might bring in a computer program that does something like that for them. In intermediate algebra if we're talking about lines or parables, I might bring in graphing calculators and have them use graphing calculators since we don't require graphing calculators in that class. It pretty much depends on what we're supposed to be doing that day and what's the best way of handling it.

So, depending on what the topic is, you try and have them interactively do something in class.
Yes

What about cooperative groups?
I use that more . . . well, in class I only use that in contemporary math where I have a group activity or I've handed it out a couple of weeks before and this being a commuter campus rather than sit there and try to force them all to arrange their schedules, I schedule a class period where they can do it. In calculus or differential equations, I have them work on, I have outside computer activities that I usually have them work on in groups because typically what I've found at that level, the students tend to form study groups and if I can get them into groups they'll usually keep together as a study group through the course of the semester. Often times there, unless they've had a lot of questions over homework, typically there's more time in

the day than there is material for me to lecture over, Again, if they haven't asked a lot of questions, they've got some sort of computer activity that they're supposed to work on, then I'll release them early, half hour early and let them work on their activity.

Because one of the community colleges was a strong proponent of using chalk boards, I made it a point to ask about them. Andrew's example of board work differed from my expectation of eight to ten students going to the board.

What about board work? Do they go to the board?
From time to time. Depending on the circumstances, especially if it is something that is, say, a little more visual than it is writing stuff down. If I want a student to just to quick sketch a parable for me and why they quick sketched it that way, I'll have them go and draw it. If I have them looking for the target region for a linear programming problem, I'll have somebody come to the board and point it out. . . point out the vertices or something like that. In the past, I've tried to have them. . .have the students go to the boards and work on problems for whatever reasons the classes I'm in, students tend to be a little shy about that.

Andrew implemented boardwork for individual student presentations. Andrew also emphasized student attendance, motivation, perceived ability, attitude and concept mastery and understanding. He adheres to the two level theory of mathematics similar to Christy and Edward and referenced practice and continual processing as components Andrew is thoughtful about his teaching strategies and reads and listens to others looking for better structures and outcomes. He indicated his role in the classroom was that of controller, mentor, and information source. Recently he had a problem with a very controlling student and saw the efforts of a controlling student as a strong inhibitor to his accomplishing his own roles.

Rob's Classroom Structures

While the roll sheet is passed around, Rob begins a ten minute discussion of homework questions, sets the objectives, and then proceeds to lecture.

> I don't start lecturing the material for ten minutes into the class. . . then I try to kind of, "OK, we've done this, this, and this. We're going to do this today and then we'll be doing this in the next couple of classes." It doesn't take but a couple of minutes to do that. . . not very elaborate. Then I go ahead and start on the lesson. It's the framework, the basis of what's going to allow us to do for the future. . . I tend to teach by example. I'll tell the students fairly frequently, "What I'm doing is not necessarily the only way of doing things, but it's a model." And I hope that they follow it and I do show steps for a certain reason. And that I do things in a certain order for a reason. For instance, if we're solving absolute value equations, I have absolute values in the equations and then I don't have them all of a sudden for a reason. . . I want them to follow my example. I work examples. If there's formulas that they have to work with, I tend to have them remember formulas in terms of words that they can remember. . . not that mathematical terms and definitions aren't important and I'll use them, but I also try to reword things that they can have something to think about.

Rob does not use board work, but will let calculators be used in class and the computers in the math lab later. He prefers the chalk board to overhead projectors because he likes to walk the room while lecturing. Rob uses examples in his lecture and will include small group activities occasionally. He emphasized instructor control, his availability during office hours, test correction, and relevant problem examples. He commented on student effort, motivation, number patterns, practice, student attitude, and his own reflections on teaching. Rob perceived his role in the classroom as encourager, mentor, and facilitator. The major inhibitor to those roles was student attitude.

Mark's Classroom Structures

When Mark walks into the class he may look at them "with very big eyes" and act as if he is listening to them, if they are talking. He wants their attention and uses this activity to obtain *control*. He prefers to assign seats for attendance reporting. The first activity is to address any house keeping chores and then he asks for questions related to the unit topic. The next activity is to review or introduce vocabulary and definitions and then he begins the lecture.

> I open the floor for questions. They can ask me about reading, previous lecture material, examples worked in the text, any experience they had in the lab, reading from another resource they found in the Learning Resource Center, questions on their homework, and anything that is relevant to the topic. . . If we're halfway through the unit, I might let them go back to the beginning and if it's not a review item, every unit has a review day right before the exam. But if it's quite far into the unit and we're not on review, perhaps I won't let them go all the way back to the beginning . . . depending on what I have to do. The length of that open period will be dictated by what I want to say that day.
>
> *When you go on to present the material, how do you set that up? Do you tell them what you're going to talk about?*
> Sometimes I scribble a little on the board. . . We did this last time. . . here's a stumbling block. We could only go so far because of the tools that we had. And so there were all these kinds of items that we could not deal with and not we want to create something new that will let us deal with the rest of the items. And then we'll start off and do some definitions. . . make sure we define all the words we're going to use that are in the unit. And that's one of the things that our remedial courses. . . our students' vocabulary is so thin that they can't even hardly read the book. Assuming that they're going to complete the course, I don't want them to go to the next course and find themselves in that situation. So, the best thing I can do for them is make sure that they can access the literature.
>
> *Tell me a little bit about when you get into your lecture.*
> A lecture is basically definition to make sure we have the vocabulary defined, then any concepts will be labeled in real course facts without the dreaded theorem, and then we want to apply facts in an example or two or three. I am very careful to not do 100 examples. . . . If I use examples I want to make sure I don't do 50 of them because then it seems like if you move your pencil like I move my chalk, you are doing mathematics. And it if doesn't reinforce concept, then I don't understand its focus.
>
> *What activities do you have them involved in during the class?*
> Thinking, hopefully.

Mark begins with homework questions and sometimes follows with objectives for the current class lesson. After lecture, use of calculators and problem solving activities for thinking were the major activities. He commented on concept understanding, student motivation, perceived ability, practice, and attitude. He spoke about teaching structures and changes he had made. Mark perceived his role as lecturer, tutor, and evaluator. Student attitude was reported to be the main inhibitor to those roles.

Liz's Classroom Structures

Greeting students is the first activity and then Liz requests questions related to the homework or previous class. While they consider their questions, she takes role and discussion follows. She introduces the objectives, new material, lectures, and includes many examples within the lecture. The lecture may be interspersed with activities like use of calculators if a college level class or sending an individual to the board. She tries to model enthusiasm for her subject to her students, "What I try to do to motivate my students is that I try to be lively and vibrant when I make my presentations."

In her college level courses she sometimes uses calculators, but usually she teaches developmental courses, elementary and intermediate algebra as well as a math for health careers course. Sometimes she uses board work and reports that students volunteer to go. She also reported not using cooperative or collaborative groups though she did encourage study groups. Competitive groups were not part of her design for instruction. She was a proponent of active learning and her version of active learning included class attendance, watching her work problems, class note taking.

> *What's the advantage of attending?*
> They get a chance to actually see problems done, because I give a lot of examples in class, to see problems done on the board. They get to ask questions about things they don't understand and if they don't attend class they don't benefit in that way.

They get to see, they get to hear, and they get to do. Once it's here in the head, then what happens?
They have to then go and practice. I encourage them to take notes also. They have to take notes because when they've got notes then when they get ready to study then they have something to help them to review what's been covered in class. And they just have to work harder, work on the problems. And not just think that they can sit and watch me and go do problems and then they know how to work.

So you're going to promote some kind of an activity.... active learning rather than passive learning. Why does active learning help better than passive learning?
I don't think anybody can just sit by and watch a technique, watch a process and then think that they can do it. I don't think it works that way. I mean you can watch a person skating up and down the street, and it looks easy, and it looks like you can do it, but until you actually try it, you just don't know what it's like. And so it takes, and some students think that they can sit and watch and it looks easy, sure, because I'm doing the work. It's a different story sometimes when they're on their own and they have to actually go through the process themselves.

Liz also made comments about the need for students to understand the concepts, and expend effort through practice and thinking. She was reflective of her teaching, mentioned her availability during office hours, and was concerned about student motivation and attitude. Liz said her role in the classroom was to impart knowledge, motivate, make them understand both the importance of the course, and the importance of trying to learn the material. An inhibitor to her roles was student attitude in the form of lack of motivation and lack of attendance.

Jan's Classroom Structures

After roll is taken, Jan asks for any questions about homework. As she lectures, Jan tries to relate the new material to the last class topics. Class lecture is the dominant activity, but she includes numerous questions in order to keep them involved in the dialogue. Through the questioning strategies she hopes students "discover" the concepts.

So much of the way they do discovery is the students really don't discover and you're

> still going to end up leading them anyway, so mine is more of an organized discover together rather than for them to just muddle around with themselves. . . Sometimes I will pick out a problem and have them work it while I go around and see how they are doing. I try to encourage them to. . . a couple of them to work together.

Although Liz reported using board work with classes of 35, Jan does not because of so many students. Group work is seldom used but she does encourage them to form study groups in the math lab. Calculators are used in the appropriate developmental classes. Jan commented on attendance expectations, student effort, motivation, study groups, practice, and attitude. She was reflective of her teaching and mentioned numerical underlieing patterns and relationships.

Jan's role is that of guide, counselor, and expounder of knowledge. By "expounder of knowledge" she meant that she tries to "draw it out of them." She tries to "lecture in a questioning manner to get them to. . . " and then she stopped. When asked about inhibitors to her successful accomplishment of her role, she suggested the short time span for each class. She would prefer classes that were longer than 50 minutes.

Trends and Patterns Across Responses: Definitions, Beliefs, Structures

The purpose of this section is to report obvious trends and patterns used by faculty with high retention and pass rates as opposed to those used by those with low retention and pass rates. Therefore, the patterns within the two groups and their use of structures, definitions, and beliefs are reported. Finally, the trends and patterns across the total group of participants will be reported.

High Retention and High Pass Rates Faculty: Summary of Beliefs and Structures

Danielle, Christy, Edward, and Andrew's vocabulary in defining mathematical ability varied but together they defined it as a knack for mathematics, a mathematical maturity, and two levels of mathematical thinking. They thought there may have been some genetic components, but environment provided a strong ingredient for development of mathematical ability. The high retention and high pass rates faculty used lecture, questions, and examples, but they also used cooperative groups. They voiced beliefs that students could be successful in their mathematics classes if they would expend the effort in the form of regular class attendance, participation, and preparation.

Low Retention and Low Pass Rates Faculty: Summary of Beliefs and Structures

Faculty with low retention and low pass rates defined mathematical ability as attention to detail, abstract thinking, organizing information to justify conclusions, autonomous thinking, curiosity, questioning, and logical thinking. Three referenced a stronger genetic component relative to the other participants, and one abstained comment saying the job was to encourage students to push their limits. Environment was recognized as a component in the learning process. Instructional design focused on lecture and imbedded questions and examples. Classroom control was mentioned by the two males. Again, faculty supported effortful strategies on the part of the student in order to improve mathematical ability.

Total Group: Summary of Beliefs and Structures

Faculty found it easier to define adult student mathematical ability in terms of behaviors and those behaviors often related to their own mathematical experiences. Some recognized genetic influences, but only as a component contributing to a possible limit or ceiling. All faculty quickly denied use of competitive win-lose structures. The use of group activities and board work were the two activities defining the high rates group as well as more general comments related to learning. Lecture and imbedded questions and examples were used by everyone. Negative student attitude and student motivation were concerns. All seemed to reflect on their teaching.

Trustworthiness of Interpretations

Three activities were completed to establish the trustworthiness. First, the participants received a copy of their profile and were asked to evaluate it for truthfulness. Secondly, a doctoral candidate in the Department of Education at the university read the interview transcripts and then the results in Chapter 3. Her job was to read objectively for categories and compare the patterns and categories she saw with those I had listed and discussed. The reported observations, patterns, and trends transcripts were similar. She found faculty had no common or formal definitions of mathematical ability. She also reported that no one thought mathematical ability was totally genetic and did believe students could learn mathematics although they may achieve at different levels. The faculty evidenced a concern about students' attitudes, perception of themselves, and felt that class attendance, practice, and involvement in learning were important to mathematical ability change. Finally, she observed that the eight participants loved math and enjoyed what they were doing.

Another participant in establishing the trustworthiness of the results chapter was the Chairperson of my Dissertation Committee. She also found the interviews congruent with the results listed in Chapter 3.

CHAPTER 4

DISCUSSION

The first section of this chapter is a summary of the results and is followed by a discussion of the interview results and research questions as they relate to the theories of Nicholls' (1989), Ames (1992a; 1992b), Maehr (1984), and Epstein (1988). The next sections will present limitations, implications and recommendations, and final comments.

Summary of Results

The purpose of this section is to summarize the results. Therefore, the observations common to both groups will be presented first, then observations within the high retention and pass rates group will be presented, and finally the low retention and pass rates group follow. Note again that the labeling of faculty as high retention and high pass rate versus low retention and low pass rate was set by their rankings within their own college institution. Their definitions, beliefs, and use of activities were of interest and were explored with the goal of more focused and definitive research where warranted in the future.

Summary of Common Observations

Faculty seemed to have ideas about the skills they wanted students to perform, they did not have well-articulated statements of the mathematical ability behaviors they were targeting with their instruction. Although not asked with a direct question, they did not have well defined formal theories based on a common definition of adult mathematical ability and they also did not hold a common or formal belief about the limitations of their students' mathematical ability levels. There were some common thoughts about student practice, effort, and attitude. Some faculty could describe behaviors they looked for as evidence of mathematical ability and some could describe behaviors of mathematical thinking at two different levels. When asked about classroom activities, several did try to relate the classroom tasks to relevant examples outside the classroom, but they did not speak in terms of including meaningful learning activities that drive numerical pattern analysis, cause and effect comparisons, and other cognitive learning strategies. Tasks requiring student choice and task autonomy, varied rewards and recognitions, assessments of learning other than tests, deliberate design of activities motivating students to efforts like completing assignments, attendance, participation, and practicing skills and problem solving were not mentioned in a systematic manner. Thus, a conclusive answer to the definitions and beliefs research questions as well as the one related to inferences between beliefs and instructional activities could not be reached. The rationale for the selection of strategies may be simply that they taught as they were taught and therefore that is why they primarily used lecture and imbedded questioning strategies.

This study was an exploratory one and much was learned from it that should fuel more focused research in the future. Certain classroom instructional activities were evident. All eight assigned homework and seven of the eight mentioned beginning class by reviewing the homework. The eighth faculty probably reviewed, too, but the activity did not appear in her conversation. Both campuses had discussed the use of computers, but while all used them, those from one of the community colleges reported not using them in the early developmental courses. All used calculators; those from one of the community colleges reported not using them in the developmental courses. All eight faculty reported not using competitive activities. All four in the high retention and pass rate group reported using cooperative group activities. All used lecture imbedded with examples and all used practice in classwork and homework. Just as all used classwork and homework, all referenced the importance of practice or the process of practicing in order to learn. All faculty reflected on their teaching to some extent and all referenced student attitude as problematic. Student attitudes also included references to self concept and self-confidence. To a strong degree, the instructional activities were alike in the classrooms. Therefore, if the theoretical framework referenced is relative to retention and pass rates then it would seem that these common classroom tasks and reasons for their inclusion in instructional design may also require change.

Another observation was that having advanced degrees did *not* appear related to having high retention and pass rates. While all eight participants hold masters' degrees, two from the low rate group have significant work beyond the master's level. One holds a Ph.D. and two masters degrees and another holds a masters degree and many graduate hours into a doctoral program. There were no significant advanced degree patterns in the high rate group.

The only age or gender pattern observed was that of classroom control. Three of the four men brought up classroom control techniques. This may be a gender or age related issue for these three men are probably in their mid thirties to mid forties while the fourth, who did not mention classroom control, was well into his fifties.

The overall trends and patterns across the interviews pointed to varied definitions of mathematical ability and a belief that mathematical ability in adult college students may or may not be genetically predisposed. They seemed to say that student ability level was not important because their job was to work at teaching students mathematics. How students should learn mathematics was often defined in terms of how they themselves had developed mathematically. Three of the faculty with high rates and one with low rates were more likely to have specific behaviors in mind related to their own experiences.

Summary of High Retention and High Pass Rate Faculty Observations

Faculty with high rates used slightly more classroom activities and more active activities involving students than those with low rates. For instance, all four used cooperative groups and three of the four used board work. Three of the four reviewed the previous class content before introducing the current day's lesson. Among the comments referenced, all four referenced strong attendance expectations and experimentation with their instructional designs. Three out of the four mentioned the importance of understanding concepts, the importance of student effort in learning, their availability to help students, and encouragement of study groups.

Three of the four participants with high rates and one with low rates had a two-level way of thinking mathematically that they expected of students. One level was at the skill or tool building level and the other was at the concept or mathematical maturity level.

When considering continued educational growth following their master's degree, those in the high group reported attending as many or more professional conferences and as a group reading more journals than those in the low rate group. Individually and as a group they seemed more attentive to their own professional learning.

The high retention and pass rates group had high confidence that their students could learn mathematics if they would expend the effort and as a faculty group they seemed to have high energy and skill in actively facilitating that change. There was an attitude of shoulder-to-shoulder working with students in groups and individually. The job of students were learning mathematics, but the job of faculty was to learn about effectively teaching mathematics to students.

Although high rates faculty used slightly different instructional strategies, their main activities mirrored those of the low rates faculty --- lecture and imbedded questions. Therefore, to determine stronger inferences would require more research.

Summary of Low Retention and Low Pass Rate Faculty Observations

The belief trends and patterns of the low retention and pass rate faculty seemed more focused on skill or tool development. That may have been because most of their classes were developmental ones. Feelings during an interview are difficult to document on paper, but during the interviews and since, I felt a distance on the part of faculty from their students as they talked. There was not the same sense of involvement with students, but more of a sense of distance in attitude for the job of learning was the students. A lack of learning partnership threaded the conversation.

Three of the four denied use of cooperative groups and the fourth said he used them only rarely. Common comments were much sparser than in the high rates group, but three of the four referenced student effort.

Research Results as Related to Theories of Motivation

Since the basic underlying problem is motivating students to attend, prepare, and participate in order to complete and pass the course, the overiding goal is to better understand what motivates students to engage in learning. Nicholls, (1989), Bandura (1993) and Wigfield and Harold (1992) reported that achievements are related to beliefs about ability. Motivation is not ability, motivation is not achievement, but both are affected by motivation. Beliefs about ability are related to achievement behaviors like effort and persistence (Nicholls, 1989; Bandura, 1993; and Wigfield and Harold,1992). If there is a belief behind every behavior and faculty have beliefs about the mathematical abilities of their students, then faculty choices of instructional activities for use in the classroom are behaviors based on their beliefs about their students or possibly some other beliefs. Therefore, the first question was to better understand faculty definitions and beliefs about adult student mathematical ability and then consider connections to the instructional activities used.

Maehr (1984) suggested that students read meaning into the instructional activities that may or may not determine whether they engage in the activities. Ames (1992a; 1992b) and Epstein (1988) suggested changes in ability levels can be facilitated by the use of TARGET strategies of task, autonomy and authority, reward and recognition, grouping, evaluation, and time. Faculty definitions and beliefs about adult student mathematical ability were central to faculty design of classroom instruction, fundamental to student motivation, and key to resulting retention and pass rates. Discussion follows integrating motivational theory with faculty definitions, beliefs, and use of instructional activities.

Mathematical Ability Definitions and Beliefs

Trends and patterns across the interviews indicated that the eight faculty did not have a common definition or a formal theory-based definition of mathematical ability. Without a definition how could faculty construct learning activities leading to an undefined and therefore unknown mathematical ability level? Some could describe behaviors or ways of thinking that they watched for, but for the most part they lacked the vocabulary to concisely describe mathematical ability in adult community college students. Faculty definitions and beliefs about mathematical ability were often framed in terms of their own mathematical experiences or efforts. Some of the eight faculty talked about their struggle when they "hit the brick wall" and discussed their ways of overcoming those times. Although mathematics was easier for them than for many, faculty had points in their past where they had to expend effort and work, too. Some consciously modeled expected behaviors for their students and their enthusiasm and perseverance was apparent.

With these limited intuitive beliefs, faculty designed instruction and included activities to foster a vaguely described mathematical ability. As Thompson (1992) pointed out, teachers use their assumptions and beliefs within the design of their teaching and activities. Because there were so many threads of intuitive theory about students' motivations and learning rather than research based ones, it may be that faculty's reflection on their implicit beliefs and theories may develop into more explicit statements at a later date. This, in turn, might influence a change in their classroom instructional activities. Opportunities for exposure to current theories of cognition, motivation, and instructional design may also affect their classroom activities choices.

In looking more closely at mathematical ability in relation to goal orientation theory, Nicholls' (1984) suggested that ego oriented students may think that ability is set at birth and cannot change. Faculty did not seem to hold this belief. A genetic predisposition was not the issue, but what was important to faculty was working hard at teaching students mathematics. They recognized the importance of skill level or tool development and three of the high rates faculty and one of the low rates faculty envisioned a second level or more mature mathematical way of thinking. Faculty with high retention and pass rates were more likely to have specific behaviors in mind supporting thinking at both a skill level and a mathematical maturity level.

Christy's beliefs about classroom success was both unique and interesting in light of the research of Eccles and Wigfield, 1984). According to her, student success is related to instructor success. Eccles and Wigfield (1985) argued that instructor beliefs or expectations about future performance were more important than students current levels of performance. In other words, students' achievement levels were more affected by their instructor's beliefs about whether their ability could improve than they were by their current performance or grade. Thus, faculty beliefs and their choices of classroom instructional activities influence student investment or participation and effort. Faculty attitude or belief about whether students can pass college level mathematics courses initiated this study. Although the distinction is not easy to see in this report, the high retention and pass rates faculty demonstrated a stronger conviction that students could learn mathematics. If teacher affirmation in public schools and helping students encourages mathematical ability or development, then faculty affirmation in the college classroom would seem to have a positive impact on students' attitude and mathematical progress, too. Andrew's story is a prime example supporting this hypothesis.

Sometimes faculty spoke about student attitude as a component affecting student ability and achievement. Bandura (1993) wrote about the importance of student self-efficacy and all faculty spoke about student attitude or student self-efficacy toward mathematics as evidencing a lack of confidence in their ability to be successful in mathematics. Self efficacy is an expectation or belief in one's ability to perform a task. Nicholls (1984) suggested that students need to have learning goals and work toward those in order to change ability. This should also change self-efficacy (Bandura, 1993). Therefore, student effort as a part of goal setting and in the form of practice of skills and ways of thinking should effect changes in self-efficacy or student attitude and ability. Faculty spoke frequently of the need for effort on the part of students. Nicholls' (1984) theory was developed by studying children and adolescents. He believed that ability improves through effort. Because this study was about a mature adult faculty rather than K-12 students, a more precise understanding of how faculty defined mathematical ability and what they believed about their adult students mathematical ability, as referred to in questions one and two, was sought. In the interviews faculty were more comfortable discussing effortful behaviors and lack of effort rather than ability.

At a professional level, the high rates faculty were more like Nicholls (1984) learning goal oriented students. Faculty have beliefs about learning for themselves and act on those beliefs. High rates faculty attended more professional conferences and read more journals than those in the low rates group. These activities would seem to provide evidence that they were openly interested in learning more about the teaching profession and how they could improve their instructional strategies and outcomes. On the other hand, advanced academic work toward a Ph.D. or two masters and a Ph.D.were not characteristic of the high rates group.

Behaviors: Classroom Instructional Activities

The problem for both high and low faculty groups was to get students to come to class, to prepare for class, to participate in class, and to persist until they understood. Of interest in this study was the teacher/learning situation or classroom activities selected by faculty. Since faculty primarily used lecture and imbedded questioning strategies, Maehr's (1984) and Epstein's (1988) theories about students reasons for engaging in classroom activities may present insights into student motivation for faculty to consider. For example, since faculty with high retention and high pass rates reported using slightly more activities and more active activities rather than passive activities, there is reason to examine the classroom activities more closely. Maehr's (1984) Personal Investment Theory suggested that instructors select tasks for teaching and learning purposes and that students find some tasks more inviting to participate in than others. He reported that past personal experiences, socio-cultural context, teacher/learning context, self-efficacy, goals, and action possibilities contribute to students' interpretation of the tasks. This was also suggested by Shavelson and Borko (1979) in their research review of instructor beliefs. They said instructor beliefs influenced their behavior, e.g. instructor perception of students' learning aptitude resulted in instructional choices related to their beliefs about those aptitudes.

Research exists that includes examples of tasks that discourage engagement in classroom instructional activities (Ames 1992a; 1992b). Students read negative meaning into social comparison, public evaluation, reinforcing ability rather than effort, communicating low expectations, permitting students to be uninvolved in learning, reinforcing performances instead of learning, excessive emphasis on success and grades, lack of recognition, poor working and learning conditions due to noise level and over crowding. Examples of social comparison and public evaluation would be testing and placement in developmental mathematics classes, board work, and ability grouping within the class. On the other hand, if students were aware that their placement in a developmental class was designed for their success and that to start them at their current ability level would aid them in moving forward more efficiently and successfully to the next level, then correct placement might be perceived and accepted as part of their goal. Working math problems at the chalk board could have negative connotations for students if they are graded or their mistakes are highlighted. Working at the board with another student and along with discussion of the logic used between them and other groups, would promote effortful behaviors, thinking, and a safe environment in which to explore and master mathematical skills and concepts. Because most faculty primarily take content intensive courses in college and very few have any "how to teach" courses relating theories of cognition or motivation, the examination of these theories and imbedding them in their instructional design might foster better student attendance, participation, and learning outcomes.

In other words, the task itself communicates purpose to the students. If the task is designed emphasizing academic progress and mastery, then students are more willing to participate, i.e. tasks that begin at the students' level of competence and become more and more challenging. Faculty implemented varied strategies. They were aware of the placement score ranges on the ACT and COMPASS tests their students achieved in order to be placed in each class. Their emphasis was on the concepts and material to be covered. Another approach might be to examine the prerequisite competencies within the range of scores that were stronger and the ones that were weaker and include activities that reinforce the strengths and give added practice opportunities for those needing work. This would promote mastery and students' acceptance of involvement in the learning process according to Epstein's theory (1988).

Again, according to theory (Epstein, 1988), tasks that provide some autonomy or choice for students rather than instructor authority decisions are important to include. All but two of the tasks mentioned, cooperative group work and projects and study groups, were faculty authority dominated. Rewards and recognition are ways to emphasize academic progress and mastery rather than win/lose competitions, but faculty did not mention any specific activities. Students learn from each other as well as from the instructor. Grouping activities that foster student interaction and teaching or tutoring each other are suggested by Epstein's (1988) theory. Faculty in the high rates group implemented cooperative group activities on some level. Evaluation structures should be about level of performance toward an academic competency goal rather than comparisons with other students' performance. Faculty reported they did not implement competitive activities. They graded on skill and concept understanding. Some mentioned mastery, and all students receive grades. Finally, in reflecting about instructional time elements, students learn some concepts quicker than others. One faculty participant mentioned a longer class time as desirable. Elasticity in time emphasizing practice and competency and accepting longer periods for those needing it and shorter periods of time for those who master the concept more easily would address student progress and mastery and the time element. Current computer software may be quickly bringing this strategy into the classroom for it provides students the opportunity to practice and drill to automaticity on skills and concept understandings using as much or as little time as they individually need.

Again, Nicholls' goal orientation theory (1984) proposed that students are fearful of being exposed as having low ability. A comment like, "Statistically speaking, I know that only one out of three in this class will pass," may also remind students of other teachers, parents, and friends' comments and continue a fearful attitude. The entry level testing and placement requirement may also contribute to students' fears of being labeled "dumb" when placed in developmental classes. The terms "developmental" or "remedial" may relate to the "dumb" label. The term "pre-college" may be a more acceptable term to these ego oriented students. Emphasis on meeting their goals through correct placement and course mastery would encourage safety in engagement in learning activities. Again faculty may find it beneficial to examine each of the instructional activities used in light of student perception as well as their usefulness in the learning process.

In review, Maehr's (1984) premise is that students find some instructional activities within the learning environment more engaging than others and Ames (1992a; 1992b) and Epstein (1988) reported that change in ability levels comes through use of the TARGET strategies, task, authority, reward, grouping, evaluation, and time. The tasks themselves are reported to provide students with information about their own ability level, whether to persist, how much effort to exert, and the level of task satisfaction they can expect (Ames, 1992a). These are important keys for faculty to consider when selecting tasks. The structures need to support knowledge construction and be motivating to students. For instance, in one study when task mastery was emphasized, students used more effective strategies, preferred the task challenge, and believed that effort impacts the level of success (Ames and Archer, 1988). If faculty selection of tasks that students will select is important, the logical question to follow is, "What tasks did the high retention and high pass rates faculty group select and what did the low retention and low pass rates faculty group select? What was not selected?" For instance, formal competitive activities, win-lose activities, were loudly absent from the list of classroom instructional activities. When asked about competitive activities, every participant replied quickly that they did not use them.

Faculty with high rates implemented slightly more activities in addition to lecture, questions, and examples, and commented more often about attendance, concepts, effort, office hours' availability, mastery, peer support, perceived ability, and practice. They discussed their class design experimentation and seemed to reflect more on their teaching (Table 2, page 86).

Faculty in the low retention and pass rates group used slightly more passive instructional activities. Although they, too, reported using lecture, review of homework, questions, and examples, this seemed to be the mainstay of their instructional design. Maehr's (1984) suggestion that students read meaning into activities may mean the ones students are "reading' are not interesting or engaging to them if they are not participating, Thompson's (1992) review of public school teachers' beliefs about mathematics suggested a need for teachers to consider those imbedded messages and meanings being communicated. This recommendation may be appropriate for community college faculty as well.

Limitations of the Present Study

Although this study provided insights into faculty definitions and beliefs about adult students' mathematical ability and faculty usage of classroom instructional activities, there were some limitations that may have affected the data and interpretation of those data for future use.

Although I have assumed that pass and retention rates are an important indices of student academic achievement, it is possible to consider the opposite and assume that faculty with high retention and pass rates may not teach anything in their classrooms since those indices are not directly dependent on student learning. Additionally, administrative and faculty policy may be a factor. At one of the community colleges, policy supported student retention rates and at the other student pass rates were emphasized. There may be other institutional variables influencing retention and pass rates, too.

Observations of classroom and office interactions between faculty and students could have provided additional perspectives validating some patterns and presenting others. Confident tenured faculty with high retention and pass rates may not object to observation, but faculty with low rates may feel threatened.

Faculty were not thoroughly questioned about the classroom activities used, but their use of instructional activities was self-reported by faculty. Thus, the quantity and quality of the structures implemented were probably not reported without some bias.

Another concern may be the number of participants but by its very nature a qualitative study is usually conducted with a small number of participants. Although this was not an extremely small study, one or two participants, it would have been stronger to have twenty to twenty-five participants.

Finally, another limitation was the short time span for interviewing. More detailed information could have been obtained and validated with two or three interviews. The themes and patterns reported in this study may be unique to the eight faculty interviewed and further research could verify and corroborate or redefine the results.

Implications and Recommendations for Future Research

What faculty believe and how those beliefs manifest themselves in the design of instruction and resulting retention and pass rates requires more exploration. The faculty participants in this study did not have clear definitions of mathematical ability nor beliefs about the nature of mathematical ability. All used lecture and imbedded questions as the primary instructional activities. They had common concerns about students' attendance, participation, preparation, and attitude. Often faculty seemed to say that the problem was out there with the students. A more appropriate approach may relate to faculty beliefs about their own ability to facilitate learning in their classrooms. Faculty are confident of their content knowledge, but the question would be about their confidence in their professional skills as teachers of mathematics. Faculty may benefit from inservice professional development programs focused on learning theories and particularly the active learning strategies.

As part of an effort to address the quality of teaching within the classroom, faculty may also benefit from discussions about how students learn most effectively and efficiently, particularly when they "hit the brick wall." Review of the characteristics of students with task involvement or ego involvement and development of orientation programs and workshops as well as classroom emphasis on effort, strategies, and persistence may also benefit student retention and pass rates. As Cross (1998) said recently, "Educators must necessarily take the lead in establishing the environment for learning, and to do that we need a good, workable understanding of what learning is and how we can cultivate it." The solution to the common concerns of low retention and pass rates may be found in both the college classrooms and in the classrooms before students arrive at the community college as the learning process is better understood.

Part of the purpose of this study was to lay the ground work for further empirical studies. For example, because there appears to be a different attitude and slightly different use of classroom instructional activities between high and low retention and pass rate faculty, it would be interesting to use a more quantitative approach and develop a survey based on definitions and beliefs about mathematical ability and the use of classroom instructional activities. Understanding any administrative or faculty driven policies in relation to retention and pass rates would be important to determine prior to the study. Such a study would further define mathematical ability as an appropriate course related outcome, two thinking levels of mathematical ability, and beliefs about the limits of mathematical ability. If more specific differences between high and low rates faculty were evidenced, the results would drive the selection of specific professional development programs for faculty.

Students' are often fearful or indifferent and have passive attitudes toward mathematics. Nicholls' (1984) model of ego involved students suggests that they do not want to appear studious because that would speak to their lack of natural ability and mean they were not smart. Nicholls (1984) model may also speak to faculty attitudes toward their own ability or inability to effectively facilitate learning. This would be another subject worthy of further exploration.

Since the use of instructional activities was self-reported by faculty, classroom observations to better validate the number and type of activities as well as the quality of instruction would provide additional information. The quantity and quality of the activities may prove instructive for future use in establishing patterns used by high retention and pass rates faculty versus those used by low retention and low pass rates faculty. A recent comment by Cross (1998) at the League for Innovation reads:

> One of the strongest and most consistent findings from outcomes research is the evidence that shows that students who get involved with people and activities of the college demonstrate higher retention rates; greater personal growth, achievement, and satisfaction; and increased participation in further learning opportunities than those who participate only in classroom learning experiences

(Astin, 1985). Indeed, one of the reasons that residential colleges have higher retention rates than community colleges is that residential colleges have many more ways of involving students with the people and organizations of the college. Students are a captive audience on a residential campus, spending study time as well as leisure time on campus; socializing with fellow students in the dorms; joining organizations that involve them with others sharing their interests; and talking and working with faculty. The research shows that, when it comes to retention, even working at a part-time job on campus has a significant advantage over working off campus (Astin, 1985).

Further questioning about institutional policies in relation to developmental courses may also influence choices made by faculty and thereby influence retention and pass rates.

Two methodologies I would pursue with more rigor if I were to repeat the study would be to probe more thoroughly about the classroom activities after an initial exploratory discussion about the activities they had chosen to report on, and to return for a second interview to ask questions that occurred to me later.

Final Comments

Participants in this study expressed beliefs about ability as being related to achievement behaviors such as effort and persistence which are consistent with motivation theory (Ames, 1992a, 1992b; Nicholls 1984; Bandura, 1993; Maehr, 1984; and Wigfield and Harold, 1992) but common definitions and beliefs about the nature of mathematical ability were not verbalized by the participants in this exploratory study. Faculty referenced a belief that mathematical ability level can improve with effort on the part of students and the high rates group did have a clearer picture of the effortful behaviors needed to accomplish the two levels of mathematical learning. Because there was only a slight difference in the instructional activities reported, a more detailed questioning of what happens or does not happen in the classroom seems appropriate before attempting inferences. Although the first three research questions could not be answered conclusively, groundwork for further research has been achieved.

Determining how beliefs manifest themselves in the design of instruction and resulting retention and pass rates was also informative through the theories of Nicholls (1984), Ames (1992a, 1992b), Maehr (1984), and Epstein (1988). Fear of being perceived as having a low ability level (Nicholls, 1984) may be strongly incorporated in student attitude and contribute to the reasons students do not engage in the effortful behaviors like attendance, preparation, and participation. Careful selection of motivating activities that promote mastery as Epstein (1988) suggests may contribute to higher and more reliable retention and pass rates. For this reason exploration of professional development opportunities supporting faculty designed instruction imbedded with cognitive strategies and motivating activities are in order. They should foster adult student engagement in learning and promote specific mathematical ability level achievement outcomes.

This study contributes to the current body of research literature as a first attempt at examination of the patterns of faculty beliefs and related use of classroom instructional activities impacting retention and pass rates. The theories of Ames (1992a, 1992b), Bandura (1993), Epstein (1988), Maehr (1984), Nicholls (1984), and Wigfield and Harold (1992) are appropriate for consideration in relation to both faculty and student beliefs about mathematical ability as well as students' perception of the task's meaning. Instructors and students who are not afraid of ability exposure, but who know how to expend the appropriate effort to learn and change their ability levels would mean better prepared students arriving at community colleges. Under the instructional strategies of theory based college faculty instruction, better retention and pass rates may be produced. Motivation theory and mastery goal orientation programs are appropriate for both public schools and community colleges. Again, professional development activities along these lines are highly recommended for public school and community college instructors.

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Appendix 1
INTERVIEW QUESTIONS

Introduction

Let's begin by talking about you and what drew you to teaching mathematics?

Research Questions

1. How do mathematics faculty describe their mathematics classes, i.e., instructional activities? What structures do instructors with high pass and retention rates and those with low pass and retention rates use in the classroom?

Describe a your mathematics class on a typical day. How do you begin the class? What are some other formats or activities you incorporate? (What do students do in class? Calculators? Boardwork? Cooperative group work? Team competitions?)

Do you use the same format or group of activities with all classes? What are your reasons for this decision? What do you believe motivates students to engage in learning? Does what motivates students change with ability level?

Talk about your syllabus for MATH XXXX. (Ask specific questions about various sections, i.e. grading, activities, lecture vs student participation, etc.)

What led you to make these decisions on how to teach this class? (Learning models?)

How does this syllabus compare to one you used early in your professional career? Describe. What prompted the changes? What decisions go into making instructional changes?

On a continuum describe what students can do who have little or low mathematical ability and those who have high ability.

How do you adjust your classroom activities for the differences?

2. How do some community college mathematics faculty define mathematical ability? What do they believe about the nature of adult students' mathematical ability in their classes?

When staff or faculty voice concern about whether students with low mathematical ability should have to take college level math, what are they saying?

What is mathematical ability or knowledge? (Can it change or is it fixed? Is it inate or learned or both? Why do some students have more and some less?)

How is mathematical ability different from reading or writing ability?

Should college level mathematics be mandated in the curriculum? Explain.

What are some strategies you have used to help a student understand a particular concept?

What do you do when your students "hit the brick wall?"

How does faculty belief about the nature of student mathematical ability inform their teaching?

4. Can we infer from their descriptions, patterns in the areas of beliefs, expectancies, and selected classroom structures that may contribute to some instructors having higher pass and retention rates than others? Using Maehr's personal investment theory, is there reason to consider both faculty beliefs and student task meanings when designing classroom learning environments?

(Extra questions if there is time: What is your job in the classroom? What inhibits your being able to do that? In the _____ years you've been teaching, what student success stories come to mind?)

Appendix 2
EDUCATIONAL AND PROFESSIONAL BACKGROUND

What are the approximate number of college credit hours you have completed in math education courses?
_______________ undergraduate hours _______________ graduate hours

What are the approximate number of college credit hours you have completed in learning theory?
_______________ undergraduate hours _______________ graduate hours

What are the approximate number of college credit hours you have completed in cognition?

_______________ undergraduate hours _______________ graduate hours

What are the approximate number of college credit hours you have completed in instructional design?

_______________ undergraduate hours _______________ graduate hours

What are the approximate number of college credit hours you have completed in motivation?

_______________ undergraduate hours _______________ graduate hours

What are the approximate number of graduate level college credit math courses you have completed? ____________undergraduate hours ___________ graduate hours

How many years of teaching experience do you have at the elementary school level? _____ middle school level? _____ high school level? _____ and/or college level? _____

List your undergraduate and post graduate degrees and number of additional graduate hours. ____

____

What professional mathematics education conferences have you attended in the past three years? i.e. NCTM ____

____

What professional journals do you read regularly? ________________________________

DANIELLE

Danielle began her college education in her middle thirties in a community college and graduated with an Associate of Arts degree in Liberal Arts. She then proceeded to a four year college and received a B.S. and M.S. in mathematics. Danielle taught 3 years in middle school, 2 years in high school, and 5 years at the college level for a total of 10 years. As an undergraduate she received 3 hours credit in learning theory, cognition, and instructional design, but none as a part of her 36 hours of graduate work. She reported having attended NCTM, OCTM, and OKAIDE in the past three years and regularly reads one mathematics related professional journal. All the classes she teachers are developmental.

She credits a college instructor as proposing the idea that she consider teaching mathematics. According to her, he seemed to think she had "the knack for mathematics" or that she was "very careful, precise, checked everything," and she asked questions. He recognized she wanted to understand her mathematics and Danielle acknowledged that although she had struggles understanding mathematics at times, she made it a point to ask questions and work until she understood the concepts and relationships.

As far as a definition of mathematical ability, Danielle did not give a precise one. She thought that some students progress faster and are more easily bored than others. Those students with low ability require more effort to get them to participate. For instance, she sees a relationship between low ability students and those students who choose to sleep in class. One of the reasons she uses board work activities is to actively involve students with each other and in developing mathematical answers to problems. Some students have the "knack for math" and some do not. "Some of them just don't have the ability to ask questions. Some of them don't know even how to get started on anything." At one point, she related mathematical ability as being "already built in." Although this would seem to say it was genetically based, Danielle discussed it in terms of students' attitudes.

Students' beliefs about their mathematical ability need to include good feelings about their math. In her words, "It's their attitude and they think they don't have the ability." They do not want to expose their "insecurity as far as math is concerned." Later on she commented that, "Unfortunately there are some that have already been told that they aren't going to be very good at that. Some of them have told themselves that they're not going to be good at it or they've had a failure so they think they can't succeed." This attitude is "built-in" when they walk into her class. Undergirding her comments was a consistent belief that students have different abilities of value, "They've each got their own . . . they have their abilities to do things and do things well. Sometimes math is not it."

Danielle begins classes by recapping the previous class activities through a mini lecture and follows with relevant questions from homework assignments. The next step is to present an overview of the current class objectives and outcomes, lecture, and then discussion with activities. The activities may include board work, partner activities, calculators, and classwork/homework.

Danielle sees her role in the classroom as that of teacher, instructor, and helper in preparing students for the mathematics courses they need to take next. The inhibitor to her accomplishing this was student attitude, "They think they can't do it or they don't want to do it, or don't want to be . . . sometimes it's just breaking that barrier down to tell them that they can. You tell them, "You can do it, you can do it, you can do it." Obviously, Danielle believes that mathematical ability level is not fixed, but can change.

CHRISTY
Christy teaches arithmetic and elementary algebra at the community college. She holds a B.S. and M.A. in mathematics including 21 undergraduate hours in mathematics education, 6 undergraduate hours in instructional design and several learning theory workshops. Of her 26 total years years teaching, 5 were in middle school, 9 in high school and 12 at the college level. Her reasons for teaching mathematics centered around growing up and as a good student, she found herself tutoring others frequently in mathematics. In college she started off in calculus, established herself in a study group, and continued to tutor dorm friends and others. Although she achieved an A in her first college English course, she preferred the mathematics and just kept working at it. She reported having attended six conferences in the past three years and regularly reading two professional journals. All the college classes she teachers are developmental.

At first Christy did not understand the question about a definition of mathematical ability, but later she referenced a level of mathematical maturity where students recognized they did not understand concepts and skills required and would question the instructor. "There's just a maturity focus on what they want to do." She also stated that it was her observation, particularly in her own family, that there was both a genetic as well as environmental component. Christy discussed age, toys played with as a child, self esteem, and homework practice as affecting mathematical maturity or mathematical ability.

She believes that students with low level mathematical ability tend to be angry, frustrated, have low self-esteem, and require more time and examples. Students with high level mathematical ability require less time and are easily bored. Christy's basic assumption is that although students have limits, "I can't take a moron and train it into a genius. No I can't, I can't." She repeatedly narratesdexamples of efforts to support student learning and the need to transition from starting "where they are" and moving forward.

As far as activities, Christy begins the class with roll call, listing the objectives for the day's class, lecture, and activities. She is an advocate of attendance, boardwork, handouts, lots of examples, calculators, group or team building work and lots of practice. She does not support competitive activities. Christy referenced the importance of positive self-esteem in order to develop confidence and felt that those without it were probably subject to someone else's negative attitude toward mathematics at some point in their formative years in public schools. In her problems she tries to include relevant examples so that students can see the practical application of the topic being discussed.

Christy sees her role in the classroom as coach and score keeper. When asked about inhibitors, she focused on her own limitations like her nervousness on the first day of a semester and how to effectively handle student anger and frustration. She seemed to be saying that student attitude and how she responded were key to student progress.

EDWARD

Edward is a veteran mathematics professors with 34 years experience of which 5 were at a middle school, 4 in a high school, and the remaining 25 at the college level. He has given much thought and effort to what he does as a mathematics instructor, is confident of his approach, believes in his students' ability to develop math skills and eventually think at an acceptable level. He is constantly working to improve his own strategies - just as he expects his students to do. Edward was teaching five sections of mathematics. One was at the developmental level and the other four were college level.

Edward grew up in a small rural agricultural community and recognized his life's work would be either in farming or education. He also recognized that he liked math, spent time thinking about and doing mathematics and as he compared his performance to that of others, recognized he was better than most at mathematics. When asked why he was good at math, he replied "because I had an inquisitive mind." He liked to take things apart and put them back together. For instance, he likes to take mechanical things like engines and lawn mowers apart and reassemble them. To him, mathematics is a puzzle where one puts "things together and all of a sudden a picture emerges." He enjoys recognizing patterns and putting the "patterns down in mathematical language so that other people can understand the same pattern."

To explain his thoughts on mathematical thinking he considers the fact that many students must learn basic arithmetic skills in developmental classes. Developmental mathematics is where some students acquire the tools they need for mathematical thinking. New problems allow students to transfer the basic tools to new situations using mathematical thinking to arrive at a solution. Mathematical ability, according to Edward, is something that some people have more of than others, but he didn't want to call it "genetic." He believes that a strong component of mathematical ability is contributed by the environment --- through parents, peers, interests, and activities. Over a period of time some students develop "mathematical maturity." Mathematical maturity is the ability to do applied problems or solving mathematical problems using the "concepts of mathematics without using mathematics."

Classroom activities varied. Before arriving in the classroom Edward has reviewed the objectives and activities for the class. He arrives in the classroom early, greets the students there, and begins to set up his activities. Class objectives and any announcements are written on a corner of the board. Class begins with a request for any questions about the previous class or homework. An overview of the day's objectives lead into the lecture and activities. Activities may include use of examples, demonstration, or some small group activity. The activity is determined by the topic. Activities not included are board work and competitive activities. Calculators are used in college level courses where the environment is more loosely structured than in developmental classes. Edward saw his classroom role as interpreter, motivator, actor/performer, and coach. The major inhibitor to effecting his roles was student attitude. He reported attending two conferences in the past three years and regularly reads one professional journal. He has attended numerous workshops and seminars on technology and calculus reform.

ANDREW
Andrew obviously enjoys his work, has a Master's in mathematics, and has taught at the college level for 15 years. When asked why he was teaching mathematics, he quickly admitted, "I am good at it for whatever reason." Before majoring in mathematics, he had considered engineering. While in the military, he was told he was good at teaching mathematics. Additionally, teaching at the college level allows him some flexibility in scheduling his time for other interests and pursuits. He listed two conferences in the past three years and regularly read three professional journals. Andrew taught eight mathematics classes of which three were developmental and five were college level.

Andrew attributed his being "good at it," meaning being good at mathematics, to being able to do things in his head better than doing them on paper. . . to daydreaming about math. "Well, I daydream and math comes into my thoughts. I will be. . . working on something, or doing something and the problem I've been working on pops into my head and I'll be thinking about it for awhile."

He defined mathematical ability as having an interest in mathematics and thinking or daydreaming about it. He thought he'd arrived at his own mathematical ability by taking an interest in it, studying, and getting better. His choice of mathematics as a college major was due to his knowledge that he was good at it and it interested him.

His beliefs about mathematical ability and motivation related to students perceived ability level about themselves. Students perceived ability or confidence in themselves affected their performance. "Students have a lot more ability than they give themselves credit for . . . or a lot higher level of mastery level than they give themselves credit for." Additionally, "Everybody can have a certain basic level of mathematics. . . Genetic? I don't think so. . ." He felt that not everyone could be a mathematician, but everyone unless there was a physical inhibitor could achieve a basic level of mathematics and that level may vary somewhat from student to student. His belief about the value for a college level mathematics course is that mathematical reasoning gives the student a way of looking at problems and piecing things together. The logic would compare to a philosophy or programming course, he thought.

Activities included greeting students on arrival in the classroom, roll call, announcing any administrative items, and then inviting questions on the previous assignment. After a few minutes of discussion, he would lead into the topic for the day, lecture, and some kind of activity. He uses more lecture in the developmental courses, but no board work or competitive activities in developmental or college level courses.

Andrew saw his role in the classroom as controller, mentor, and information source. He saw a contolling student as an inhibitor for him in accomplishing his role.

ROB

Rob has a Bachelor of Science and a Master of Science degree in mathematics. Since graduation, he has taught mathematics for twelve years. Five of those years were at the middle school level, one was at the high school level, and six were at a community college. He reported having 22 graduate mathematics hours and 11 in math education courses in preparation for teaching. Included were three in learning theory and 2 in instructional design. He listed no conferences or professional journals. Rob teaches six mathematics courses and all six are developmental. Rob teaches six mathematics courses and all six are developmental.

He perceives himself as having a talent in mathematics and capacity to effectively tutor students. Rob discovered both the talent and the tutoring abilities while growing up and although he initially considered an engineering physics major in college, he returned to mathematics and teaching. Teaching mathematics is a challenge to help others "see some things I see about mathematics." He believes God gave him his mathematical ability and he chose to develop it through "a lot of time working" on it. In graduate school because of his struggles, he felt he reached his limit, ceiling, or capacity. When the work ceased to be fun, he decided not to push any farther.

One of the major characteristics of mathematical ability according to Rob has to do with a "meticulous-pay-attention-to-detail"way of thinking. Students need to be able to copy a problem out of the book correctly without help, see differences in numbers, examples and equations, and be able to use model examples to solve new problems. He believes attention-to-detail is both a genetic trait and can be taught to some extent. Another needed characteristic is the ability to read the problem, understand the problem, reword it it in their own words, and then solve it.

As far as Robert's beliefs about mathematical ability, he referenced a mathematical way of thinking that had to be developed. He felt that it took him longer because of his "natural ability." Mathematical thinking has to do with how to approach mathematical problem. He referenced abstract thinking as one component. Mathematical thinking also helps students organize information and justify conclusions based on what is already known to be true.

Activities include passing around a roll sheet, questions on homework, and lecture. Robert is not a user of cooperative learning groups, board work, or competitive activities. Students may use calculators and are encouraged to use the computers in the math lab. The value of computer practice was in repetitive drill and step by step to a solution practice. He has found that above average students benefit from the computer software more than average and below average students. He prefers to use the chalk board as part of his lecture rather than the overhead projectors because he likes to walk all over the room while lecturing. He likes to present examples for students to use as models. Sometimes he will initiate small group activities, but not cooperative learning groups where students are grouped according to ability level. Robert emphasized instructor control in his instructional design.

Rob perceives his role in the classroom as encourager, mentor, and facilitator and the major inhibitor to those roles was student attitude. A student's perception of their instructor affects their openness to learning. He tries to address this by being available, promoting test correction, encouraging questions, teasing and joking around in class, rewording problems for understanding, and making problems relevant to their understanding.

MARK
Mark has both a Bachelor of Science in meteorology and Master of Science degree in mathematics as well as additional hours toward a Ph.D. He mentioned no math education conferences attended in the past three years, but regularly reads two professional journals. All together he has taught college level mathematics for the past 16 years. When asked about why he chose to teach mathematics, he replied, "Because I wanted a stipend to help me live." Mark teaches five mathematics courses. Three of them are college level and two are developmental.

During high school, mathematics was not challenging and his first college mathematics course was intermediate algebra, a 1000 level course at that time. During his undergraduate assistantship at the state university, he discovered and fell in love with mathematics. Excellence was not expected or encouraged in high school, but in the college environment excellence was supported. He remembered high school mathematics as only problems from a book without explanations.

Mathematical ability, according to Mark, is a way of thinking. It includes focusing on mathematical vocabulary and attention to detail. Mathematical ability is based in part on genetics as well as cultivation. The cultivation of the ability must be done by the individual and is strongly supported by reading and writing abilities. His definition of mathematical ability includes both a technical and a creative skill level. He referenced himself as an example of a great technician. He emphasizes mathematical language or vocabulary, the science of logical patterns, and an autonomous nature as part of mathematical thinking. Autonomy is related to higher order abstract thinking and transfer of concepts from a known problem to a new and unknown problem. His experience in high school of mechanically working many problems without explanation or understanding as an example of what was not mathematics or mathematical thinking.

Thus, Mark believes that mathematical thinking can change with cultivation or effort on the part of the student. He relates it as a very personal and private way of thinking that is difficult to convey to another person. One of the reasons he dropped his Ph.D. program was he felt he only understood the details or the technical level, and was not mastering the creative level of mathematical thinking. He also believes that "everybody has a ceiling" and that motivation is about taking the "courage to try to find that ceiling." A student's perception of their own ability as capable may mean they are more motivated or courageous.

Mark's mathematics classes at one time began with roll call, but today he prefers to assign seats and take roll from that. Following any house keeping chores, as he calls the first activity, he asks for questions related to the unit topic, but comments that there are few responses. If there are no questions then he may try to provoke discussion or move on to new vocabulary and definitions. Then he plunges into the lecture. Board work, group work, and competitive activities are not components of his classes. Calculators are used when appropriate and he tries to create opportunities for thinking. Some of his activities appear to be driven by his need for control. For instance, if students are talking when he arrives he looks at them "with very big eyes" and acts as if he is listening. Once he has their attention he begins class by announcing dates of exams, gathering homework, and such. Control needs may also drive his choice of other activities.

Mark perceived his role in the classroom as lecturer, tutor, and evaluator. Student attitude was the main inhibitor to those roles. He listed no conferences in the past three years and reported regularly reading two professional journals.

LIZ

Liz has a Master's in mathematics and has taught college level mathematics for almost 22 years. When asked her reasons for choosing to teach mathematics, she replied enthusiastically, "I could do it!" She enjoyed mathematics, wanted to study as much as she could, and so pursued two degrees. She also knew that she could help people by becoming a teacher. She has a Bachelors and Masters in Mathematics and reported reading one journal and attending one professional conference in the past three years. Liz teaches seven mathematics courses of which one is at the college level and the remaining six are developmental.

The most important thing about mathematical ability, according to Liz, is intuition. She felt it important to be able to "look at a problem and just think about what the answer should be or think about a method for solving the problem. And sometimes these ideas just come to you." Thus, mathematical ability is a way of thinking or problem solving.

Liz did not believe that some people had math minds and some did not. She did not believe that mathematical ability was something students were either born with or not and she did believe that the ability level could change. She believes that if a student has the ability to learn English or history, then they can learn mathematics, too. The problem for students is that they do not *know how to learn mathematics*. They do not know the learning approach to take. The way to overcome their problem was to have some success. According to Liz, "They have to be willing to get in there and work at it and try; then they get more confidence," Once they discover "they can do it, they work harder and I think they will achieve more." In response to how she helps them get beyond the "brick wall," she explained the process that she uses. She thinks about it, then gets away from the problem for awhile, and then come back to it. Work intensely on a problem, rest, and come back. This is the process and things come together.

She begins the class by greeting the students, asking for any questions related to the homework or previous class, taking roll while they get their questions ready, discussion, introducing new material objectives, lecturing and providing lots of examples throughout the lecture. Sometimes she may use calculators or send an individual to the board. There is no groupwork or competitive activity. Liz tries to model enthusiasm for mathematics to her students.

Her roles and goals in the classroom are to impart knowledge, motivate and make them understand both the importance of the course and the importance of trying to learn the material. She felt that lack of motivation plays a role in inhibiting her role in the classroom. Another inhibitor was lack of attendance. She said, "They have to be willing to do what is necessary to learn and the first thing is to get to class. And it just amazes me that students can find everything else that is more important to do to keep from coming to class." The advantage of attendance is that the student gets to see problems and examples. They get to ask questions, take notes, and review. Then they have to go and practice. Students learn by practicing and the more practice, the better they get. "Mathematics is an accumulative subject" and each lesson is important to master.

JAN

Jan has the degrees, 2 masters and a Ph.D. One of the master's degrees was in mathematics and the other in English. Altogether she has taught 37 years of which 30 years were at the college level and 7 were in middle school. She commented that she had always liked mathematics, been good at it, and decided when she was 10 years old to pursue a career in teaching. She reported attending two conferences in the past three years and regularly reads one professional journal. Jan teaches five sections of mathematics of which two are college level and three are developmental.

In talking about the development of mathematical ability, Jan suggested that questioning strategies foster it. Instead of having students memorize number facts and regurgitate them, she proposed asking questions that have them consider relationships and alternative patterns. Jan believes that mathematical ability is related to a way of analyzing and thinking through problems. Considering logical alternatives is also part of the thinking pattern. Some students have this ability and some have not learned it because they were taught to memorize in high school rather than think mathematically. Mathematical ability is about "curiosity and a way of looking at things. . . Curiosity to see how things work and willingness to analyze and try things and explore what would happen if you did such and such."

Mathematical ability can be changed as faculty teach students to work at mathematics and consider alternatives. "The student has to be open to trying things and thinking and working." Jan spoke of aspects like encouragement to try and work at mathematics as affecting young children. She believes college student attitudes toward mathematics are a result of earlier dialogue and activities. Students may or may not have an ability ceiling, but Jan felt her job was to encourage students to push their limits. She also believed that the background skills affected their success in any given classroom. If they did not have the background, then they needed to be placed in an appropriate classroom to build the needed skills and knowledge base. She believed mathematical ability could change with appropriate effort.

Activities included beginning the class by taking roll and moving into any questions about homework they had. Jan tried next to relate the new material to the last class topics. Lecture is the dominant activity, but she interjects numerous questions for discussion. Her goal is to keep them involved in the lecture dialogue. She likes to think that her style is one of "organized discovery." Collaborative or cooperative group work is not used though some students develop their own study groups in the math lab. Board work is not used at all due to the large class sizes. Manipulatives were evident in her office and used in appropriate classes. Jan said her role in the classroom was that of guide, counselor, and expounder of knowledge. Her problems in accomplishing these roles were due to the short class time span. She preferred the 50 to 80 minute classes for some courses and recognized that it is important to vary activities more in the longer time frames to hold student attention.

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