INFORMATION TO USERS

This manuscript has been reproduced from the microfilm master. UMI films the text directly from the original or copy submitted. Thus, some thesis and dissertation copies are in typewriter face, while others may be from any type of computer printer.

The quality of this reproduction is dependent upon the quality of the copy submitted. Broken or indistinct print, colored or poor quality illustrations and photographs, print bleedthrough, substandard margins, and improper alignment can adversely affect reproduction.

In the unlikely event that the author did not send UMI a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyright material had to be removed, a note will indicate the deletion.

Oversize materials (e.g., maps, drawings, charts) are reproduced by sectioning the original, beginning at the upper left-hand corner and continuing from left to right in equal sections with small overlaps.

Photographs included in the original manuscript have been reproduced xerographically in this copy. Higher quality 6" x 9" black and white photographic prints are available for any photographs or illustrations appearing in this copy for an additional charge. Contact UMI directly to order.

Bell & Howell Information and Learning
300 North Zeeb Road, Ann Arbor, MI 48106-1346 USA

UMI®
800-521-0600

Downloaded from SHAREOK. Persistent Handle URL: https://hdl.handle.net/11244/5924

THE UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

A CRITICAL EXPLORATION OF DEVELOPMENTAL MATHEMATICS STUDENTS' CONCEPTIONS OF THE ROLE OF MATHEMATICS IN SOCIETY

A Dissertation

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

degree of

Doctor of Philosophy

By

DANA DARBY

Norman, Oklahoma

2000

UMI Number: 9962953

UMI®

UMI Microform 9962953

Copyright 2000 by Bell & Howell Information and Learning Company.
All rights reserved. This microform edition is protected against
unauthorized copying under Title 17, United States Code.

Bell & Howell Information and Learning Company
300 North Zeeb Road
P.O. Box 1346
Ann Arbor, MI 48106-1346

© Copyright by DANA DARBY 2000
All Rights Reserved

A CRITICAL EXPLORATION OF DEVELOPMENTAL MATHEMATICS STUDENTS' CONCEPTIONS OF THE ROLE OF MATHEMATICS IN SOCIETY

A Dissertation
APPROVED FOR THE
DEPARTMENT OF INSTRUCTIONAL LEADERSHIP
AND ACADEMIC CURRICULUM

BY

ACKNOWLEDGMENTS

I truly cannot imagine that anyone has ever had a better committee than the one I have had. Jayne Fleener, Pamela Fry, Paul Kleine, Susan Laird, and Anne Reynolds combined to form a team intent on helping me "learn to learn" in new ways. Susan Laird's term "nurturing challenge" is a fitting description for the role they have played in my graduate studies. I have always felt completely supported, yet also inspired to go beyond the frequent advice of others to "just get it done." My committee has been composed of quality individuals who have an amazing grasp of balance and of the goal of a doctoral program. I always knew they had my best interests at heart. Jayne Fleener, as my committee chair, has been especially instrumental in my completion of this degree. I am blessed to have had a chair that is all the things mentioned above *and* a friend.

I am very grateful to the participants in this study. Six of them gave me permission to include their names here. Marty, Mary, Marianne, John, Kim, and Wendy were willing to openly share their stories and beliefs. I appreciate them not only for the benefit I received, but also for the benefit of "those who come after." I will carry their stories throughout my career, and I will hopefully be able to share those stories with others.

It cannot go without saying that my family has been an incredible support. I sit here typing with tears in my eyes as I think of all the sacrifices they have made so that I could do this. My oldest son would say, "Oh, Mom, you're not crying again, are you?" But, yes, I am because of the tremendous gratitude and pride I feel toward Richard, Ben, and Jonathan.

I also must acknowledge the role played by my friends and extended family for all the times they "picked up the kids," or babysat while I went to class, or just asked how my dissertation was coming along. The "little things" meant more than they will ever know.

The last acknowledgment is for God. My God gives me meaning beyond myself and beyond any of the things I accomplish here. This precipitates a freedom and a peace without which I could not survive.

I dedicate this dissertation to Mother and Daddy.

I just wish you could have been here to see this.

TABLE OF CONTENTS

Page

Abstract.....ix

Chapter 1: INTRODUCTION.....1

Narrowing the Focus.....6

Beliefs.....10

Research Questions.....13

Chapter 2: INFLUENCES.....16

Science as Philosophy.....17

Adult Learning Theory.....23

Critical Mathematics Education.....28

The Framework (not the container).....34

Chapter 3: RESEARCH DESIGN.....39

Participants.....40

Method.....43

Trustworthiness.....47

Analysis.....49

Ethics.....52

Considerations.....54

Chapter 4: PARTICIPANT TALES.....57

The Participants.....58

Terri.....59

Kelsey.....65

Zach.....71

Rachel.....78

Michael.....82

Brenda.....89

James.....94

Chapter 5: PARTICIPANT VIEWS.....101

A Deconstructive Tale.....101

Deconstructing "Why?".....102

Critical Questioning.....107

Learning as Action.....132

Deconstructing "How?".....143

The Scene.....147

Participant Conclusions.....157

Chapter 6: REFLECTIONS AND CHALLENGES.....161

Summary.....161

Further Reflections.....163

The researched.....164

The researcher.....167

The reader.....171

Recommendations for Future Research.....176

REFERENCES..... 179

APPENDIX A: EXPLANATION OF DATA CITATIONS..... 191

APPENDIX B: PARTICIPANT INVITATION AND QUESTIONNAIRE.....192

APPENDIX C: PARTICIPANT LETTER..... 195

APPENDIX D: RESEARCH PARTICIPATION AGREEMENT..... 196

APPENDIX E: REQUEST FOR PERMISSION TO CONDUCT THE STUDY..... 198

APPENDIX F: INSTITUTIONAL RESEARCH BOARD APPROVAL..... 199

APPENDIX G: INTERVIEW TIMETABLE..... 200

APPENDIX H: FIELD LOG..... 201

ABSTRACT

This study explored with seven developmental mathematics students their conceptions of the role mathematics plays in society. Approached from a critical, qualitative standpoint, the participants of the study were asked to recount their mathematical autobiographies and to critically assess the role mathematics has played in their lives. The participants were further asked to assess how mathematics is used in society in general.

The setting for the study was a small, rural community college in a southwestern state. Methods of data collection included three individual interviews, a group interview, and journal writing. The data were collected over a four-month period during a Fall semester in which these seven students were enrolled in either Beginning Algebra or Intermediate Algebra. Four women and three men participated in the study. They ranged in age from 18 to 51 and were experiencing varied levels of academic success.

Analysis of the data was based primarily upon Skovsmose' theory of critical mathematics education and Mezirow's theory of perspective transformation. Through analysis, two major divisions in the findings were developed. These two divisions represented a deconstruction of traditional authority structures and of the uses of mathematics. First, most participants questioned the inclusion of "academic" mathematics in the required curriculum for non-mathematical degrees, seeing it as more of a barrier than a benefit. The questioning process was explored both from the standpoint of distorted beliefs or perspectives and from the standpoint of intentionality in the learning process.

Second, in an effort to spur a deeper critique of the role of mathematics, the study utilized "scene-setting," or a scenario in which mathematics was used in an unconventional way. Within the group interview setting, participants wrestled with a use of mathematics that was no longer objective and value-neutral.

The participants began the study with a limited view of the role of mathematics in society and ended much the same way. Concluding statements made by the participants, though, indicated that the critical process had a spiral effect rather than a circular one, thus creating the potential for future growth. The questioning process illuminated ethical issues underlying the use of mathematics and reactions to those issues by the participants. Implications of the study include the need for more opportunities for students to explore ethical issues related to mathematics and its uses.

CHAPTER 1

INTRODUCTION

The winds of change--sometimes within education they seem to be simply a light breeze, but they exist nonetheless. For the field of developmental mathematics education, they have increased somewhat in intensity. Precipitated in part by movements in the National Council of Teachers of Mathematics [NCTM] and the American Mathematical Association of Two-Year Colleges [AMATYC], developmental mathematics education, sometimes referred to as remedial mathematics education, is shifting from decontextualized, lecture-based instruction to a more holistic, dynamic experience. Educators are placing more emphasis on support services such as placement testing, mathematics laboratories, and after semester workshops (Testone, 1999) as well as more emphasis on alternative instructional formats such as small-group instruction, "package courses," and mediated learning (Depree, 1998; Wilcox, delMas, Stewart, Johnson, & Ghere, 1997; King & Crouse, 1997).

Colleges have traditionally defined remedial education as "any programs, courses, or activities designed for first-time entering freshmen who have basic deficiencies in reading, written or oral communication, mathematics, study skills, or other skills necessary to do beginning college-level work as defined by the institution" (Abraham, 1992). This definition assumes that remedial education and developmental education are synonymous. Exemplifying the change in emphasis in developmental education, Higbee (1996) "bristles" at such an equivocation because of her belief that the mission of developmental education is

the development of the whole student, not just the development of intellectual competence. As early as 1976 Cross drew a distinction between "remedial" and "developmental." She defines remedial education as correcting deficiencies and developmental education as developing diverse talents of students, academic or otherwise. Professionals in the field use "developmental education" as an overarching term that refers to a continuum of services ranging from remedial courses as the low end to learning assistance centers at the high end (Boylan, Bonham, & White, 1999).

The AMATYC (1995) provides direction for change as it advocates the following standards for pedagogy in introductory mathematics courses: 1) increasing the use of technology, 2) promoting interactive and collaborative learning, 3) connecting mathematics with other experiences, 4) modeling multiple approaches to problem solving, and 5) providing opportunities for students to experience mathematics. These standards mirror those developed by the NCTM (1989). The NCTM Standards rest on such premises as 1) students learn by doing, 2) teachers and students should utilize technology, 3) activities should grow out of problem situations, and 4) students should experience genuine problems. While these documents address two different student populations, they both reflect constructivism, the belief that learners construct their own knowledge by being actively involved in their learning rather than simply receiving transmitted information (von Glasersfeld, 1996). This is a significant break from the traditional theory of learning that leads to highly structured lecture courses—typical of many developmental mathematics classrooms.

A catalyst for change in addition to the AMATYC and the NCTM is a general shift in higher education from the "teaching paradigm" to the "learning paradigm" (Barr & Tagg, 1995; Cross, 1993; O'Banion, 1995-96; Flynn, 1999). Though learning is fundamentally what higher education is all about, institutional structures, academic curriculum, and instructional methodology have commonly placed instructors at the center of attention. Cross (1993) states that "learning has many ends, but teaching has only one—to enable or cause learning. If teaching does not result in learning, then it has failed its only purpose" (p. 4). Her point is that while teaching is important, it is subordinate to learning; structures, curriculum, and methodology should be about learners, not instructors.

This paradigm shift has had an interactive effect with the "access/success" discussion surrounding developmental education as a whole. Historically, the discussion has been more appropriately termed a debate—"access versus excellence"—with reformists advocating greater access to higher education and traditionalists striving to maintain stringent admission and retention standards (Almeida, 1991; Casazza & Silverman, 1996; Cross, 1975). Payne and Lyman (1996) would disapprove of using the word "historically," asserting that access versus excellence is still one of the primary issues affecting the definition of developmental education.

A compromise between the current traditionalists and reformists is to allow 4-year institutions to uphold rigorous admissions standards while community colleges would remain as open door institutions (Lively, 1993). States such as Florida, Missouri, and South Carolina have already adopted this

measure, making community colleges the sole providers of developmental education (Lazarick, 1997). Bills introduced during the 2000 legislative session in the House and Senate in Oklahoma (access at www2.lsb.state.ok.us/billtext.html) sought to eliminate remedial courses at comprehensive universities by the 2001-2002 school year and at all four-year colleges and universities by the 2004-2005 school year. The house version, House Bill 1710, was modified to affect only the state's two comprehensive universities, with remedial courses being eliminated at those institutions by the fall of 2001. The bill's author included no language affecting admission standards; therefore, a student needing remediation could still be admitted to a comprehensive university, but would have to seek the necessary courses from a community college.

A further measure introduced before the Oklahoma Senate would have required payment of fees for remedial courses in addition to regular tuition as follows: comprehensive universities—$137 per credit hour; regional colleges—$86 per credit hour; and two-year colleges—$13 per credit hour (which is the current fee charged for remedial courses). Also proposed in the Oklahoma Senate was the authorization for vocational-technical schools to offer remedial instruction when no higher education institution in the geographic area offers such courses. Following the passage of House Bill 1710, these two senate bills were dropped from consideration. The senate also dropped House Bill 1710 from its consideration after issues were raised regarding remediation of student athletes at the two comprehensive universities.

Rather than a dichotomy between access and excellence, the "learning paradigm" embraces the concept of access *with* success (Barr & Tag, 1995). Literature in the developmental education field reflects a slow change in this direction (e.g. Maxwell, 1994; Casazza & Silverman, 1996), slow because the idea of access *with* success has been promoted for over twenty-five years. Cross (1975, 1976) and Roueche (Roueche, 1968; Roueche & Kirk, 1974; Roueche & Snow, 1977) have advocated this approach since a flood of underprepared students began arriving on campuses in the late 1960s and early 1970s. The civil rights movement had opened access to higher education and reversed the meritocracy of the 1950s (Cross, 1975). "New Students" (Cross, 1974), young people scoring in the lowest third on traditional tests of achievement, came to college campuses without the academic skills or the support system necessary for success. During this time colleges aimed to provide access to higher education, but too often mere access has not served students well.

A recent article by John and Suanne Roueche (1999) reflects the frustration that can accompany slow change. After thirty years of research into best practices, higher education institutions implement the practices only sporadically. The authors use words such as "sadly," "costly," and "discouraging" as they discuss developmental education issues. They repeat their "recipe for success" which includes among others such practices as proactive pre-enrollment activities, orientation to student support services, mandatory assessment and placement, and a reduced number of credit hours taken by working students. In the end, however, the authors reaffirm their belief that

remedial programs *do* work and can help colleges "make good on the promise of the open door" (p. 18).

Finally, a subsuming factor in the change in focus in higher education as well as developmental education is a general societal shift. The information explosion and a global marketplace has forced us to rethink our "banking" conception of education (Freire, 1970). Furthermore, it has forced us to admit the complexity of human relationships and activities. Waldrop (1992) in describing complexity theory in science refers to the interdependence of species within an ecological environment. These species do not simply evolve in isolation; as they adapt to changes in the environment, they in turn change the environment so that other species also evolve. This complex give-and-take is called co-evolution. This idea can be extended to metaphorically include much (if not all) of who we are and what we do as humankind. As we adapt to our contexts, we change those very contexts for others. Developmental education is no exception; it is caught up in the broader co-evolution of our society. As higher education struggles to adapt to societal pressure for more and differently educated people, developmental education struggles to adapt to higher education pressure to "stand in the gap" and provide access *with* success to the underprepared.

Narrowing the Focus

Having considered the broad context of change in the field of developmental education, it is important to once again narrow the focus and consider the current state of affairs specifically in developmental *mathematics*

education. The AMATYC (1995) identifies two intersecting national trends: "a growing societal need for a citizenry with a sophisticated level of mathematical preparation and an increasing number of academically underprepared students seeking entrance to postsecondary education" (p. xi). A National Center for Education Statistics (1996) report demonstrates evidence of the numbers needing developmental mathematics by stating that 29% of entering freshmen were placed in at least one remedial course with enrollments in mathematics outpacing those in reading and writing. A 1992-93 study indicated that as many as 8% of all undergraduates were enrolled in remedial mathematics (Knopp, 1995). In a survey of the higher education institutions in the 15 Southern Region Education Board [SREB] states, Abraham (1991) found that 38% of first-time students were underprepared in mathematics. In all 15 states the percentage of students needing at least one remedial course in mathematics was significantly higher than the percentage of students needing such a course in reading or writing; in several states the percentage needing remedial mathematics was double that of reading or writing. Even these statistics are likely underestimated because, at the time of the study, not every institution had mandatory remediation. For all institutions in the SREB region, public and private, the median percentage of remedial students who successfully completed the prescribed remedial program in mathematics was 65% (Abraham, 1992).

Oklahoma follows the Southern Region trend. A 1993 study (Oklahoma State Regents for Higher Education) reported that about 1/3 of entering freshmen required remediation in at least one area. Of remediation enrollments, 65% were

in mathematics. Newer data suggests decreasing numbers of entering freshmen enrolling directly from high school who need remediation; adult remediation enrollments, however, continue to increase (Oklahoma State Regents for Higher Education, 1997). Mathematics persists as the area of greatest need with twice as many remediation enrollments as English (which is the next highest demand).

This increasing number of students needing more preparation is also characterized by increasing diversity. In the years since Cross' (1974) initial work in describing "New Students," the focus has shifted from their similarities to their differences. Richardson and Elliott (1994) suggest the use of the term "diverse" rather than "underprepared" to describe developmental learners. At-risk students are defined as not only being poorly prepared recent high school graduates, but also as adults with poor academic backgrounds and with incredible demands on their time. These students often bring to the educational setting a complex mix of personal and family issues, a lack of motivation and self-esteem, and a long history of academic failure (J. E. Roueche & S. D. Roueche, 1993; Higbee, Dwinell, McAdams, GoldbergBelle, & Tardola, 1991). A study comparing "remedial" and "nonremedial" first-year college mathematics students concluded that remedial mathematics students start college at a marked disadvantage. The sample of students in the study were more likely to come from families with lower incomes and lower educational levels, and were less likely to be encouraged to enroll in college (Hagedorn, Siadat, Fogel, Nora, & Pascarella, 1999).

Other recent writings by leaders in the field of developmental education,

though, downplay the drama of diversity (Boylan, Bonham, White, 1999; Boylan, 1999).

> So, who are developmental students? They are, in most respects, typical college students. Some are talented artists who have trouble in math. Some are outstanding in math and have trouble writing. Some were once good students who have simply been out of school for a long time....Who are the developmental students? They are the parents of our public school children, they are the people who fight our wars, they are the citizens who vote in our elections, they are the workers who pay their taxes. All they want is the opportunity to go to college and have a chance for success. In essence, they are a lot like the rest of us (Boylan, 1999, p. 2).

As the AMATYC (1995) stated, though, the increasing number of underprepared students entering higher education comes at a time of greater need for mathematically educated citizens. In the late 1980s, an informed citizenry was set forth as a goal both by the Board on Mathematical Sciences (1989) and the NCTM (1989). The Standards developed by the NCTM (1989) state that "in a democratic country in which political and social decisions involve increasingly complex technical issues, an educated, informed electorate is critical.... Citizens must be able to read and interpret complex, and sometimes conflicting information" (p. 4-5). It is imperative to understand not only the modeling process itself, but also the functions and influences of the applications of mathematics in society (Hartz, 1990; Skovsmose, 1990; Skovsmose, 1992). Tate (1994) states that "traditionally, mathematics education has been connected to the

issues of national economic survival, rather than to the development of democratic citizenship through critical thinking in mathematics" (p. 482). Schools should educate students to become critical citizens, "prepared to take risks and to challenge and to believe that their actions can make a difference in the larger society" (Skovsmose, 1994, p. 24).

Beliefs

Mathematics, however, is seldom thought of as anything but objective and value-neutral, bearing little connection to the everyday world of developmental mathematics students. They often arrive in class with a conception of mathematics learning as simply being rote learning (Oaks, 1994), and they tend to see "all mathematical knowledge as external, fundamental, and black or white" (Buerk, 1994). Indeed, student beliefs about mathematics have become a dominant theme in the developmental mathematics literature.

For example, Stage and Kloosterman (1995) found beliefs about mathematics to play a more important role for women than for men. They found women's beliefs about mathematics to be related to final course grade; high school mathematics background, however, did not seem to have this same relationship with course outcome. Conversely for males, high school mathematics background was related to final course grade, but beliefs were not.

Caniglia and Duranczyk (1999) conducted a qualitative study focusing on student beliefs regarding mathematics. Using autobiographies collected over a two-year period from students in a pre-algebra class, the authors found both

external and internal factors that influenced student beliefs. Internal factors were related to teaching and learning within the educational system while external factors were those not directly linked to the institution. Internal influencing factors that emerged from the data were teachers, counselors, grades, and course placement. More participants referred to the negative impact of teachers than any other single factor. External factors included, among others, the influence of family, medical conditions, life experiences, effort, and affective factors. Overwhelmingly, the most cited external factors were affective factors such as anxiety, fear, and panic. The students viewed mathematics in terms of its application to a future career and to everyday activities and in terms of computation and algorithms. Further, the students seemed to possess only minimal metacognitive strategies and were unaware of what they "knew" about mathematics.

Burton (1987) conducted a study of a mathematics course designed to provide alternative experiences for students needing a remedial-type course before entry into a teacher education program. Part of the course used a mastery learning format, whereas the other part of the course utilized a problem-solving, discussion format. The author conjectured that such a course would "enable these students to change their image of mathematics and of their own relationship to it" (p. 306). Learner comments at the end of the course indicated that their view of mathematics had indeed become more positive.

Not all studies support the impact of beliefs on performance, though. Harper (1995) considered variables that affect re-entry women in developmental

mathematics. Based on adult education participation literature, the study revealed that nontraditional-aged students exhibited higher success rates and appeared more highly motivated than traditional-aged students. No difference was found, though, between the two groups in terms of anxiety, self-confidence, perception of the usefulness of mathematics, mathematics as a male domain, and attitudes towards success in mathematics.

Though not research studies, the following articles are evidence of the increasing emphasis on learners' conceptions of mathematics. Darken (1991) advocates the use of technology as an aid to conceptual understanding of mathematics rather than computational proficiency. Similarly, Koch (1994) calls for the development of instructional materials that give students the opportunity to change their view of mathematics. She stresses the importance of a learning environment in which students can explore misunderstandings of mathematical concepts. Gourgey (1992) explains and advocates a model for tutoring developmental mathematics students that is designed to address student conceptions about mathematics. "Mathematics instruction for students who have a history of anxiety and poor performance must attend not only to the mathematics but also to students' beliefs about mathematics and about themselves as math learners" (p. 11). The tutoring model includes dialogue, analysis of error, response to affective needs, and reeducation about the learning process.

Additional articles concerning learners' conceptions of mathematics include one by Gray (1991) which places learner beliefs about the nature of mathematics and about themselves as learners in the metacognitive domain. As

such, beliefs influence performance. To develop metacognitive abilities, the author recommends strategies such as pair problem solving, problem rewriting, and small group problem solving. Another author (Oaks, 1994) reflects on her own experiences with mathematics teaching and on how conceptions of mathematics seem to determine the students' perception of experiences in the classroom. Students who start with a conception of mathematics as sterile and algorithm-intensive are at odds with instructors who teach for meaning. Oaks asserts that one of the teacher's primary responsibilities is to help students see that such beliefs limit possibilities for understanding and for expanding their views of mathematics.

Buerk (1994), in her work with math avoidant college freshmen, found that the stages of development through which students progress as they begin to change their conceptions of mathematics are as follows:

1. Seeing all mathematical knowledge as external, fundamental, and black or white
2. Acknowledging personal thoughts and ideas, often in a subjective way
3. Integrating known theories and new, carefully developed, individual ideas into an internal model and thereby gaining ownership of the mathematics they are learning. (p. 46)

Research Questions

The literature dealing with developmental mathematics students' beliefs or

conceptions about mathematics has been written with the intent of finding the conditions under which students can begin to view mathematics more positively. Given opportunity, the students in the previously cited studies did tend to develop more positive views of mathematics from a *personal* standpoint. To extend this research, student conceptions of mathematics from a critical, social standpoint need to be explored. The calls for a mathematically educated electorate and for "the development of democratic citizenship through critical thinking in mathematics" (Tate, 1994, p. 482) are well reasoned and well intentioned, but how do we accomplish this? Are developmental mathematics students willing and able to engage in the questioning process? What happens when students reflect on the political, social, or cultural nature of mathematics rather than on seemingly value-free economic or physical applications? The purpose, therefore, of this study was to explore with students their view of the role of mathematics in society, their view of themselves and how the interaction between the two relates to the mathematics they learn. This purpose had its foundations in a problem-posing (Freire, 1970), critical approach (Lather, 1991) to transformative, educative experiences. Problem-posing, critique, and transformation all involve reflection, which in turn affects action. Through this study developmental mathematics students had the opportunity to experience the dialectical relationship of reflection and action, i.e. research as praxis (Lather, 1991). The following research questions provided a point of origin for reflections.

1. What are the students' initial conceptions of the role of mathematics in society?

2. How do these conceptions change over the course of the study?
3. What do the students question about mathematics and mathematics education in our society, and why?
4. How does the critique differ among various types of students represented in the study (for example, non-traditional and traditional, male and female)?
5. In what ways do the participants anticipate the study will affect their future actions?

CHAPTER 2

INFLUENCES

Traditionally, the purpose of a literature review is to piece together the puzzle related to the subject of interest (Langenbach, Vaughn, & Aagaard, 1994). The proposed study is then justified in terms of how it will add a piece to the puzzle. Qualitative researchers, though, are sometimes discouraged from conducting a literature review prior to conducting a study (Bogdan & Biklen, 1992). Philosophically, it does not "fit." Most qualitative researchers work within a perspective-seeking paradigm (Langenbach, Vaughn, & Aagaard, 1994), and as such run the risk that a literature review will prejudice interpretation of the data.

Such an approach, however, is unrealistic, particularly for a novice researcher. Furthermore, every researcher brings his or her subjectivities to the research project, whether they reveal themselves in the choice of theoretical frameworks and literature or whether they are revealed by the themes that "emerge" from the data. Neither the positivist's literature review of the "puzzle" nor the interpretivist's "clean slate" accurately reflects my worldview and the purposes of this study. I have chosen to include a literature review, but in a modified form. The remainder of this chapter is intended to lay out the sources that influenced my thinking in choosing and designing this study, but not to set up a framework that will limit the boundaries and interpretation of the data collected during the study. In her discussion of "dialectical theory-building versus theoretical imposition", Lather (1991) states that

> building empirically grounded theory requires a reciprocal relationship

between data and theory. Data must be allowed to generate propositions in a dialectical manner that *permits use of a priori theoretical frameworks, but which keeps a particular framework from becoming the container into which the data must be poured.* The search is for theory which grows out of context-embedded data, not in a way that automatically rejects a priori theory, but in a way that keeps preconceptions from distorting the logic of evidence (p. 62, emphasis added).

The following literature has interesting implications for constructing theory about critical mathematics in developmental education. It blends ideas about the complex nature of society and of learning and of the place where the two meet.

Science as Philosophy

Science provides some very appropriate metaphors for constructing educational philosophy. Traditional educational processes have reflected a Newtonian worldview. This scientific paradigm gave the world much more than a theory of physical science; it also gave a philosophy through which to interpret experiences. Newton's physical laws were based on an objective reality separate from the observer. A machine-like universe could be studied part by part, and if given approximate knowledge of inputs, approximate outputs could be determined. Margaret Wheatley (1992), in describing organizational practices, stated that

> we manage by separating things into parts, we believe that influence occurs as a direct result of force exerted from one person to another, we

> engage in complex planning for a world we keep expecting to be predictable, and we search continually for better methods of objectively perceiving the world....Intentionally or not, we work from a world view that has been derived from the natural sciences. (p. 6)

Betts (1992) claims that while the rest of society has moved into a post-industrial era, schools remain firmly rooted in the paradigm of the industrial age—an age built on Newtonian technology and philosophy. Similarly, Doll (1989) states that many of the social sciences, including education, still use the Newtonian paradigm as a foundational model. It is a model that considers product rather than process, that believes the whole is equal to the sum of its parts, and that views knowledge as separate from the knower.

Developmental education, in particular developmental mathematics education, has traditionally taken this view of teaching and learning. Following from a belief in cumulative, linear learning, the curriculum has been dissected and carefully sequenced into small, digestible bites. Knowledge of initial student characteristics, combined with carefully crafted lessons, is expected to yield successful outcomes. Lecture has been the predominant mode of instruction, indicating that knowledge is static and can be transmitted from one person to another. Instructors have honed lecture notes and examples looking for the one best method that will "work" and will continue to "work."

The call for building communities (Commission on the Future of Community Colleges, 1988; Matthews, 1994), for holistic approaches to student development (Higbee, 1996), and for alternative approaches to remediation

(AMATYC, 1995; Myers, 1996; Boylan, 1999) is evidence, however, of a paradigm shift taking place in developmental education. Just as Newtonian science parallels the dominant educational paradigm, so the New Science parallels the foundational changes beginning to take hold in developmental mathematics education. This New Science has ushered in an alternative way of "scientifically" viewing our world through its focus on interactions in open systems (Darby, 1996).

Open systems are those which "have to maintain a continuous exchange of energy and matter with their environment to stay alive" (Capra, 1983, p. 270). Such systems provide a contrast to closed systems which are predictable and can be controlled, especially when equipped with efficient negative feedback loops. Behavior in open systems may at times settle down to a steady state, but because of their sensitive dependence on initial conditions, small changes can flow through the system and produce unexpected results. An excellent example of this type of system is the weather. The Butterfly Effect—"the notion that a butterfly stirring the air today in Peking can transform storm systems next month in New York" (Gleick, 1987)—emphasizes the profound effect even small differences can have in an open system. Because of the inherent complexity of the system, long-range predictability is unlikely and can even be counterproductive.

Likewise, some of the researchers in developmental education are finding the road to prediction and control a rocky one. In a study of factors leading to success in developmental introductory algebra, Barker (1994) stated that nontraditional student achievement in developmental algebra should not be

considered solely in terms of traditional undergraduate theories and pedagogies. In a study of developmental mathematics student retention, Umoh, Eddy, and Spaulding (1994) asserted that developmental students differ from typical college students because the expected factors do not affect retention in developmental mathematics programs. Constructs such as age, gender, grade point average, and parents' education seemed not to impact retention.

Another study on retention in developmental mathematics found none of the variables under consideration to have a relationship with success in the class (Berenson, Carter, & Norwood, 1992). The study

> suggests that there may not be a predictive model that can be applied to this group of at-risk students....The individual characteristics of at-risk students are too widespread for us to apply a remedial template to predict which student will be successful and who will drop out. (p. 58)

The New Science addresses this diversity and complexity by emphasizing relationships rather than singular entities, process rather than product, and becoming rather than being (Gleick, 1987). It searches for pattern on different scales and seeks explanation rather than prediction. It recognizes that the relationships between realism and relativism, objectivism and subjectivism, status quo and reform are dialectical rather than dichotomous. It is a post-modern science that provides a post-modern foundation for education (Doll, 1989).

The New Science fits nicely with the renewed emphasis on individual transformation. The parallels remind us that just as nature is complex and defies prediction and control, so learning is much more complex than the simple

transmission of knowledge upon which many educational structures are built. Within the framework of the New Science, every component of a system is affected by all others. Waldrop (1992) states that "except for the very simplest physical systems, virtually everything and everybody in the world is caught up in a vast, nonlinear web of incentives and constraints and connections. The slightest change in one place causes tremors everywhere else" (p. 65). Likewise, learning affects and is affected by all other components of the learner and the learner's environment. Thus learning has a history and a context. It fits within the broader perspective of the learner's beliefs, experiences, and prior knowledge. Code (1991) places the construction of knowledge within a subjective-objective continuum. Factors affecting the construction of knowledge include the sex of the knower, creativity, affectivity, historical location, and location within social, linguistic, and economic contexts. In parallel to the New Science, Code proposes an ecological model of knowledge construction. Such a model would be "cognizant of the fact that every cognitive act takes place at a point of intersection of innumerable relations, events, circumstances, and histories that make the knower and the known what they are at that time" (p. 269).

Along with context and connection, the New Science is concerned with structure. First, structure in open systems is emergent. As agents of a system come together, they acquire properties that they do not possess individually. Water has the property of liquidity, but only in the presence of a plurality of molecules. A hurricane emerges after the interaction of agents such as water vapor, sunlight, and wind (see Waldrop, 1992). Likewise, learning "emerges"

only after the interaction of agents in the learning environment, such as the learner, instructor, materials, etc. These agents taken individually cannot account for knowledge construction, but taken together, they organize so that learning takes place.

A second type of structure appropriate to this discussion is a dissipative structure. With respect to its environment, an open system can exist a) at equilibrium, b) near equilibrium, and c) far from equilibrium (Sawada & Caley, 1985). Though dissipation is usually associated with a loss of energy, it plays a different role in open systems. In this case, the dissipative process is interrupted by small fluctuations from the environment. These fluctuations interact with the system, and if they create enough disturbance, the system enters a far from equilibrium state and can reorganize itself at a higher level—one better able to deal with the environment. "Dissipative structures demonstrate that disorder can be a source of order, and that growth is found in disequilibrium, not in balance" (Wheatley, 1992, p. 20). Significant learning also is preceded by a disturbance, e.g. an "uncomfortable ambiguity" (Cross, 1976) or a "disorienting dilemma" (Mezirow, 1991). Such situations have the potential to invoke in the learner a transcendence—the ability to operate at a higher level than before.

In summation, the beliefs underlying this study reflect foundational ideas illustrated by the New Science. First is a belief in complexity, a belief that all is indissolubly connected: the knower and the known, the researcher and the researched, society and the individual. Secondly, though prediction and control are appropriate goals in some circumstances, they are not the goals of this project.

The goal here is to observe and even promote the process of transcendence as learners (and the researcher) become more than they were before.

Adult Learning Theory

In keeping with the philosophy exemplified by the New Science, theories of adult learning reflect a philosophy of holism, relationship, and context. Even (1987) claims that adult learning is based on a holistic philosophy and that it has cognitive, affective, and psychomotor dimensions. She further claims that "new" learning is related to prior learning; therefore, history and context are important considerations in learning theory. She also refers to the "Baggage Barriers" adults bring to a learning program; because of these barriers, educators must address students holistically rather than maintaining a singular focus on content.

Merriam and Caffarella (1991) provide a synopsis of several comprehensive theories of adult learning. They categorize the theories into those based on adult characteristics, those based on an adult's life situation, and those based on changes in consciousness. These authors criticize theories included in the first two categories as being descriptions of characteristics and situations rather than theories about the learning process itself. They single out Peter Jarvis' model (see Jarvis, 1987) of adult learning as addressing the learning process but criticize it as not being peculiar to adult learning. They include in the third category Jack Mezirow's perspective transformation theory. In a later article, Merriam (1993) states that transformational learning and situation cognition "seem to hold the most potential for moving toward a comprehensive theory of

adult learning" (p. 109). Transformation theory both addresses the process of learning and claims to be unique to adults, though "unique" may be an overstatement.

In describing transformation theory, Mezirow (1994) defines learning as "the social process of construing and appropriating a new or revised interpretation of the meaning of one's experience as a guide to action" (p. 222). Interpretation of the meaning of experience, i.e. learning, is affected by meaning perspectives and meaning schemes. Meaning perspectives are the lenses we use to "see" our experiences; they are most often developed uncritically in childhood from parents, teachers, and authority figures. Specific manifestations of these perspectives are called meaning schemes. Within the context of transformation theory, all else follows from the idea that these uncritically assimilated ideas affect how we perceive and make meaning of our experiences.

Mezirow (1991) characterized meaning perspectives as being of three different but interrelated types. First, epistemic perspectives deal with our ways of knowing and the uses we make of our knowledge. Factors include learning style, developmental stage perspective, scope of awareness, global/detail focus, concrete/abstract thinking, and reflectivity. Second, sociolinguistic perspectives pertain to social norms and roles and include cultural/language codes, philosophies/theories, secondary socialization, and ethnocentrism. Psychological perspectives are the third type of meaning perspective; they address our assumptions about ourselves as individuals. Factors include self-concept, locus of control, inhibitions, defense mechanisms, and approach/avoidance. Mezirow

(1998) eventually expanded the list of perspectives to include those based on logical, ethical, ideological, economic, and spiritual assumptions or habits of thought.

Transformation theory is constructivist in nature. Mezirow (1991) states that "specific constructivist assumptions underlying transformation theory include a conviction that meaning exists within ourselves rather than in external forms such as books and that the personal meanings that we attribute to our experience are acquired and validated through human interaction and communication" (p. xi). This is not to be confused with what von Glasersfeld (1996) terms "trivial" constructivism which maintains that a "child does not appropriate adult knowledge in one piece and therefore has to construct it bit by bit" (p. 307). Yet neither is it completely reflective of "radical" constructivism that "drops the requirement that knowledge be 'true' in the sense that it should match an objective reality. All [radical constructivism] requires of knowledge is that it be viable, in that it fits into the world of the knower's experience, the only 'reality' accessible to human reason" (p. 310). Though the distinction is probably more a matter of degree rather than substance, social constructivism is closer to Mezirow's use of the term. "Social constructivism regards individual subjects and the realm of the social as indissolubly interconnected. Human subjects are formed through their interactions with each other (as well as by their individual processes)" (Ernest, 1996, p. 342). The accompanying metaphor for this brand of constructivism is "persons in conversation" (p. 342).

Mezirow's emphasis on human interaction and communication is based on

Jürgen Habermas' (see Habermas, 1971) theory of knowledge interests. Mezirow adapts Habermas' ideas about the role of discourse in adult learning. Discourse is not simply the routine use of speech in daily life, but rather is a form of dialogue in which the validity of ideas is addressed as problematic and an attempt is made to reach consensus. Under optimal conditions of rational discourse, participants would:

- have accurate and complete information
- be free from coercion and distorting self-deception
- be able to weigh evidence and assess arguments objectively
- be open to alternative perspectives
- be able to become critically reflective upon presuppositions and their consequences
- have equal opportunity to participate
- be able to accept an informed, objective, and rational consensus as a legitimate test of validity (Mezirow, 1991, p. 77)

Though these conditions are seldom met, participation in discourse would *ideally* help adults become critically reflective of their meaning perspectives and hence arrive at more inclusive, differentiated, permeable, and integrated perspectives. In response to postmodern and feminist critics, Mezirow (1998) clarifies his conceptual development of rationality, reason assessment, and critical reflection.

> Transformation Theory maintains that human learning is grounded in the nature of human communication; to understand the meaning of what is being communicated—especially when intentions, values, moral issues,

> and feelings are involved—requires critical reflection of assumptions....Transformation Theory does not hold that critical reflection and rational discourse represent some transcendental version of the eternal verities or are of an order of reality that transcends the empirical world of change, but *simply that they have been found to work better* in more circumstances than have other options (p. 188).

He maintains his stance of rationality, but presents it as situated in time and culture.

Mezirow also adapts Habermas' three areas of human interests in knowledge generation: technical, practical, and emancipatory. The technical domain deals with instrumental learning, i.e. manipulation and control of the environment, and may be addressed through empirical tests. The practical domain deals with communicative learning, i.e. understanding others and making ourselves understood, and is seldom given to empirical testing. Validity rather than truth becomes the goal. The emancipatory domain deals with identifying and challenging distorted meaning perspectives. Mezirow contends that emancipatory, reflective learning can be involved in both instrumental and communicative learning.

Transformation theory yields four forms of learning: 1) learning through existing meaning schemes, 2) learning through developing new meaning schemes, 3) learning through the transformation of meaning schemes, and 4) learning through the transformation of meaning perspectives. Reflection is the catalyst for all forms of learning and generally takes place within the context of problem

solving. Content and process reflection can lead to a change in our meaning schemes—a common occurrence. Premise reflection can lead to a change in our meaning perspectives—a less common and more significant type of learning. Perspective transformation may occur through an accumulation of meaning scheme transformations or it may occur suddenly as the result of a "disorienting dilemma" (Mezirow, 1994, p. 229). Reflective learning involves a critique of assumptions, and when those assumptions are found to be invalid, reflective learning may become transformative.

Mezirow's transformation theory addresses the philosophical issues discussed earlier. It is holistic, contextual, and transformative. It recognizes the interplay between the learner and the environment; it recognizes that learning is embedded within the learner's prior experience; and, it recognizes the potential of the learner to transcend the present self and gain a more integrative, permeable, and inclusive point of view. It is at this point that I bring critical mathematics education to the scene. It is desirable for developmental mathematics students both to transform their present mathematical selves *and* to see mathematics in its broader, social context.

Critical Mathematics Education

Marilyn Frankenstein and Arthur Powell have been primarily responsible for the introduction of critical mathematics education in the U.S., particularly in the developmental setting. Frankenstein (1987) applies Paulo Freire's work to mathematics education and delineates how teachers in the U.S. can use ideas

originated in a very different culture. Foremost is the focus on problem-posing in contrast to problem-solving, intended to involve students in dialogue and coinvestigation with teachers.

> Freire's theory compels mathematics teachers to probe the nonpositivist meaning of mathematical knowledge, the importance of quantitative reasoning in the development of critical consciousness, the ways that math anxiety helps sustain hegemonic ideologies, and the connections between our specific curriculum and the development of critical consciousness. (p. 189)

She concludes the article with suggestions for what this type of curriculum might include, e.g. analysis of statistics regarding social issues and applications of percent. Teaching methods could include analyzing error patterns, keeping a mathematics journal, students peer teaching, and students working in groups.

Frankenstein and Powell (1989) relate the concepts of a critical mathematics education to non-traditional college students. Many non-traditional students come from groups in society that have been systematically denied equal opportunity in education. Often these students have had less than positive experiences with their previous educational encounters. Misconceptions and beliefs about mathematics acquired in primary and secondary schools further reduce their chances for success in mathematics. In addressing the ideology of approaches to remedial instruction, the authors contend that neither an instrumental ideology nor an interaction ideology are adequate to address the needs of non-traditional students. Instrumental ideology produces teaching

methodologies that atomize content and strip it of any context. The focus is on prediction, efficiency, and control. Its crudest expression is in methods which concentrate on mechanical proficiency and rote memorization. Interaction ideology is reflected in teaching methods that intend to reduce math anxiety, to individualize instruction at the student's own pace, and to engage in problem-solving that stresses process over product. While this humanistic approach is an improvement over the traditional instructional strategies, it omits a critique of the uses of mathematics and fails to equip students to engage in such a critique.

A critical ideology supercedes both the instrumental and interaction ideologies. It sparks teaching methodologies that are dialogic and that create opportunities for students to reflect more deeply on the role of mathematics in society. The authors suggest strategies that will facilitate critical interpretation and reflection including group work, multiple-entry logs, free writing, and journals. Frankenstein (1990) continues these ideas in a critical mathematical literacy curriculum she developed that "focuses on using statistical data to reveal and explode all the...myths that are slipped into our lives" (p. 336). In addition to the ability to ask basic statistical questions in order to deepen understanding of particular issues, she maintains that critical mathematical literacy "involves the ability to present data to change people's perceptions of those issues" (p. 336).

Frankenstein and Powell (1994) broaden the theoretical base of critical mathematics education by relating it to the field of "ethnomathematics." This field asserts that there is no universal mathematics. It seeks to illuminate the cultural aspects of mathematics and its uses. To make mathematics education a

liberatory act, educators should account for subjectivity and should be sensitive to the impact of various cultural inclinations for doing and learning mathematics. The authors maintain that the significant contributions of an ethnomathematical perspective are 1) reconsidering what counts as mathematical knowledge, 2) considering interactions between culture and mathematical knowledge, and 3) uncovering distorted and hidden history of mathematical knowledge.

Skovsmose (1994) makes an initial attempt to develop a philosophy of critical mathematics education. He begins with a general interpretation of what critical theory is. He states that

> to be critical means to draw attention to a critical situation, to identify it, to try to grasp it, to understand it, and to react to it....A critique of ideology is directed towards certain belief systems and attempting to do this in a theoretically based and more organised way is what characterises a critical theory (pp. 16-17).

Interestingly, his writings fit well with the New Science discussed earlier. Skovsmose maintains that crises may interact making prediction of consequences impossible. "Emancipation" should to be used cautiously, for solving one crisis may create, or at least affect, another. "We do not face calculable consequences but structures of risk, and these structures may interact in the future in unpredictable ways" (p. 20).

What Frankenstein (1990) referred to as "critical mathematical literacy," Skovsmose (1994) refers to as "mathemacy." Mathemacy need not be a direct correlate of literacy; the question is simply, how does mathemacy fit into the

development of critical education? Skovsmose maintains that education should help develop democratic attitudes and the competencies needed to participate in a democracy. He further maintains that mathematics has formatting power in society. Mathematics becomes transformed from a formal structure into empirical and social realities. "Mathematical models become guidelines for our design of our world and, therefore, they become not only descriptive but also prescriptive" (p. 55). For example, we cannot "subtract" mathematics from our current warfare or from our tax system, etc. Mathemacy, therefore, becomes an important tool of democracy because it enables one to engage in a critique of mathematically informed social and political realities. Without critique, mathematics education becomes socialization of students into a technological society and virtually eliminates the possibility of developing a critical attitude towards that society. Granted, technological knowledge is necessary, but it is not sufficient; a critical stance also requires a reflective knowledge.

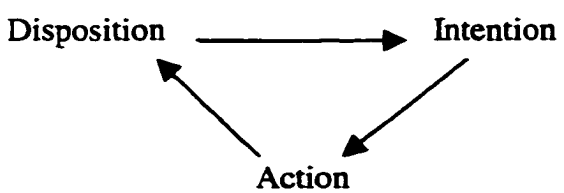
Movement from technological knowledge to reflective knowledge, however, is not an automatic process. Challenging questions are required to prompt this movement in students. Skovsmose develops six entry points into reflective knowing and frames them as the following questions:

1. Have we used the algorithm the right way (correct answer)?
2. Have we used the right algorithm?
3. Can we rely on the result from using the algorithm?
4. Could we do without formal calculations?
5. How does the actual use of an algorithm, appropriate or not,

affect a specific context?

6. Could we have performed the evaluation in a different way? (p. 120)

Action is a crucial part of Skovsmose' philosophy of critical mathematics education. He assumes an interdependent relationship between disposition (made up of an individual's history and present circumstances), intention (cause of action), and action (which modifies disposition). This relationship can be illustrated as follows:



He parallels this to learning, with the same three components involved. First, "disposition" is the totality of the learner (past, present, and future). Disposition is a complex mix of the student's background and foreground. Background includes the student's situation and social heritage; his or her foreground involves perceived possibilities for the future. Second, "intentions of learning" are the guides that lead the learner in a variety of directions. Intentions of learning might deal with matters of content but can also deal with such issues as pleasing the teacher, making good grades, or getting a job. Third, "learning as action" is learning that follows from *intention* to learn. Within Skovsmose' framework, the definition of action assumes intentionality, or the activity is nothing more than

reflex or habit.

"Learning as action" illuminates the process of critical mathematics education; critique is only possible as the learner assumes some responsibility for the learning process. Students must be given opportunities to investigate reasons and goals for suggested teaching-learning processes. Directed activity alone (typical of many mathematics classes) gives no heed to intentions of students; it contributes to the development of "underground intentions," e.g. be a well-behaved student, get top marks, be popular, etc.

> It is not only important that mathematics education provides the opportunity to understand essential features of society and the role of mathematics, but also that different intentions of the learning are negotiated and shared, and that the students in this way become actors of the learning process—and not blind passengers. (Skovsmose, 1994, p. 192)

The Framework (not the container)

This literature, together with my own experiences in developmental mathematics education, piques my interest in the complexity of learning, and particularly the complexity of learning mathematics. If knowledge is constructed and if that construction is based on prior learning experiences, developmental mathematics students have some needs that other learners do not. Cross (1993) states that learning is not simply an additive process with new learning being added to existing knowledge. Rather it is "an active, dynamic process in which

the connections are constantly changing and the structure transformed" (p. 4). She further states that "developmental educators can see, perhaps better than anyone else, that in order for new learning to take place, it has to be related to what the learner already knows. For developmental students existing knowledge is poorly organized and distressingly sparce" (p. 4) [emphasis added].

The constructivist literature in mathematics learning theory discusses the need to address conceptions that have not been viable in the experiences of the learner (von Glasersfeld, 1996). Developmental mathematics students, though, have maintained such conceptions for years. The negative feedback loops of the teaching-testing-reteaching paradigm, intended to cull out the small inadequacies in mathematical knowledge, were not successful with these students. Rather, those inadequacies fed back on themselves so that the mathematical meanings of our students are malformed and provide a structurally unsound foundation for future learning. They have mathematical meaning perspectives and meaning schemes that are distorted and prohibit more integrated, permeable, and inclusive views of mathematics and the power it affords.

Besides the distorted epistemic meaning perspectives and schemes about mathematical knowledge that students bring to the developmental mathematics classroom, they also often bring distorted psychological and sociolinguistic meaning perspectives and schemes. In expanding the affective dimension of psychological meaning perspectives, Cranton (1994) makes an observation particularly appropriate to developmental mathematics students:

A learner may lack self-confidence in her ability to succeed as a result of

past educational experiences. Perhaps she failed courses, was criticized extensively by a teacher, or was simply studying a subject that was inappropriate for her abilities or nature. This learner will have distorted assumptions about her ability to succeed as a learner. (p. 39)

Furthermore, developmental mathematics students often have accepted their role as passive receptacles of information, even to the point of resisting active approaches to learning. They believe education is an individual process so that group interaction is often seen as dishonest or unethical. Within transformation theory, learning is viewed as being guided by a habitual set of expectations. Students only have the opportunity to learn what their meaning perspectives allow them to learn. Until foundational ideas about what mathematics is, the mathematical self-concept of the learner, and societal definitions of the role of mathematics are called into question, developmental mathematics students have little opportunity for transformative mathematical development.

Mezirow's transformation theory deals with learning, but it goes one step further than traditional learning theories; it adds a critical dimension to learning that is supposedly unique to adults. I recognize that traditional pedagogy has constricted critical awareness in children and adolescents and that by introducing discourse at an earlier age, critical abilities might be fostered. Children, though, are still in the process of constructing their meaning schemes and perspectives, and the point of transformation theory is that schemes and perspectives already in place can be transformed. This can only be done by content, process, and premise

reflection.

This is where critical mathematics education enters the scene. Its purpose is to help students question their underlying assumptions about mathematics. Literature on the beliefs of developmental mathematics students has tended to focus back on mathematics—treating it as a closed system. Skovsmose (1994) suggests the existence of a "web of interrelationship between the types of knowing" (p. 123) and contends that traditional education has served to destroy the web by ignoring reflection and by promoting mathematical knowledge as self-contained. This undermines the critical potential of mathematics education. Critical mathematics education "tries to criticize authentic, real-life applications of mathematics" (p. 141) demonstrating the interactive nature of mathematics with the broader environment.

Critical mathematics not only empowers students to see the contextual nature of mathematics, but also empowers students in the teaching-learning process. Students make their own learning process an object of reflection, and they negotiate and share different intentions of learning. In this way they become "actors of the learning process—and not blind passengers" (Skovsmose, 1994, p. 192). This of course requires relinquishment of many aspects of traditional instructor roles. Cranton (1994) describes three types of educator power: (1) position power (inherent in the role), (2) personal power (friendship, charisma, loyalty), and (3) political power (ability to influence decision-making processes). In reformist-oriented education, the educator relinquishes position power but maintains personal and political power.

When "'trying harder' in old ways does not work, ...we become compelled to redefine the problem" (Mezirow, 1990, p. 144). If we accept the tenets of transformation theory and of critical mathematics education, the role of educators becomes that of helping students "redefine the problem." Mezirow (1991) delineates the responsibilities of adult educators as 1) actively fostering learners' critical reflection, 2) establishing communities of rational discourse, and 3) helping learners learn how to take appropriate action resulting from transformative learning. Cranton (1994) describes the role of the educator as "provocateur." This is "one who challenges, stimulates, and provokes critical thinking" (p. 128). The focus moves from simply trying to teach mechanical procedures to helping students dig to the very foundation of their mathematical expectations.

A final thought is that developmental mathematics students can be paralleled to the dissipative structures in the New Science. Many are "at equilibrium" because of their rote conceptions of mathematics; they do not attempt any exchange with their mathematical environment and therefore experience only disempowerment. Others are "near equilibrium" and are ready to add to their existing knowledge, but their controlled exchanges with the environment allow only for cumulative, linear growth rather than transformative growth. The goal of this project, however, is to encourage a "far from equilibrium" state in the learners and explore the events that happen at the "edge of chaos" (Waldrop, 1992).

CHAPTER 3

RESEARCH DESIGN

The purpose of this research project was two-fold: to construct theory regarding what it means to be critical in developmental mathematics education and to give participants the opportunity to engage in praxis. As such, a qualitative approach was appropriate. Design of a qualitative study, particularly one with a critical nature, is somewhat ambiguous. Qualitative inquiry is "emergent" in that it is not possible to know enough ahead of time to develop a specific design (Borg & Gall, 1989). "It is not that qualitative research design is nonexistent; it is rather that the design is flexible" (Bogdan & Biklen, 1992, p. 58).

The influence of the literature in the previous chapter was not limited to providing focus for the study. It also impacted the methodology of the study. An interest in complexity, in process over product, and in becoming rather than being requires a methodology that can attend to such matters. Qualitative research is descriptive and is concerned with process rather than product. Qualitative researchers "seek to grasp the processes by which people construct meaning and to describe what those meanings are" (Bogdan & Biklen, 1992, p. 49).

Some qualitative researchers hope to empower their research informants. Action oriented or critical researchers seek to change some aspect of society. In such case, the role of the researcher is that "of a facilitator who works collaboratively with research participants" (Glesne & Peshkin, 1992, p. 11). Lather (1991) maintains that in critical research "we consciously use our research to help participants understand and change their situations" (p. 57). The initial

intent of this project was for developmental mathematics students to become more aware of their situation and of societal and educational structures that have contributed to it. Furthermore, it was the intent that the students would act on this awareness to create a more equitable situation for themselves and others. "The goal of emancipatory research is to encourage self-reflection and deeper understanding on the part of the researched at least as much as it is to generate empirically grounded theoretical knowledge" (Lather, 1991, p. 60).

Participants

Participants in the study were sought from developmental mathematics students at a small, rural community college in southwestern Oklahoma. The town in which the college is located has a population of about 25,000 and serves as the economic and educational hub for several surrounding rural counties. The primary influences regarding culture, economics, and politics are agriculture and the military. These two entities conjoined provide an interesting mix between stability, with influential farm families who have lived in the area for several generations, and diversity, with Air Force families from all over the United States moving in and out of the area on average of every three years.

The major division between military personnel is based on educational level upon joining. Officers are those who go into the Air Force with at least a bachelor's degree, while enlisted personnel have a high school diploma but do not have a college degree. Enlisted members of the Air Force and military dependents make up approximately 20% of the student population at the

community college. Enlisted personnel take advantage of the opportunity to attend college because the Air Force pays tuition and books and because college courses and degrees "look good" at promotion time.

The college serves a large number of at-risk students. At the time of data collection for this study, seventy-seven percent of degree seeking students were first generation college students. Fifty-three percent were classified as low income, and twenty-two percent worked forty or more hours per week (Western Oklahoma State College, 1997). Reflecting the trend of a greater proportion of students requiring remediation in mathematics, in a recent year, seventy-four percent of incoming freshmen were deemed in need of developmental mathematics coursework (Western Oklahoma State College, 1996). Of those passing a remedial mathematics coursework sequence, 55% eventually completed a college level mathematics course (Western Oklahoma State College, 1998).

The college has traditionally followed the philosophy and practice of student remediation rather than student development. If students test below 19 on the ACT in any content area, they are given secondary testing to determine remedial course placement. Remedial mathematics courses at the time of the study included Beginning Algebra which involves integers, linear equations, and polynomials, and Intermediate Algebra which involves graphing linear equations, working with rational expressions, and solving quadratic equations. The college has since added a course in basic mathematics.

In selecting participants, I utilized purposeful sampling (Bogdan & Biklen, 1992) in that I chose participants who seemed to have the most potential for

facilitation of expanding theory. I visited six sections of Beginning and Intermediate Algebra taught by four different instructors at various time slots, and, after a brief introduction to the purpose and method of the study, invited students from those classes to participate. I gave each student an "invitation" and questionnaire to complete (see Appendix B). I returned to the class during its next session to collect questionnaires from those interested in participating. Out of approximately 20 potential participants, I narrowed the field to nine because of time and resource constraints and because I was more interested in depth than breadth. Shortly before the first interviews began, one participant dropped out of the study because a temporary duty assignment with the military took her out of the area. After the first round of individual interviews, another participant was given a temporary duty assignment that prevented his further participation. The remaining seven participants consisted of four women and three men.

As I examined the questionnaires to select participants I relied on the demographic information they gave as well as their responses to the questions concerning their views of mathematics and their reasons for wanting to participate. Because there is no "typical" profile of developmental students, I sought diversity among the participants. I also sought those whose answers to the final two questions on the questionnaire indicated their willingness to engage in reflection and critique. For example, one participant, later to be introduced as Zach, gave a metaphor for mathematics that captured my attention. He said that doing mathematics is like

> *pushing a cart uphill. If you don't keep going forward, you might slide*

back. If you don't keep learning or using it, you might forget what you've learned.

His reason for wanting to participate in the study indicated a willingness to examine his (and others') assumptions and a desire to proactively address his frustration with academic mathematics.

I like to express my opinion in things that frustrate me. This is one subject I don't understand why they don't show real-life application.

This will help in understanding and being able to retain what you learned. (and understand why we need it)

Finally, I selected students from a variety of class times and instructors, but, because of ethical considerations, did not include my own students. Though the critical mathematics literature cited in the previous chapter advocates research collaboration between teachers and students, this particular project was initiated to advance my own interests, i.e. to complete my graduate degree. I wanted none of my students to feel compelled to participate either out of obligation to me or out of fear of reprisal. Further, I wanted the participants to feel free to express their opinions without feeling the need to "please the teacher." Dismissal of position power (Cranton, 1994) is much easier said than done.

Method

Research methodology of a critical project is dialogic and transformative (Comstock, 1982; Guba, 1990; Mezirow, 1990). Participants must have an opportunity to voice opinions, feelings, thoughts, and ideas and an opportunity to

interact with other participants to validate new theories and to uncover distorted perspectives. While designs can be more or less participatory, some degree of dialogue is necessary to protect the research from the researcher's enthusiasms (Lather, 1991). Furthermore, Lather calls for reciprocity in emancipatory research projects. She makes the following suggestions which were included in this study:

- Interviews conducted in an interactive, dialogic manner that requires self-disclosure on the part of the researcher...
- Sequential interviews of both individuals and small groups to facilitate collaboration and a deeper probing of research issues...
- Negotiation of meaning...through recycling description, emerging analysis and conclusions to at least a subsample of respondents. (p. 60)

Additionally, most studies and articles involving beliefs about mathematics utilize writing as a means of reflection. Koch (1993) contends that writing provides a way for students to demonstrate and confront misconceptions. Frankenstein and Powell (1989) advocate the use of writing as a means of articulating critical interpretation and reflection.

After participants were selected, they were asked to reflect on and respond in writing to the following: 1) What do you think mathematics is all about? 2) Describe yourself as a person, and 3) Describe yourself as a person doing mathematics (see Appendix C). The purpose of this exercise was to initiate the process of reflection and to give us a starting point for discussion.

An initial group meeting was scheduled for all participants; the meeting

provided an opportunity for the participants to become acquainted and to get a feel for the research project and its intent. As recommended by Morgan (1997), we started with an "ice breaker" question (Describe yourself as a shoe) and provided each participant an opportunity to speak. Both they and I told a bit about ourselves and shared our views of mathematics. We scheduled individual interviews, and I asked them to begin keeping a journal of thoughts related to the study; in particular, I asked them to begin with a mathematical autobiography—to reflect back on memories of mathematical experiences throughout their education. They in turn had questions for me. Some questions regarded my purpose for doing the study while others regarded my doctoral program and experiences in graduate school. They also wanted to know if I had any influence on the selection of the mathematics textbooks because the ones in use were "way too expensive."

The first individual interviews (we referred to them as visits) were conducted in an open-ended format giving the participants a stronger role in defining the content and direction of the interview (Bogdan & Biklin, 1992). The beginning point of discussion was the mathematical autobiography of each participant, and this eventually led to other areas of interest and concern. The interviews were tape recorded and transcribed prior to a second round of individual interviews. This allowed for preliminary analysis and negotiation of meaning (Lather, 1991) within the second interview. The second interview was more structured than the first as there were specific questions and areas to explore based on the first interview for each participant. Individual interviews lasted from forty-five minutes to two hours and were usually ended because of a time

constraint rather than an exhaustion of the topic.

Following the second round of individual interviews, the participants divided into two groups based on compatibility of schedules. One group was composed of men, and the other group was composed of women, though separation by gender was not by design. A degree of homogeneity is desirable in group interviews (Morgan, 1997) to allow for more free-flowing conversations and to maximize the likelihood that participants will have something to say and feel comfortable saying it to each other. This proved to be the case for the women, but not for the men. The women seemed to relate easily to one another, but the air in the men's group interview was one of contention and competition. This was a surprising development because individual interviews conducted with the men were open and cordial and very productive. The dynamics of either the personalities of the men or the mix of a female researcher with a group of men, or both, made the men's group interview uncomfortable, though certainly not unproductive.

A final individual interview was held with all but two of the participants following the group interview. The purpose of this interview was to formalize their thoughts concerning the themes that had emerged throughout the study and to give the participants a chance to "debrief" regarding the group interview. One participant had suddenly moved from the area preventing this final interview and another was unable to schedule a time to meet with me. Both of these participants, though, submitted written answers to follow-up questions I mailed to them.

I asked each participant to keep a journal in which to record thoughts, insights, and reactions, but I gave them no pre-specified format in which to do this. The intent was to review these at each individual interview. However, one participant never wrote anything, and the others were quite sporadic about their entries. What they did write was valuable to the project, but they simply had little time between work, family, and school to spend writing in their journals. They also seemed to be unsure of "what I wanted." The lack of structure regarding what specifically to write about seemed to immobilize their efforts. This illuminated the difficulty in balancing structure with openness. In their journals as in their interviews, rigid "schedules" regarding what the participants should address restricts the scope of the research and funnels data into a researcher-determined container. Yet, too little structure can result in data that is shallow and without focus.

Trustworthiness

"Critical postmodern research respects the complexity of the social world" (Kincheloe & McLaren, 1994, p. 150) and as such rejects traditional notions of internal and external validity. "Trustworthiness" replaces "validity" because it is a better reflection of the philosophy of critical research. It implies a dimension of relation and ethics rather than an objective, value-free assessment of reality. Trustworthiness, not unlike validity in the traditional sense, is difficult to evaluate. Credibility for "accurate" portrayal can only be awarded by the participants themselves, yet the researcher might see issues not yet within the

consciousness of the participants (Kincheloe & McLaren, 1994). This paradox creates a dilemma for the critical researcher: in reporting only what the participants agree to, the researcher affirms the voice of the researched, yet also may participate in the reification of the status quo. In reporting issues the researcher sees but the participants do not, he or she identifies critical issues, yet denies the voice of the researched and asserts her/himself as the arbiter of truth. The paradox, though, does not eliminate the need to address issues of trustworthiness, it only magnifies the need for self-reflexivity and disclosure on the part of the researcher.

Issues of trustworthiness in this study were addressed first by multiple data collection methods. Group interviews in addition to the individual interviews provided a means for the participants to compare their own experiences with those of others and gain new insights into the issues being explored. Though the journals were not kept as faithfully as intended, they did provide a few of the participants with an alternative means of expression and encouraged reflection outside scheduled interview times. Multiple interviews with each participant also increased trustworthiness of the data. Through these interviews, participants had the opportunity to clarify or even recant statements made in earlier interviews.

A second issue that affects trustworthiness is researcher bias. Glesne and Peshkin (1992) call for a continual alertness to one's own biases and to one's own subjectivity. Lather (1991) calls for research designs that "demand vigorous self-reflexivity" (p. 66). Memo writing or field logs help the researcher reflect on issues and events as well as meanings and interpretations. In response to these

concerns, I kept a field log during the data collection and analysis phases. This field log is included as Appendix H.

Another issue relevant to trustworthiness is what Lather (1991) terms "face validity." It reflects that "ah, yes" experience of the participants as descriptions, emerging analyses, and conclusions are recycled back to them. I addressed this issue through multiple interviews. Participants were given opportunities to explore the issues of importance to them and then had the opportunity to critique analyses and ensure that my understanding paralleled theirs. Lather (1991) also proposes "catalytic validity" as a criterion for trustworthy critical research. This is "the degree to which the research process re-orients, focuses and energizes participants toward knowing reality in order to transform it" (p. 68). The purpose of the group interviews was not only to facilitate the uncovering of distorted assumptions, but also to help the students gain energy, confidence, and strength from each other. It gave them the opportunity to help one another voice issues that were difficult to articulate.

Analysis

"Data analysis is what researchers do to answer their particular research question(s)" (Langenback, Vaughn, & Aagaard, 1994). Miles and Huberman (1994) state that analysis actually begins with the design of the study through the choice of conceptual framework, of research questions, and of research procedures. These begin the broad process of data reduction by giving attention to certain types of data and systematically eliminating others. The design of this

study places it in the reform/perspective-seeking/qualitative portion of the conceptual cube developed by Langenbach, Vaughn, and Aagaard (1994). From this standpoint, my conceptual framework, research questions, and research procedures pointed to certain data and relationships. Though analysis could have taken many directions, my questions and framework kept my focus on critical issues for developmental mathematics students. I also began a preliminary type of analysis as soon as I read the responses to the participant questionnaire. It was from these questionnaires that I chose the participants of the study, which again was a type of pre-selection of the issues to which I would attend.

From a more traditional view of analysis, I accepted the advice of Bogdan and Biklin (1992) for beginning researchers by borrowing strategies from their "analysis in the field mode," and by leaving more formal analysis until most of the data were collected. Specific strategies for analysis in the field included beginning with substantive theoretical questions relating to the particular participants in the study before moving to formal theoretical questions. We began with substantive questions regarding their mathematical autobiographies and the role mathematics had played in their own lives before we moved to formal questions regarding a more general role of mathematics in the broader society.

Another strategy was to plan data-collection sessions in light of what was found in previous sessions. Interviews were transcribed and read for emerging themes. From these transcripts and entries in my field log, I went back to participants with themes that were emerging from the data for their further clarification and analysis.

Analysis after data collection involved developing preliminary coding categories, which consisted of approximately 25 different codes. From this, I defined two broad categories which are the major divisions contained in chapter 5. I sifted through the preliminary codes and placed them under one of the broad headings or, in some cases, eliminated them because they were not directly relevant to the direction of the study. I also referred back to a list of "codes," or constructs from the influencing literature. This highlighted some issues in the data that I had overlooked. Finally, I went back through the transcripts, cut them up by code, and placed them in a notebook divided by the two major headings. From this organization—and from frequent trips back to the uncut transcripts for context—I began the final writing process.

Lather (1991) contends that grounded theory (Glaser & Strauss, 1967) is somewhat different than the critical theory generated from praxis-oriented research. In grounded theory, theory follows from data whereas in praxis-oriented research, theory and data have a dialectical relationship. Critical research must illuminate the experiences of the participants while maintaining an eye toward false consciousness. This is also the central challenge to praxis-oriented research: "how to maximize self as mediator between people's self-understandings and the need for ideology critique and transformative social action *without becoming impositional*" (Lather, 1991, p. 64). Participants had the opportunity to critique the preliminary analyses, but I reserved the right to illuminate issues that I perceived the participants had not fully addressed.

As mentioned earlier, theory and data produced in the study were

interrelated with the literature. After having read through the data several times and having developed preliminary codes, I saw several areas of correspondence with Skovsmose' writings regarding critical mathematics education. An interplay existed in that Skovsmose was included among the literature that influenced the framework and design for the study and hence provided focus for questions and issues to explore—an *a priori* role. Yet it also served to illuminate issues that I had not thought of before data collection and to deepen my level of understanding of those issues I had anticipated—an *a posteriori* role. Mezirow's transformation theory also played a key role in analysis with its focus on content, process, and premise reflection and on critical theory. While the specific role played by these two frameworks will be developed in chapter 5, a possible role as "container" must be considered. Did I see the issues reported in the remainder of this study because I set myself up to see those issues? This, however, sets up a dualism that is unsupportable. The role of the literature, particularly Skovsmose and Mezirow, played a role *both* in data production and in data analysis.

Ethics

Bogdan and Biklen (1992) suggest four areas of concern as they relate to ethical practices in qualitative research. First, participants' identities should be protected to avoid harming them in any way. In the body of the text, pseudonyms have been used to protect the participants identities. Reflecting the participatory philosophy behind this research design, though, participants were given the option of including their real names in the forward of the dissertation or of remaining

anonymous (see Appendix D). All but one participant chose to be included. However, upon further consideration *after* data collection, I decided to use only their first names in the foreword of the study.

The second concern is treating participants with respect and asking for their permission to proceed. In this study, I gave each participant a form to sign explaining the tentative nature of the design, the intent of the study, the option of leaving the study at any time, etc. (see Appendix D). The third concern is to be clear about any agreements negotiated in receiving permission to do a study. I provided a written description of the study that included expected duration, facilities needed, and relationship to job duties to the Vice-President for Academic Affairs of Western Oklahoma State College and obtained approval to conduct the study (Appendix E). Permission was also obtained from the Institutional Review Board at the University of Oklahoma (Appendix F). The final concern involves telling the truth when reporting the findings—regardless of the outcomes. Though this particular concern seems so self-evident as to not need to be repeated, it was sometimes difficult to maintain. The temptation to use exaggerative words and to gloss over mistakes I made during data collection were quite disconcerting to me. I never expected that to be an issue at all.

Glesne and Peshkin (1992) discuss another issue related to the ethics of research. They use the term "reciprocity" to refer to what the researcher does to "reward" participants. Though this is most often assumed to be a monetary reward, they encourage the consideration of other "commodities" that are often a part of the research process such as listening to the participants stories, speaking

at the Rotary Club, etc. One researcher offered free mathematics tutoring to the participants in her study (Mau, 1993). Because of time constraints and my role within the institution, the most appropriate plan for this study was a monetary reward. I paid each participant an amount equal to half the general fees for the succeeding mathematics course (approximately $58). This amount was also consistent with the number of hours they spent in data collection activities (approximately 7). The participants received payment upon completion of the final individual interview. Rather than simply stating that they would be paid a certain amount to participate, I worded the offer in terms of future enrollment as an encouragement to continue with the succeeding mathematics course.

Considerations

> It is healthy medicine for researchers to make their preferences clear. To know how researchers construe the shape of the social world and how they mean to give us a credible account of it is to know just who we have on the other side of the table (Miles & Huberman, 1994)

In reading and interpreting this research report, the reader should consider my philosophy and approach to knowledge construction and the background information about the research process itself. Regarding philosophy, my choice of influencing literature (the New Science, critical adult learning theory, critical mathematics education) reflects a propensity on my part to question the status quo. Though I question it, I do not always reject it. I am somewhat of a moderate in that I seek the "middle ground" that Code (1991) refers to:

> A well-mapped middle ground offers a place to take up positions of strength and maximum productivity from which exclusionary theories can be tapped critically and creatively for criticism and reconstruction....It draws on the theoretical and practical resources that surround it to incorporate what is best in them and to reject what is damaging and oppressive (p. 318).

I reject dichotomous formulations of objectivity, politics, research, etc. as do the authors of the literature upon which this study is based.

I also approached this study as one steeped in academic tradition. For all the "questioning," I still automatically referenced standard academic lingo. I spoke in semester hours, credits, grades, tests, departments, and majors. Though I espouse the learning paradigm (Barr & Tagg, 1995), I reverted back to the teaching paradigm out of my own habits of thought (once again, dualism surfaces). As I read and reread transcripts, I saw the unconscious prompts in questions and comments regarding the established institution. I, in collaboration with the participants, was calling into question the environment in which I had excelled. Mathematics as an objective, value-neutral, context-free subject was enjoyable and rewarding for me as a student and became a career for me as an adult. So why did I choose to conduct a study in which I question a seemingly positive force in my life? The reason lies in the experiences of my students over the years; mathematics for them has typically not been enjoyable or rewarding nor has it been anticipated as a career. It has been a barrier. It was only through finally *hearing* the voices of my students that I began to contemplate our (both my

and their) limited, narrow view of mathematics and its effects.

Regarding background information about the research process itself, I ask the reader to consider the following. Because of a "surprise" addition to my family, the collected data sat untouched for about one year. Though an intervening year gave me lots of time to gain fresh insights, it prevented my return to the participants if I needed follow-up information. The final individual interviews gave me the opportunity to ask for conclusions, but, after getting back into the data, there were a few instances in which I wished I could have gotten a bit more feedback.

Qualitative studies are ideally completed when theoretical saturation has been reached (Glaser & Strauss, 1967). This study, not unlike other critical studies, reached a type of saturation, but not necessarily the type intended. The participants went through the reflection/questioning process, but most ended the study much where they began. Though I would liken it more to a spiral than a circle, it nonetheless indicates that either the reflection process was left prematurely or reflection yielded no reason to change perspectives—or that this study is a work in progress, and those small changes that form a circle into a spiral will continue to build on themselves and benefit the participants even after this research report has been placed neatly on the shelf.

CHAPTER 4

PARTICIPANT TALES

In this chapter I tell a tale (Van Maanen, 1988) of the seven developmental mathematics students who are the main characters of this study. The intersection of our lives produced a distinctive story that I am convinced could never be reproduced by any other characters or even by us. It was produced when these students were new to the higher education arena and were just beginning to "find" themselves educationally—and they "found" themselves in different places. Their individual characteristics, joined with the characteristics they saw in me, produced a relationship that produced the following story. They saw in me both a friendly face (Terri: "I told [my husband], Dana is not like a teacher, she's more like one of us.") and an institutional face (Kelsey: "You're the math teacher. You tell me.") In an interesting way, however, these two faces helped us maintain a balance between subjectivity and objectivity. Code (1991) purports that a balance between these two seemingly dichotomous positions actually creates "knowledge worthy of the label" (p. 28). Relational metaphors of knowledge construction, whether referred to as "second persons" (Code, 1991) or "persons in conversation" (Ernest, 1996), emphasize that our context profoundly affects what we come away from a research project "knowing." My connection with the institution kept us grounded in the purpose for our investigation, while the friendship connection we built allowed us to question that very institution without the participants fearing reprisal.

Knowing people does not negate the idea of knowing about them. It is

from that standpoint that I begin my realist tale (Van Maanen, 1988). It is realist in the sense that its overriding purpose is to present the meaning I have made of the conversations with the participants. However, I am neither naïve enough nor unreflective enough to assert that I am absent from or dispassionate about the "findings" of this study. "I" will appear throughout the study, not as an effort to center myself in the data, but rather as a reminder both to me and the reader of the role "I" played both in data production and interpretation. As set forth in the preceding paragraphs, I am well aware of my influence on the creation of this story.

The Participants

Brenda, Michael, Terri, Kelsey, James, Rachel, and Zach are remarkable people who seemed to willingly and openly share their ideas and beliefs. At this particular juncture, through a combination of choice and chance, they came together in developmental mathematics courses in a small community college in a rural community in a southwestern state. What makes this combination noteworthy is that Brenda is the only one native to the area. In this narrow window of time, persons from Mississippi, Texas, New Jersey, Illinois, Florida, and Oklahoma joined in a common venture—considering the role of mathematics in society. Why is there such diversity in a rural area? The town in which the community college is located is home to an Air Force Base. Every participant is currently or has at one time been connected with the military, either as active duty or as a dependent.

The ages of the participants ranged from 19 to 51. There was diversity in race: Caucasian, African-American, and Asian-American. Some had families; some did not. Some were excelling in college; some were not. The point is: though commonalties existed among the participants, the richness of the data sprang more from their individuality. They all had much to say about how they view themselves, how they view math in society, and how these two perspectives work together.

Terri

Most of the interviews with participants were held in my office or in a study room adjacent to my office. Both interviews with Terri, however, were held in the new library at my institution. Both were during afternoons in which the library was closed, so we had the place to ourselves. She seemed to enjoy getting away from the kids for a while, which was understandable since she has four children under the age of six. She started the study with only three, but delivered the fourth in October and went back to school four days later. That in itself says a great deal about Terri. She describes herself this way:

> *I am a very independent mother of 3.5 kids. I have been married for almost eight years. During the past eight years I have grown into a person who is confident, caring, and giving to others. Yet, I do have my tendencies to be selfish, but not too often. I like to plan everything because I hate the unexpected. I guess you can say that I am a bit of a control freak. If it wasn't for my husband I would probably worry myself*

to an early grave but he has helped me to look on the lighter side of everything. (TJ.1)[*]

Terri says she has certain ways she does things and certain places for everything. It drives her crazy when people put the toilet paper upside down. She has certain ways of folding clothes and washing the dishes. She likes to have her way, and is not afraid to speak her mind.

Terri is 28 years old and is married to a person in the United States Air Force. She grew up in an upper middle class family in which both parents had college degrees. Her father is American, and her mother is Vietnamese. Her father was in the military and met her mom when he was in the Vietnam war. She describes both herself and her parents as materialistic. As a teenager, she would throw violent temper tantrums if not allowed to do something she wanted to do. She had no responsibilities, no chores. Her entire responsibility in life was going to school and making grades. She says that her parents were very materialistic, but her husband and his family helped her see that there are more important things in life.

You wouldn't have caught me dead in a Wal-Mart or a K-Mart. If it didn't come from the mall, you didn't need it. That was my outlook on life. [My husband] was just the opposite. His family worked; my parents buy you everything. ...I remember meeting Mark's grandparents for the first time. I had never eaten beans and cornbread. They said they used to eat that when they couldn't afford meat. I had never really met anybody who had

[*] See Appendix A, p. 191, for an explanation of data citations.

not had steaks. It just really shocked me. I learned to crochet; I just enjoyed this hands on stuff. Where I was raised, if you want it done, pay to have someone do it for ya. That was how I was raised. [My husband] just made me realize that there's more important things in life than what you wear, what kind of car you drive—which I love nice things! (laughs) (T1.31)

Terri says she was an exceptional student and, in fact, was an honor student in junior high and high school. She began school in Michigan and completed the 8th grade before her family moved to Texas. Moving from a northern to a southern school, at the crucial time of starting high school, was very difficult for her. Friendship circles had already been formed and she felt like an outsider. She hated Texas, and she rebelled. This combined with a constant pressure to perform led her to drop out of school in the middle of her junior year.

I think because of my parents putting so much expectations on me, because in high school I took a full load. I took Algebra I, I took Geometry, Algebra II. I was in Chemistry when I dropped out. I was taking a lot of the classes that I really didn't have to, but I took because my parents expected it of me. I think my parents put so much limitations on me, I didn't have any freedoms and I rebelled. And the way I rebelled was "you want me to go to school; you want me to do this and that. My way of hurting you is I'm not gonna go to school." (T1.12)

My teachers really tried. I know I had a couple of teachers who were like, we know you can do this. I just didn't want to. I had had too many years

of just being pushed academically so far. (T1.23)

She moved away from home and in with friends. About a year and a half later, she married and intended to go back and get her G.E.D., but she and her husband started their family and life took over. About a year ago "*something clicked inside*" and she decided to get her GED.

> *How am I supposed to expect my daughter, my kids to go to school and to do well if their mother hasn't even graduated? I thought, you know, I am such a hypocrite. I thought to myself, well, I've got to do something. I think because [my husband] had started going back to school last year, I felt us going down two different roads. You know, I'm talking at a five-year-old level, and here he is coming home wanting to talk to me about school and we just weren't really clicking. (T1.13)*

Terri has concerns about whether she will experience success in college and, more particularly, in mathematics. The interviews for the study were conducted during her first semester in college and she was experiencing a lack of confidence in her abilities, still not quite sure if she belonged. She says

> *coming back to school after acquiring my GED after being out of school for ten years was a real accomplishment. I thought it would take a while for me to study and test for the GED but to my amazement, I had retained more schooling than I had really thought. When I tested at [the college] with their placement test I was already anticipating being told that I had to take at least beginning algebra. I was really amazed that I had done well enough to enroll into intermediate algebra and with only three more*

points I could have gone straight to college algebra. Only problem was—

I didn't know if what I answered was knowledge or just plain luck. (TJ.2)

She consistently refers to her fear and hatred of mathematics while following up with a comment about how she is doing well in her classes. Two consecutive journal entries illustrate this.

Entry A: I am really dreading chapter five. Rational exponents and radicals. Those words scare me. I think this is where I am going to have the most trouble.

Entry B: So far so good with chapter five. (TJ.3)

Despite her fears, she says she has done fairly well, but that the anxiety and frustration are always there making her doubt everything she does.

One major source of frustration is inconsistency. At several points during the interviews she expresses her confusion over different expectations in what is supposed to be the same course.

So here I am, I learned it this way, but now this teacher won't accept that; he wants it done this way. And I think that that is where you get a lot of confusion, fear, because you don't know what to expect. (T2.4)

Not surprisingly, Terri views math as nothing more than rules and formulas and balancing a checkbook. She has no idea why she is learning algebra, but *"apparently somebody higher up feels that we need to know it." (T2.18)*

Another source of anxiety and frustration relates to her mom. She feels intimidated because she did not "inherit" her mom's skill for mental calculation—a skill Terri attributes to her mom's Asian background and education.

The first time I remember really hating math was in the seventh grade. It was my first year out of elementary school and boy was it a change! I had been an exceptional student for most of my academic life, so it was difficult to understand why I was having difficulty understanding algebra. My mother is Vietnamese, and if you think of all the stereotypes, one that stands out is how well they do in math. Well, my mother is no exception. She can figure out any problem in her head. I think that that has always made me feel very intimidated—wondering why I didn't inherit her math skills. (TJ.2)

Terri's major is still undecided. At one point she considered teaching elementary school but, after helping her daughter with schoolwork, decided she does not have the patience. She is beginning to enjoy computers, so she is considering engineering. She and her mother have thought about opening a catering business and small café, in which case she would want a business background. She also loves law, but says that lawyers are a dime a dozen. Her biggest frustration in trying to decide is the many stories she has heard from people who have a degree but work in a completely different field. She does not want to waste time by selecting the "wrong" field, and she is concerned about the job market. She has been told there are plenty of entry-level jobs, but she wants a job that pays well so she can support her family and send them to college.

Terri has other motivations for being in college and in the mathematics classroom.

If I put my mind to it, I can excel. I know I have no problem doing well in

school. It's just, do I want to put my mind to it? Is it that important to me? Right now it is yes, I want to excel. I want those A's. I want to make the honor roll. I want to be on the National Dean's List. (T1.25-26)

For me, even though I hate math, I want to learn math because I don't like feeling intimidated by anybody. It's like when I changed my degree plan to computer science, [my husband] was like "why do you want to do that?" He's in computer science. I think part of it is I don't want him feeling superior to me. There is no way he is going to make me feel bad; there is no way he is going to leave me back here. ...I don't know if I'm too much of an overachiever or if I just can't fathom the thought of someone knowing more. (T2.19)

Terri is a perfectionist and fears failure. She makes life miserable for herself until she knows her academic performance has met her goals. She wants to prove to everybody that she can get her GED, go to college, earn a degree, and have a good career.

I want to excel in whatever I do. I think that depends on the type person you are. For me, I was always raised in a family where unless you're the best at what you do—my mom has always excelled. My dad was always at the top of his class. It seems like everybody I've ever encountered has always been the top of their game. And that has pushed me. (T2.20)

Kelsey

Kelsey and I had our "visits" during weekday afternoons. As a house

manager at a shelter for battered women, her evenings were taken up with work while her mornings were taken up with school. She has worked at the shelter for about 5 years, and she plans to continue working there after getting her degree. She is a criminal psychology major "*because it sounds good.*" What she most wants to do is work with teenage domestic violence victims.

Twenty-four year old Kelsey is married and is the mother of two-year-old twins. She is currently taking Intermediate Algebra, though she says she knows she will not pass the class. She is taking it as a refresher and as a preparation to re-take it in the future for credit. During our visits, there were no lulls in the conversation as Kelsey really enjoys talking to people and in turn, enjoys drawing them into the conversation.

> *I've never been shy. I've always tried to be the center of attention, always wanting to talk and meet people. So I've never been shy, but I think, and still to this day, I have more of a problem wanting to talk, get out and make friends instead of concentrating more on my schoolwork. So that puts a big damper on learning (laughs). (K1.1)*

She says she wants to remain working at the shelter—possibly in a counseling role rather than as a house manager. She likes her work because she likes connecting with people.

> *I like to talk to people, and I like to figure out why people think the way they do and why they do the things they do. (K1.11)*

Kelsey's parents were in the military and as such moved somewhat frequently. She attended schools in New Jersey, Germany, and Oklahoma,

graduating from a school in Oklahoma. Her parents were very easy-going, not worrying much about her schoolwork. Kelsey did not worry much about it, either.

> *I can't do homework for long periods. An hour is pushing it for me, especially if I can't figure it out. Just forget it! Life's too short to stress out on things. Just move on. (K3.2)*

Kelsey sees the effect her parents have had on her outlook on life. She maintains that they spoiled her somewhat by always ensuring she had the latest in fashion.

> *It's good thing I was an only child because there would have been no way I could have had the stuff I had. I must have thought my parents were made of money because when the Cole Haans were in style a few years back, I had to have the Cole Haans and the Dexters and the Guess jeans and all of it. (K2.20)*

She also sees how her mom affected her concern with what people think and her self-consciousness.

> *My mom used to always say stuff like "Oh, you gotta get your hair brushed. If you don't get your hair brushed, the other kids are gonna think you're ugly. ...I wish she would have said stuff like "Oh, if you don't get a good grade, the kids are gonna think—" then maybe I would think "Oh, I've gotta get a good grade, the kids are gonna think—" (K2.23)*

She says that she has always listened a great deal to her parents. Her parents encouraged her to attend the community college rather than going away to a

university. Now two years has turned into four. After the twins were born, her mom tried to dissuade her from going back to college. Her mom's opinion was that Kelsey was married, had children, and had a job, so what was the point in going back to school? Kelsey says that this discourages her with her schoolwork, but she is going ahead with her college career despite her mom. She wishes she had had her parents' support from the very beginning—including high school.

> *With my parents it was no big deal. If I brought home an F, "Do better next time." It wasn't a big deal. You know, like some people get grounded because they bring home an F. All I would have to say was "Well, I really tried but I just couldn't get it." "Oh, well, as long as you tried, that's alright." ...I guess that's why school's so hard for me because I never had to prove anything when it came to school. I only had to prove stuff when it came to name brand clothing and stuff. (K2.25)*

Kelsey's concern with image pervades much of her life. She has little peace about her situation, seeing herself as somewhat of a victim of circumstance. Her pregnancy with the twins was unplanned and this has placed her on a path inconsistent with the one of which she had always dreamed. She had planned to "*go to a real school and get into the sorority thing and have all these friends and do all the fun stuff." (K2.12)* She says she does not regret having the twins and being married; she just wishes she had done it later in life. She is having a difficult time sacrificing her romantic notion of how life was supposed to be.

> *Even if I went to a big school now, I would still have to live at home with my kids and my husband and still be this old fart that can't run around*

and party and have a good time. I guess I'm—I'm getting old and I don't want to. I should have just went off and had my fun at a college, whether I flunked or passed. I should have just went off and experienced that because now I'm regretting that I didn't, and I'm always trying to probably be something I'm not—like trying to be younger, trying to dress the hip teenage styles, and always wanting to keep up with that. If I would have had a chance to do that when I was that age, then maybe I wouldn't be wanting to do it now, and then maybe I could settle more into the mom and the wife type roles. (K2.14-15) ...I guess I just try to make my life kind of like something off of "90210" or "Party of Five" where it's just kind of perfect. The scene has to be great, so you have to be in the right kind of style, the right kind of atmosphere because everybody is watching you and what you do. (K2.21)

Kelsey's struggle with mathematics began in third grade. She remembers having a teacher who, if Kelsey did not understand something, would tell her not to worry about it and then would not explain it. Though Kelsey was unsure of the name of the program, she began during her third grade year going to an alternative classroom setting to spend more time on her math. When she was in 5th grade, her family moved to Germany and she remembers math class there being much easier.

Memories from secondary school include a 7th grade teacher who was "*cocky*" and who was frustrated with her lack of understanding.

If you didn't understand, he kind of made you feel like the other kids were

"God, she doesn't understand it." And instead of him being sympathetic, he just kind of went with the rest of the class. Not really made fun of you, but was like "Well, we don't have time to keep going over it, you know. It's time to move on." So I never really asked a lot of stuff in that class. (K1.4)

Kelsey's high school experiences were also less than positive. She replaced one mathematics credit with a vocational class—Allied Health Careers. She did, though, take Algebra I as a sophomore and says this of her teacher.

I don't know what if was, but she just did not like me for anything. Every time I would go to her desk, she would say—and she did this to all the kids—"It's in the back of the book; look in the back of the book." Well, the back of the book only gives you the answer. It doesn't give you how to do it. (K1.5)

Kelsey dropped this class but retook the course her junior year with the same teacher and passed the class. She says the teacher took time to explain it that second year.

Not surprisingly, Kelsey views mathematics as disconnected from human experience. She is a connected thinker and as such cannot imagine ever "needing" mathematics. After being asked about the role mathematics might play in her career decisions, she said

I think most people that are really into learning math or learning any subject for that matter, they are usually not as outgoing. They're usually more of an introvert and stay to theirself and study. ...You don't need

math on the outside world, really. You're going to be more of an introvert with math. You don't use it. You don't get out into society and start talking math (laughs). (KI.12-13)

During the study, Kelsey became quite discouraged about ever succeeding in learning mathematics. She blames herself for not studying more and for not paying attention in high school. In one of her last journal entries she states

School is so hard for me this semester. I have no idea what is going on in algebra. The teacher is great and does everything to help, but there is no help for me. It's like I am on an interstate highway and have no clue how to get to my destination point. I keep following the signs and reading the map, but the more I read, the more signs I see, the more lost I become. That's how I feel in algebra. The more I study, the harder I work, the worse I do. Have you ever been so lost somewhere and you just want to cry? Well, that's how I feel in algebra. (KJ.5)

Zach

Zach is a 33-year-old Beginning Algebra student. He takes classes part-time while working full-time in the Air Force in structures (construction). His dad was in the Air Force as well. He has been married for 11 years and has two little girls, one nine and the other five. He has been in his current assignment for 3 years, following tours in Omaha, Sicily, and Germany. He is undecided about his major, but for now is saying that it is applied science. He has also considered law, journalism, and teaching. His goal is a two-year degree because it *"looks*

good" for enlisted personnel to have at least an associate's degree when trying for a promotion to senior or chief master sergeant. Yet longevity in the Air Force is not really what he wants.

> *I'm getting out* (of the Air Force) *as soon as I get the chance to retire. I don't mean to be negative, but I've always wanted to try something different anyway. I've been in this a long time, and I think I should retire. But if they offer 15-year, I'm taking that. And even if they don't, the kind of overtime they expect you to put in for senior, I don't think it's worth it anyway. I've got a family life, and I work to live; I don't live to work. (Z1.5)*

Zach was not a particularly good student in school. There were extreme inconsistencies between his perception of his ability and his experience in the educational system.

> *I remember when I first started having problems in math, and they stuck me in one of the slower classes, special education or something....This was in junior high in the 8th or 9th grade. The class they stuck me in was so far behind that it was holding me back. So I think I would've been better off staying in the class I was in and falling a little bit behind rather than going back and doing stuff I had already done. (Z1.26)*

At one point, Zach was retested and heard he had done well and might be moved back to his original class. Nothing ever happened. When asked if his parents intervened, he said

> *No. My mom had me tested for LD, and I got stuck in another class that*

was just for learning disabled people. I guess that's what they called it, I don't know. Special education. It was a totally worthless class. The teacher would play games with you; we did silly stuff. It was demeaning because it labeled you, plus you didn't do anything in there and that made you feel worthless....I was learning disabled, but I can't remember if [my mom] ever told me. Part of it's hand-eye coordination and part of it's a type of dyslexia, but I can't tell you for sure. (Z1.27-28)

Zach is not particularly motivated to succeed in school. He laughed at his own thought of teaching as a post-military career because of his disaffection for school and studying. His inability to focus and *"sit still"* to study has cost him not only in school, but also in his job. He has had difficulty with the testing required for promotion to the rank of tech sergeant. In fact, this is one of the reasons he decided to take Beginning Algebra—to help prepare him for testing. It is hard for him to *"learn it just from a book."* The initial decision regarding his career path in the Air Force was also affected by his academic performance.

When I came into the Air Force, I was in electronic warfare. I was going to work on the material they used—like when planes are flying over and they are being shot at, they jam the missiles' radar so the missiles couldn't find them. I was going to work on it and fix it and find out what was wrong with it. That was gonna be my job, and this is what stopped it from being my job. I went to the tech school, and all we did was algebra for the first month.... I got like an 85, 90, 95 on the block tests (weekly tests), *but I was failing the evals* (daily evaluations) *because they didn't give you*

hardly any of the formula, and I couldn't remember how to put it together. I washed out of that after about a month. That hurt me bad. (Z1.10-11)

Zach also had some less than ideal study habits in high school. He describes himself as lacking responsibility and self-discipline. He made it through algebra with a D and says he barely made it through high school, having to take summer classes to complete his requirements. He confesses

I hardly ever did my homework, I didn't do good on tests and [my teachers] basically kind of let it ride. I mean, it was my fault. I should have been responsible, but I'm saying teachers need to send notes home to parents....I just told my mom, "No, I don't have any homework." She tells me now, "Wait until your kids tell you they don't have any homework. Don't believe them." (laughs) (Z1.28-29)

He does not blame his parents for not attending to his grades. He says they simply expected too little of him.

Zach views himself as an "excitable person" with a very high metabolism. He loves sports and seems very intense. He also likes to talk and act silly.

I embarrass my wife quite a bit. Last night we had our skating party for our kids to hand out trophies for soccer. I got out there with the kids. They were doing the YMCA thing. I was just acting pretty silly. I was out there one time doing something, dancing to the music. She just left the floor. (Z2.4)

He attributes some of his difficulties in school with his "pingy" personality.

I think I'm intelligent, but I have a real problem with school stuff. I've

been listening to the ADD stuff on Dobson. My wife feels real sure that I'm ADD or ADHD. I can't concentrate. I'll be doing my math homework, and I'm up 20 times in 10 minutes. It all depends on what I'm doing....If I'm into something, especially writing or even studying my PFE (related to promotion testing) *or on the computer, sometimes I can get into it and get going. Other times I just can't concentrate at all. I'll be thinking about something else. I'll read page after page and then realize I haven't been reading and I'll have to start over. That's frustrating. (Z2.4)*

Of particular importance to Zach are children. He has been teaching first grade Sunday school for the past three years. He coaches soccer and last year was the vice-president of the local soccer club. He says of himself

I think I'm really good with kids. I'm really good at encouraging. You see so many coaches yelling directions at them during a game. It's like, they're not hearing you. They'll hear you if you yell good. It's like my wife says, they're not going to hear specific directions. You sound like Charlie Brown's teacher—wa, wa, wa. (laughs) They're out there running around and if you yell their name and say 'good' or 'great job' or something, they'll hear that and that's going to motivate them—especially at the age I'm coaching. It's 95% encouragement and 5% directions.... I enjoy it. I enjoy seeing them do good. (Z2.5)

Zach's views of mathematics are an interesting mix of the black and white conception described by Buerke (1994) and a deeper, philosophical conception of the very foundation of mathematics. Zach tends to view mathematics as a

conglomeration of rules. He compares the rules of grammar with the rules of mathematics. He contends, though, that failing to use grammar correctly has a more negative connotation than failing to use mathematics correctly.

> *Dana: So when you hear somebody that speaks that way, what's your first thought?*
>
> *Zach: Less educated.*
>
> *Dana: When you hear somebody that says "I can't do math," what's your first thought?*
>
> *Zach: Agree. (laughter). I would just say yeah.*
>
> *Dana: But does it make you think less educated?*
>
> *Zach: Depending on the situation you're in. What were they talking about? What were they trying to do? If they were like "4 x 6" or if they were counting cartons and they knew how many was in each carton and they couldn't figure how many total, then I would think less educated. (Z1.19-20)*

Zach enjoys looking beneath the surface of issues. He is skeptical about issues in the news such as the suspicious nature of the death of the Shah of Iran and has often been told how perceptive he is. He extends this to an analysis of the nature of mathematics and the discovery/invention debate.

> *Zach: See, I don't think of math as a rule just that somebody made up. I think of it as rules someone had to figure out. That they were already there and somebody had to figure out—*
>
> *Dana: That's a big debate. In my classes, that is one of the things we*

debate.

Zach: I mean, you can do it; you can physically do it, so to me it's not rules, it's physics. Is that what laws of physics are? I don't know. But it's basically that if you do this, this is what happens. Natural rules or natural laws that are there, where if somebody put a formula or number or name to them, they were already there. (Z1.23)

Zach views mathematics as an innate ability, and this in turn affects his motivation to do mathematics.

Zach: Math is one of those things that either clicks for you or don't.

Dana: Do you think so?

Zach: It's like your machine either connects at that circuit or it doesn't. To me it does, because some of the people that are good at math are usually logical, too, and it doesn't even phase them. (Z1.13)

Dana: So describe somebody that is good at math. You said they're logical, what else?

Zach was reluctant to group people—even though his psychology classes said one could do that. With a disclaimer that there are exceptions to every rule, he stated that generally "math people" are

more logical, less creative. I don't know. I associate them with electronics and computers. I don't associate them much with working with their hands. As far as labor, definitely not. (Z1.14)

Rachel

Rachel is a 19-year-old student in Intermediate Algebra. She is a traditional student according to age and the number of hours she is taking, and "traditional" fits her well with the exception that she is a single mother of a 6-month old baby. Rachel lives with her parents and recently moved from San Antonio. Actually, she has moved a great deal in her life as she is a part of a military family. Her father is in the Air Force and has a college degree. Her mother has some college hours and is a stay-at-home mom. She has a younger brother who is still in high school.

At the beginning of the study, Rachel reported her major as secondary education with a minor in business. She had planned to teach business in a high school. As the study progressed, she changed her major to physical therapy. Even after this change, when asked what it is she most wants to do, she replies

> *For a while I really wanted to be a high school teacher, and I really would love to. I would love to teach business, but it has a lot to do with math. And I like math. That's fine as long as I don't have to do it every day and I don't want to have to do it as in-depth as they want us to. If I could add numbers, that would be fine. (laughs)...I'd really like to be a business teacher, but the math kind of bothers me. (R2.14-15)*

Rachel is a very social person and speaks often of friends from high school. During that time she was active in student council, band, clubs, and yearbook. She is acutely aware of the "hierarchy" common to most teenage circles. She says of her high school days:

I was not a cheerleader. I wasn't a nerd, but I wasn't a cheerleader. You know, you have to be in the pep squads or the dance teams, and you know, things....If you're not dating a football player, which I wasn't, then you're nothing. And I was in the band, you know. (laughs) (R1.9)

Rachel was not *"into"* school as a high school student. She took geometry 3 times and says that the first two times she took the class, she made A's the first semester and then failed the second semester. As it got closer to summer, she could not maintain her momentum. Ironically, she finally passed the course in summer school. It was during these two years that she was skipping classes to spend time with her boyfriend and was having family problems. She had little motivation to *"sit down and work a proof."* Even before high school Rachel was not interested in studying.

My mom, she used to padlock the door and bolt it down. (laughs) I couldn't come out. I guess it's just because I wanted to do so many other things that they wouldn't let me do—I didn't want a tutor because it was a dorky thing to have. I wanted a real cute one. (R2.11)

Rachel's earliest memories of school mathematics were in the 3rd or 4th grade when she was required to do timed multiplication drills. She says she *"hated being under the pressure."* At that point, she was in a private school in south Texas. She contends that part of the pressure was from her parents.

My parents were real demanding on my grades, so it's real hard. My dad's a straight A college student, which really upsets me (laughs) and then my mom—she's real good if she devotes herself, but she doesn't like

doing it either. So it's real hard because I'm always living up to my dad's expectations. Like, I got an 81 on my math test, my dad goes, "Well, now you know what you did wrong" and I'm "Well, can't you say thank you or congratulations or good job?" (R1.5)

Like Terri, Rachel complained of inconsistency in how she was taught to do mathematics.

The teachers, especially in math, had a certain way of teaching how to subtract or how to add. And then you would go to your parents and they would say, "No, you have to do it this way. This is the way I was taught; this is the way you need to do it." So then I would go back and then my teacher would count off because I wasn't doing it their way. Then I would go home with an F and get in trouble with my parents. So I ended up just really not liking it. (R2.11)

Rachel has an interesting relationship with her parents. In some ways the connection is very strong, but in some ways she wants to break free.

My mom went to school, but she didn't finish. She had my brother and I real young, and the fact that I'm now a mother and I'm going to school, and I'm doing things my mom did, I really see where she is and I don't want to do that. I don't want to be a housewife; I just don't want to do that. I want to have a career and a family....I mean I love cleaning and I love cooking—that's fine, but I can't do it every day. I think if my mom had actually gone and pursued her goals, even though she had kids—you can still do that, it's hard, but you can still do it—she'd be a lot happier

than she is now. (R2.13)

Rachel's father has been extremely demanding and authoritarian, but she contends that their relationship has improved.

> *I guess my dad expected a lot. He expected too much. That was a long time ago; he doesn't do that anymore because we've talked about it, and he understands. And now that he's not pressuring me, he asks me "Well, how are you doing?" But it's not "Let me see your work." Nothing like that anymore. That really helps. (R2.12)*

When Rachel tells more of her mathematical autobiography, she says she does not *"remember any of the good stuff."* She does remember, though, a succession of bad experiences with teachers. She spoke of the boring 8th grade teacher who taught from an overhead. She spoke of her freshman year mathematics instructor who did not care if they came to class and who allowed *"community effort"* on tests—she said he was retiring that year. Following her 8th and 9th grade years, her family moved from California to Texas, and she found herself behind in her mathematics skills. Following an unsuccessful attempt at geometry her sophomore year, Rachel says

> *I took geometry my junior year, and I started off with a teacher for one week. He had cancer so he had to leave and then we had substitutes and substitutes and substitutes for like a month. And then they finally decided to hire a part-time person and so she came on and she didn't know anything about geometry. She was just an algebra major, so she was kind of learning as we were all learning....She ended up working the whole*

year because my old teacher, he passed away. (RI.11)

On the second day of her senior year, she found out she was pregnant. She was enrolled in Algebra II and began having difficulty with the instructor. Though she was pregnant, he would not allow her to use the restroom. He also would not return her mom's phone calls. She failed the first semester with a 69 average. The second semester, she dropped Algebra II and took both semesters of "Math of Money"—the beginning part of the course at night and the ending part of the course during the day—so she could graduate on schedule. "Math of Money" paralleled a consumer mathematics course, including such topics as taxes, loan payments, check writing, etc.

When the study began, Rachel viewed mathematics as being

like a bad hair day. No matter how much I try to get it right, it never comes out the way it should. (RM.1)

Rachel's "mathematical story" seems to be improving, though. Regarding her current class she writes

[My instructor] is the first math teacher I ever really understood. His jokes are corny, but he makes class enjoyable. I am going to take College Algebra with him. I figure if he gets me to enjoy math, why stop? (RJ.1)

Michael

Michael is a 24-year-old African-American student enrolled in Beginning Algebra. He works as an electrician on the KC-135 airplane. His major is electrical engineering, though he concedes the strangeness of that choice because

he does not like math. He is married, has a two-month-old baby girl, and is a very proud father. He likes to produce music, particularly rap, heavy metal, and different kinds of rock. He does not consider himself a musical artist yet, but with more time invested and a move to a different area of the country, he will. Michael likes style.

> *You know, you look in style, you basically keep up with the times, what is going on today....You see a person that's dressed stylish, up-to-the-minute—not so much he might keep in touch with the news and stuff, but just like that person has something going for themselves. You know, they like to dress. They like to see other people that dress nice. It's kind of a fashion statement. (M1.17)*

As a teenager, Michael did not care about school. His father passed away when he was 16 and after that he lost motivation to do well. Though it has since improved, his relationship with his mother was very troubled during high school. He had a *"care less attitude"* and was concerned mainly with graduating and getting out of the state and away from his family. He went to a small high school and, being next to the youngest, was often compared to his older siblings. His sisters excelled in school, but his brothers were considered troublemakers. He and his brothers had different fathers and their father passed away long before his. He believed them to be jealous of the relationship he had with his father. He says they were very intelligent and could have done well, but they got in with the wrong crowd. Michael did not run with a crowd, but rather was by himself most of the time.

I had like one person. I never really hung out with any big group. I didn't like big groups. I was like the black sheep of my class. 'You guys go on and do what you want to do because I'm going over here to this town or that town.' So I didn't hang out with the people from the city I grew up in. I didn't like them too much. (M2.4)

Michael was *"kicked out"* of his General Math I class and subsequently put into an Algebra I class. He also was transferred from his General Math II class into geometry. In both cases, his scores indicated he needed more challenging work. However, he was *"kicked out"* of geometry for negative reasons.

Michael: My geometry teacher hated me. She couldn't teach. I wound up getting kicked out of the class.

Dana: What did you do the rest of the time?

Michael: I went to gym. ...She couldn't teach and I kept asking, I kept asking, I kept asking. And then she said, "You're stupid; you can't learn anything." And that's when I blew. ...I told her "You just don't know how to teach. Maybe if you had a clue or two you could teach this class." (M3.14)

He also was removed from general math the second day of his senior year. Again, he was asking questions that the teacher either did not or could not answer. When Michael was called stupid and a troublemaker, he retaliated verbally and physically.

Michael: Then I snatched him up. He was just yelling at me.

Dana: You did what?

Michael: I snatched him up. I grabbed him by his throat. I'm sorry, slang term. ...That was not right, but he was just all in my face and yelling, and I'm like 'You better get out of my face.' He was still yelling, so I just grabbed him and shook him. (M3.15)

Michael remained in study hall the rest of the year. As he retold these stories, he repeatedly said he wished teachers knew how much affect they have on students lives.

Some of them realize and they know they can help make or break a person's future and their self-esteem. Some of them just don't care. (M3.16)

Michael's memories of his K-12 teachers and most of his military instructors are very negative. His primary complaint regards their inability to answer his questions.

They couldn't teach to me. They really couldn't. I would ask questions and they would just repeat what they said or rephrase how they said it. "I can't tell you; it's just because." For me, some answers I can accept as just because. A lot of it with math and formulas, I can't accept that it's "just because." I guess that's why I didn't care for math because a lot of teachers didn't really care either. "I'm just here to teach; if you pick it up, you pick it up; if you don't, you don't." (M1.5)

He also perceived that most of his teachers did not really want to be teaching, and particularly not teaching him. He believed they regarded him as stupid and as not

worth the effort. He just wanted someone to show concern and try to help him understand.

> *If a teacher had actually said, "Hey, stay with me after class, and I'll show you. I'll try to explain to you the best I can, or I'll try to find somebody that can help you. I'll put it in terms you understand." I wouldn't have had a problem with it. I would have stayed. I think I might even would have enjoyed math. (M1.8)*

Michael believes that now he has much more control of his education. He can take his learning in the direction he wants to go. Even if he must *"take three steps back to go forward,"* that is what he will do.

Michael experienced a great deal of racism when he was growing up. When asked if that affected his *"care less"* attitude, he replied

> *Yeah. I was the darkest person in my class. Everybody else were light-skinned, or lighter than me.*
>
> *Dana: So you could tell a difference in the way the teachers treated you?*
>
> *Michael: Most definitely. Say I went down the hall and yelled down the hall. Then I would probably get suspended, whereas if a white guy went out there and yelled and cursed, they, "Hey, come in the office. You got detention." And that's it. (M2.6)*

He says that racism is just as bad in the military—particularly overseas. He contends that racism is worse in Oklahoma than it was in Mississippi.

> *It is so bad here. I'm the type person—I don't care. ...A lot of people around here will look at you like 'there ain't no way I'm going to give you*

a job.' Some people will give you a job. The job might not be much, but you have to do it sometimes. Break down and take what they can give you, like I had to do when I first got here.... Me and the owner got into it, me and the owner's daughter got into it, me and 3 or 4 of the managers got into it my first week here. But I wound up being the employee of the month the first month I was there. I just can't be lazy. I can't just sit in the house.... Nobody is owed anything in life; you got to earn what you get. My pop taught me that, too. (M1.23)

For all he has experienced, though, Michael has been able to turn the negatives into positives. He views himself as a good person who likes to help people. He has learned to control his temper and to recognize more appropriate ways to deal with people. In fact, he now considers himself easy to get along with. He believes that everything happens for a reason.

Dana: Is that a spiritual belief or a general philosophical belief?

Michael: That's spiritual. Everything happens for a reason. I was put here for a reason. I'm in this class, working with you for a reason. The way I figure it, I was helping better myself in math. (M2.6)

He has become a very reflective person, planning for the future.

I think about a lot of things. I think about my family and how some of my brothers and sisters live. I think about life a lot more. I take it more seriously now. I think about what could have happened and what would I do. I plan ahead. Like wills—I know a lot of people my age don't have wills. Took care of that already. If something happens to me, my wife will

be taken care of. A lot of people my age aren't thinking about that. They're living life and having a party. Been there and done that. I learned enough for a lifetime partying. (M2.16)

Michael's view of mathematics is one of pragmatism. He needs to know math for his two main interests: music production and electrical engineering. Growing up, however, he had very little use for mathematics.

Michael: There's a lot of math involved with a lot of the stuff I do. I just never really liked math.

Dana: Why not?

Michael: Math is just something that I never really used all that much, except counting money. Now, I did that. (laughs)

Dana: That's kind of important.

Michael: As far as outside, when I was younger, outside of school, I really had no need for math.

Dana: Not needing it doesn't make you not like it, does it? Or does it?

Michael: Well, it makes me where I could care less. Lacks-a-daze attitude toward math. That's why I never really liked math. (M1.3)

He sees a dichotomy between the use of mathematics in his career and the use of mathematics in school. When asked to talk about the contrast between the two he says

...I've designed a couple of circuits. We had to in school. And if somebody was to look at it, "Wow, that's neat. That's perfect," but the person that designed it knows that it has a flaw somewhere. This is the

way it is supposed to work, but it's not meeting your standards. So everybody sets their own standards on how something is supposed to work. Whereas the word problems, you have it right or wrong. (M1.19)

Michael's only "why" questions related to mathematics or mathematics education were how to do specific problems. He says he is understanding the material from algebra class and is taking steps to make sure he understands, such as buying a collection of cd's on mathematics, paying better attention, and reading. Though he still has little affection for mathematics, he views it as a step toward his goal of being an electrical engineer. He seemed to "come alive" as he described his passion for his chosen career field.

It's something I always wanted to do. Just like designing circuits and creating stuff. That's something that always fascinated me. To be able to be a part of that, to design some circuit or build a circuit for some plane and maybe even NASA someday. That really excites me. (M1.14)

Brenda

Brenda is 51 years old and is taking Intermediate Algebra. She is a cosmetologist full-time while taking college classes part-time. Her major is business administration, and her goal is to use her degree specifically in a medical facility.

Brenda married at 17 and moved to California. It was there that she got her GED and her cosmetology license. Between the ages of 17 and 23, she had four children, two of whom died as infants. Following a divorce, she moved back

to Oklahoma after 14 years in California. She eventually remarried. Life's difficulties continued to follow her.

> *My husband died in '89 and of course all the plans for retiring went up in the clouds. My job has no benefits. It's just money when you have it and you are self-employed. So I had to start thinking about me in the future and taking care of me. I had to begin some kind of a career change and get into a job that had some kind of benefits. I had a sister out here at the college. She convinced me that I needed to start back, so I did and it's been part-time since. Working and taking care of myself and going to school. I enjoy school. (B1.4)*

Brenda likes her job as a hair stylist and says she will miss it when she moves to business administration. She likes it because she likes people, but she knows she will do well in another career field.

She is the oldest of five girls and grew up in a very poor family. In fact, she quit school in the 11th grade so she could get a job. She had only one sister who graduated from high school, though that sister is now a registered nurse and another is in the nursing program at the community college. Her dad "*made good money,*" but he had a problem with alcohol. He could not read or write; however, he could do mathematics well and took great pride in this. Her mother was a college graduate and worked in secretarial jobs. She says that school was important to her family, but it was not pushed; women were expected to marry and have a family.

Brenda ascribes her love of mathematics to her father. She likens

mathematics to solving a puzzle and says she enjoys the challenge.

> *I like math; I've always liked math. It's not something that comes easy to me. It's something I have to work at. You know, it's like I do math everyday. That's just the way it was, and that's the way it is now. It's always such a good feeling when all of a sudden something clicks. (B1.4)*

When asked what she enjoys most about mathematics, she replies

> *I think there's only one answer to something. There's not a lot of different answers. It might be this or it might be that. It's like a crossword puzzle. There's only something that will fit in there; nothing else will fit. It feels real good to find the answer to something. I think it has a lot to do with life, period. Going through those steps to solve problems. (B1.6)*

Brenda believes that math plays a role in almost everything we do. Though we do not always use x's and y's, we certainly use mathematics every day—basic mathematics that is. She also believes that the fear of mathematics is prevalent in society. She thinks *"we are always afraid of things we don't understand." (B1.9)*

Brenda describes herself as "a positive person who wants to grow." She also admits to being a perfectionist and an overachiever.

> *Brenda: I like to be on the front row. I want to know everything that is happening and know everything that is going on.*
>
> *Dana: So where did that come from—that wanting to know everything that is going on, that front row—*
>
> *Brenda: Then it seems like I can be more in control of the situation.*
>
> *...I've always wanted to do everything perfect. I'm a perfectionist. I want*

to be up there so I know everything that is happening. Then I can do it right. (B1.5)

She attributes her overachieving disposition to her role in the family.

I was the caretaker, the one who took care of everybody else. I was the one everybody leaned on when there was problems. It's just always having to be the best. My mother still thinks I do no wrong. She's forgotten so much. (laughs) She'll talk about my younger sisters, all the things they've done, but my mother thinks I do no wrong. It's still that way, not wanting to make mistakes. I'm slowly learning it's okay to get a B. (B1.12)

Brenda had an interesting experience during the study. About two-thirds of the way through the course, her Intermediate Algebra instructor began a new testing method. Each class period would end with one test question regarding the previous day's material. In other words, if on Monday the class learned material from section 5.2 in the text, at the end of class on Wednesday they would have one test question from section 5.2. Accordingly, Brenda felt confused and was not able to synthesize the information.

Dana: So where is your empowerment in all of this—to take control of your own learning? Do you have any?

Brenda: I can suggest, but you know, it's like anything else. You can say your feelings, but you know, the majority rules. (The class had voted on whether to continue the practice.) *You can take another vote, but if the people in the class don't want to take the overall test, then there you go*

again. So the only thing left for me is to work on me changing and accepting that this is the way it's going to be. ...It's real hard for me, and so I'm going to have to find some place in the middle that I'm going to be able to handle this, because I really don't have much choice in it. (B2.5-6)

Though she feels she has no control in this particular situation, she believes that generally speaking she could go to her instructor and be heard. In fact, she states that this instructor promotes a feeling of control because he is respectful and caring.

As one would expect, life's experiences have taken a toll on Brenda's self-worth. She is able to reflect on her experiences and evaluate them and learn from them. She began going to AA about 2 years ago and says that since then her whole perception of life has changed.

It's like seeing things out of different eyes. I go in with the attitude that maybe it's not easy, but I'm going to find things I like about it. (B1.12)

In the second interview she describes herself as sensitive but says she tries not to show it.

Dana: Now why do you try not to show it?

Brenda: I have spent my life using whatever I could to be a strong person. Whether it be people, drugs, or alcohol. I used knowledge. I used anything I could to try to make me into this person and not show my feelings, but inside I was not. I wanted it to look like that on the outside, so whatever it took, I did. It's very hard to show feelings because then you are leaving yourself open. ...I was always the one that was supposed to

succeed, and I was always supposed to be the one that was in control. When there were problems in the family, it was turned to me to take care of. And even my parents depended on me for that, so I've always been that way. I wasn't supposed to be afraid or think I can't. ...And, too, coming from a time in my life where I didn't think I had worth. You know, it's a whole new experience for me to think that my voice would matter because my life was spent to where I really didn't think—someone else was always better and someone else could always make the best decisions. (B2.15-16)

During our last interview, Brenda stated that she has learned about herself that she can be okay. She doesn't have to beat herself up. Of the challenges she will face in the future she says

as long as I reach out for help, and ask for help, then help will come. It's okay to do that. Admitting to someone else that I'm not this strong person on the outside was a big step. I can do it with the help of someone else and God in my life. (B3.2)

James

James is 21 years old and has been a member of the United States Air Force for about 2 years. He works on the C-17 airplane and has already advanced past the norm for his age and rank.

I'm doing awesome at my job. They're making me a 5-level now, which is pretty cool.... At my rank, I'm a 3-level, and then I have to wait another

year and a half to get my next rank and be a 5-level. But because of the shortage of 5-levels here, they've selected a few exemplary people (laughs) to be 5-levels. (J2.5)

James enjoys his job and is a perfectionist as far as work goes. He sees himself as a hard worker; in fact, it is at work that he feels most at home.

James: On the weekends I'm a loser, and on the weekdays I'm a hardworking, do-everything-right type guy. On the weekends it just all goes downhill.

Dana: Can I ask why?

James: I have nothing to do on the weekends. I have nowhere to go. I have no girlfriend. If I had a girlfriend, I couldn't afford a girlfriend. Always broke.... It just seems like the weekdays—most people like the weekends, but the weekdays are the only time I seem to actually be living or doing something. The weekends are just time I got to get past so I can get back to doing my job and going to school. (J2.5)

James grew up in Chicago in a devout Christian family. His dad works in the computer industry and just finished college about two years ago. James attended a public elementary school until around age 10 and then he was home-schooled until his sophomore year. He had to repeat his sophomore year when he began attending a private, Christian school. The school had the "leeway" to help make up his freshman year credits; otherwise, he would not have graduated until he was 20. His family also decided he needed *"a little supervision or something like that"* because it was at this time that he went through his "psycho stage."

There's probably some clinical word for it, or something. I was just not thinking at all; I didn't understand what I was doing back then.... I had a small drug problem, I guess you could say. I was like really into vandalism and some other stuff.... It's strange. I went home in July, saw my family and old friends, and they were telling me about things I used to do, and I'm just like I can't imagine that I did that thing. I mean, it is so not me anymore. I guess I was out to make a point or something, I don't know. Something stupid like that. (J1.15-16)

Later in the interview he says of his high school days

I tried to spend most of my time [high]. Actually, the most reason for that is my mother just died a few weeks before I started going to school. It wasn't really that, but it was some things that happened afterwards with my family that kind of—then a couple of my friends had a joint and started it up. Yeah, I spend most of my time in school high, which was pretty amazing, actually, that nobody made a big deal about that in a small school. I don't know—they just didn't care.... Maybe they didn't know.... I always had this theory that my dad's contributions to the school might have had something to do with it. I don't know. I'm thinking, you know, maybe if I got kicked out for that or something, they wouldn't get that money anymore. (J1.26-27)

James had planned to attend college right after high school. Because his school was affiliated with Oral Roberts University, he had been told that everyone from his school with a certain grade point average would be given a full-ride

scholarship for the first year. In actuality, only one student was chosen, and it was not James. He had made no other plans. He worked at various jobs for about a year and a half and then joined the Air Force. Extensive training during his first two years in the military required his time, but now he is able to begin his college career.

Regarding mathematics, he *"never really thought about it that much. It was just another class." (J1.5)* Though he sees algebra as basically useless, he thinks it is *"cool"* how math seems to *"explain itself"* and how *"everything seems to work out."* He does not remember much from elementary school, but does remember from his home school days that his mother avoided teaching mathematics. He did some basic mathematics and in junior high he took a consumer mathematics course through correspondence. He also remembers taking a class called "Algebra 1/2". A man taught James, James' brother, and some other home-schooled students in a garage converted to a classroom. The teacher and James fought terribly. *"It is so easy if a teacher makes you mad to just make their life hell." (J2.3)* James discovered in later years that the man was *"a wonderful guy"* and that he really missed out by not paying attention. He also contributes the problem to being home-schooled and rarely getting out with friends. *"We were too busy talking and throwing stuff and playing around." (J2.4)*

It was when he went to private school as a second-year sophomore that "they" *"started beating [him] over the head with [math]." (J1.5)* James never particularly experienced math anxiety, he says he just never really tried. He filled

his mathematics requirement with Pre-Algebra and Algebra I and stopped. He says he hated his mathematics teacher.

James: He was the basketball coach, soccer—What is it with making the coaches teachers at high schools? They never make good teachers, I don't think. He just made me angry. I can't really remember any specifics, even though he did finally get kicked out for molesting a couple of his students, which we all kind of wondered about. He just always had this thing about the girls in the class.... That was just a rumor. He was just a big, mean guy.

Dana: How did he teach?

James: He taught pretty well, actually, when I think about it.

Dana: What did he do?

James: Basically, he would teach out of the book. We did homework every night, or we were supposed to. He went over a lot of stuff in class....He always liked to give us a super, super hard problem at the end of class, and some brainy, nerd guy would come and give him the answer the next day....

Dana: Did you ever work in groups or do projects or do anything like that?

James: No, I don't think so. It was just plain algebra out of the book. (J1.12-13)

He says he barely passed his courses as he was working each night until midnight or later. He slept through his morning classes. Some teachers viewed it

as his problem; others finally gave up. His parents were upset with his grades, but he says

> *I think it was the same thing as the teacher sleeping in class. After you bring home so many report cards with bad grades, it gets to the point where a C+--All right! Good for you! (laughs) (J1.17)*

Whether he simply matured or was affected by something from his military training, James did an about face and now cares deeply about his family and his future.

> *James: All of a sudden I went from 'I have no idea why I'm in the Air Force.' I think it gave me an excuse—maybe living on my own for awhile and being hungry. I don't know. I just want to make something of myself. I have a goal now and all this stuff has helped me get there.*
>
> *Dana: So in high school you really didn't have that goal?*
>
> *James: No. My goal was to have fun and get out of the house. Back in high school—this may sound a little weird—the last thing that mattered was making my parents happy. But now something good will be happening, and I'll be calling my parents 'Hey, Dad.' And he'll say 'Oh, I'm so proud of you.' (laughs) I don't know why, but it's pretty cool impressing your parents. (J2.8)*

James is taking Beginning Algebra this semester and is pleased with his progress as a student in general. He is having no trouble understanding his algebra material and says that mathematics will not be a consideration when he makes his final decision regarding a major. He is a perfectionist and enjoys the

reward of making A's. He says he used to think the "geeks" were the ones who made good grades, but now that's what he wants—good grades. When asked if there were anyone else besides his parents he would want to impress, he dryly replied

> *If I could do something to impress a few of the girls in my classes, I would. (J2.8)*

The stories of the participants' experiences are poignant tales of the journey of life and the twists and turns taken whether by choice or chance. The highs, the lows, and the many in-betweens work together to affect all areas of their lives—including mathematical learning. Whether teenage rebellion against parents or fear of failure or conflicts within the educational system or an extreme desire to achieve, experience impacts readiness and willingness to learn. Experience also impacts beliefs about what "it" is being learned and why "it" is important. We now turn to a deeper discussion of the participants' views of mathematics and its role in society.

CHAPTER 5

PARTICIPANT VIEWS

A Deconstructive Tale

I told the preceding chapter from the realist perspective because the overriding purpose was for "me" to tell about "them." The remainder of this dissertation now takes on another perspective: deconstruction. Deconstruction is about making problematic the constructed worlds which both shape us and are shaped by us. This project called into question two worlds united: mathematics and higher education. The world of mathematics—a world foreign to most of the participants—has often been claimed as a value neutral, objective world in which the mathematics is simply a tool to describe life and nature. Additionally, the world of higher education has been formed over many years and in turn has taken on a prescriptive role as to what constitutes a higher education. It is not an immutable world, but often seems such to developmental students not confident in themselves or whether they belong. Organizational structures and course requirements developed to address problems in a particular era (or for a particular interest) have become "common sense." "Tradition" is not harmful in and of itself. It becomes onerous when it is no longer held up for examination—when it takes on a life of its own. It was in this vein of "examination" that I sought to address my research questions regarding the participants' initial and changing conceptions of the role of mathematics in society and the participants' critique of mathematics and mathematics education.

I found that to do a "critical exploration" as my title indicates, involved a

balancing act. On the one hand, I wanted to find out what the participants saw and questioned as they looked at the role of mathematics in society and at mathematics education, yet, on the other hand, I wanted to challenge conventional thinking and encourage them to move beyond where they were. This chapter is divided into precisely those two parts. The first part is sub-titled "Deconstructing 'Why?'" and follows the questioning process as the participants engage in "problem-posing." The second part is sub-titled "Deconstructing 'How?'" and follows the questioning process as I "pose a problem." This seemed to be the most appropriate avenue for dealing with the tension between encouraging critique yet avoiding imposition—for finding that "intersection between people's self-understandings and the researcher's efforts to provide a change-enhancing context" (Lather, 1991, p. 65).

Deconstructing "Why?"

Besides impressing girls, as James wanted to do, a myriad of reasons exists to "learn" mathematics in school—few of which have much to do with mathematics. As I began to explore with the participants their conception of the role of mathematics in society, the conversation turned to formal schooling and the lack of relevance of "school mathematics." When asked if there was anything about mathematics or about mathematics education they questioned, all but Michael alluded to the same problem:

> *Rachel: Will I really need this later on? I mean, I know I'm going to need to know how to count. I will need to know how to multiply and divide and*

subtract and all the things I already know. Now why do I need to know all this other stuff—like the FOILing method and things like that? I don't understand why. Those are my questions. (R2.3)

Terri likewise questioned the more abstract forms of mathematics.

Terri: When you are learning math, all this stuff is new to you. You get frustrated when you can't factor something out. That's when people say "to heck with it. I don't want to do this anymore." Why? I don't have to factor out my grocery bill. I know how to do my basics. I can add, subtract. I can balance my checkbook. What more do I need? ...It's not practical everyday living. It's not something that we do all the time, yet we're expected to learn it. (T2.17)

For Kelsey, the questioning was much more intense because of her failure to perform well in the mathematics classroom.

Kelsey: I'm real good at numbers, like when it comes to money and stuff. I can really get that, you know, cause I know how much I want to spend and how much I want to save and you know, bills, and I never have any late bills, and I can always figure up how much I need to save. But when it comes to this algebra, it's like nonsense. What's the purpose of it? ... I've lived on my own almost a year now, and I haven't used any algebra in the real world, you know, so what's the point? (K1.7-8)

Zach, like Kelsey, was struggling to learn algebra. It was intimidating for him that he was experiencing difficulty with the beginning levels of college mathematics, knowing that much more lies ahead. During the men's group

discussion, James commented that he could not see *"any decently successful person"* not being able to do at least the beginning level of algebra.

> Zach: *And you know, I would have thought that before until I took this class, but now that I am taking this class, I'm starting to wonder because to me, there's so much stuff that you see that they don't even know why they are teaching it. And much less practical, everyday use. It you want to have a class that is specifically business math or maybe even an algebra class that is called something a little different that has practical use, then fine. But if they are going to make people take it just so they have it on that degree—come on, that is a waste of government money, and that is what 90% of it is, government money. (GM.15)*

James struggled with grades in high school, but he claims it was simply lack of effort and concern. This was apparent as he was doing quite well in his beginning algebra class. Because of his current success in the classroom, he accepted the algebra requirement, though he still did not "see the point."

> James: *Like those word problems and stuff, they show you a little more how you can use it, if you wanted to, but I just couldn't ever see myself—an algebra equation with an "x" amount in it. I would always do something else to figure it out. A lot of the problems we are doing now, is like, you know, you already know the answer, figure it out in your head, but we are going to put "x" in there. In real life, what's the point of throwing "x" in there? I don't see myself using it very much. A little bit of math for bills and that type of thing. (J1.20)*

Though school is certainly not alone in its influence on the mathematical development of these individuals, it is the most obvious. They have many years of experience with school and have several more years to go. One of the jobs of educational institutions is to transmit cultural beliefs, and they, along with other social institutions such as the family, have transmitted the paradoxical idea that math is crucial yet useless. "On the one hand, mathematics has a pervasive social influence and, on the other hand, students and children are unable to recognize this relevance" (Skovsmose, 1994, p. 82). Jerry King (1992) says it this way:

> All of us have endured a certain amount of classroom mathematics. We lasted, not because we believed mathematics worthwhile, nor because, like some collection of prevailing Darwinian creatures, we found the environment favorable. We endured because we had no other choice. Long ago someone had decided for us that mathematics was important for us to know and had concluded that, if the choice was ours, we would choose not to learn it.... Of course, you also do not expect the person who teaches you mathematics in secondary school to think it is valuable. Why should he? No one else you know does. Your parents live their lives without mathematics and so do your parents' friends. At no place you go—the grocery store, the dentist, the movies—do you see the slightest bit of evidence that any mathematics beyond the basic ability to do simple arithmetic is anywhere needed in "real life" (pp. 15, 18).

Though the last decade has initiated a movement toward change (e.g., NCTM, 1989; AMATYC, 1995), the school mathematics establishment generally

has believed its importance to be self-evident. Some participants in the study wrestled with this idea, others accepted it, but the conversation allowed us (the participants and me) to make problematic the received idea that school mathematics, namely algebra in this case, is a prerequisite for entering the world of the higher-educated.

"To deconstruct authority is not to do away with it but to learn to trace its effects, to see how authority is constituted and constituting" (Lather, 1991, p. 144). For the conservative reader, the following tale is likely a stretch. What mathematics teacher has not been asked the "why" question repeatedly? Isn't that one of the purposes of the call for more relevance in mathematics education? But to deconstruct the question goes beyond the utilitarian idea that mathematics must be more useful in order to make it palatable and to defend its inclusion in a closed mathematics curriculum. Deconstructive questions strike at the very heart of what it means for students to become critical consumers of the educational enterprise, particularly students who in many ways have been disenfranchised from mainstream mathematics. These questions consider the politics of who decides what and for whom and why. The tale (Van Maanen, 1988) that follows is intended to "interrupt" an ideology that prevents students from taking charge of, or at the very least understanding, their educational journey. Its purpose is to make the questioning process the object of the study rather than to try to lead the readers or the participants to a "correct" version of how structures of authority should operate in institutions of higher education.

Critical Questioning

In Patricia Cranton's (1994) explication of Mezirow's theory of transformative learning, she proposes three areas of critical questioning. The first area, content reflection, asks the question, "what is the situation?" The second area, process reflection, asks the question, "how did this come to be?" The third area, premise reflection, asks the question "why is it important to think about this situation?" It will soon become obvious that the situation is one in which authority is simply trusted. Participants have yielded their educational decision making power to "Them/They"—whoever it is making the decisions about what constitutes a "higher" education. How did this come to be? And, at least for this study, how deeply can we consider the question "why is it important to think about this?"

First, what is the situation? The situation as revealed by the participants is one of contradiction. Why is it that such a useless "subject" would be required, particularly to the detriment of so many people (not the least of which are themselves)? Why is mathematics so important? What role could it possibly ever play in their lives? Such problem posing does not automatically conclude that school mathematics should be eliminated; however, it does automatically conclude that school mathematics should be held up for critical examination. Maybe these participants have a point. Maybe school mathematics as they have known it *has been* more of a barrier than a benefit. Maybe it *is* basically useless. Or maybe there are valid reasons for its inclusion, but these reasons remain a

mystery to the participants and have become "common sense" so that school authorities no longer see the need for justification.

As conveyed in the previous chapter, each participant has his or her own story about how they came to be in a developmental mathematics class at the particular time of the study. Both positive and negative factors have influenced the mathematical development of each one and have contributed to a questioning or an acceptance of current curriculum structures. Of the seven participants in the study, only Michael has directly relevant and unquestioned reasons for taking a mathematics course—his major is engineering.

> *Michael: I hate math. (laughs) It has never interested me. I don't know why I chose electrical engineering. (laughs) Kind of stupid, huh? I relate it to the way I work, like solving electrical problems. (G1.9)*
>
> *It has a lot to do with my career field, so I don't question it. (GM.4)*

Likewise, Brenda does not question the necessity of taking mathematics, though her major (business administration) is not so obviously related to upper level mathematics as Michael's is.

> *Dana: Have you ever had those thoughts? Why do we have to take this?*
>
> *Brenda: No. (laughs) You're talking to somebody that just goes along with everything. No, I really haven't. I looked at it more as a challenge and working my brain. Something new and something I was going to do and I am going to do it. I looked at it more like that instead of something that, you know, that I might not use later on. (B2.26)*

James is somewhere between the extremes. He questions the usefulness of algebra, but does not question the requirement.

> *James: This algebra stuff just seems like some other unneeded but necessary thing to go through like paperwork. I'm enjoying it; they're like fun little problems like crossword or something, but I just can't see the point in it.*
>
> *Dana: So why do you have to take it?*
>
> *James: I don't know. I don't think about that too much. It doesn't really bother me that I have to take it. It just seems like everywhere and everything you do, there's so many things that you have to do—there's really no explanation. (J2.9)*

The remaining four participants, Rachel, Kelsey, Terri, and Zach, are the most adamant about "why?" Therefore, the remainder of this section will focus primarily on the questioning process as it relates to them.

The contradiction between irrelevance and reverence (of mathematics) is interconnected with beliefs that have formed over the years, beliefs that prevent more integrative, permeable, and inclusive points of view. Mezirow's theory of perspective transformation becomes of interpretive importance because it illuminates the frames of reference used by the participants as they critique the place of mathematics in our educational system. Recall that meaning perspectives are the lenses we use to make meaning of our experiences and are of several types. The three types focused on in this study were epistemic, sociolinguistic, and psychological perspectives.

Epistemic perspectives. Epistemic perspectives relevant to this particular study seemed to revolve around how the participants view mathematics. Of course, this speaks directly to their beliefs regarding the role of mathematics in society. They have developed a meaning scheme that sees mathematics as irrelevant to lived experience—other than school experience. Most of the participants, like many others in developmental mathematics courses, see mathematics as black and white and as disconnected from themselves (see Buerk, 1994). For example, I asked Kelsey if the questioning process in the study could in some way be compared to the questioning process experienced by women who come to the shelter where she works. She replied

> *I can give them answers as to what they could do. With algebra, you can't give me an answer as to what I can do with it. ...See, these people—you just now related it to the shelter—that relates to them. Leaving relates to something they're going to do in the future, whether they stay or leave, they still want to know the pros and cons of staying and leaving. Algebra has nothing to do with my life, now nor in the future. (K2.5)*

Terri sees mathematics as too relative, too inconsistent.

> *All your life you're taught these are whole numbers, real numbers, this and that. Now all of a sudden, imaginary numbers. There's just too much, too many different angles that you can do. Well, this works in this case, but not necessarily in every case, and you are taught how to solve an equation, but then you have to re-plug that number to make sure that it works. Why are we doing this? We are solving and getting this answer.*

Shouldn't it work every time? When a person is doing math, you would think when you are solving something, you get an answer, that should be the end of it. (T2.3-4)

Terri also sees mathematics teachers as influencing mathematical content, skewing it to what they want it to be.

I fear math. I hate math—there's just too many—it's not just one person who came up with these theories; it's a lot of people, and it's like a lot of people with different ideas have come together, and why do you think your math book changes all the darn time? If it was as simple as black and white, we wouldn't have such revised books, and there wouldn't be so many different teaching styles. That is why so many people are afraid of math because each year you have a different teacher. Each year you have someone teaching you their version of how math should be. (T2.4)

Rachel, like Terri, experienced the frustration of inconsistency. Multiple approaches to "doing math" existed, but this did not translate into a more open way of looking at mathematics because she did not own the approaches. Her choice was between two dominating forces: teachers and parents.

It got to the point where my teachers, you know, would, especially in math, they had a certain way of teaching how to subtract or how to add. And then you would go to your parents, and they would say, "No, you have to do it this way; this is the way I was taught, and this is the way you need to do it." So then I would go back and then my teacher would count off because I wasn't doing it their way. Then I would go home with an F and

get in trouble with my parents. So I ended up just really not liking it. (R2.11)

Though Rachel sees math as unrelated to her life and questions the validity of algebraic knowledge and requirements, she tells a different story about an applications course she took in high school. Though certainly there was no critique of the social role of mathematics, at least it was something that seemed to relate to her life.

[Math of Money] was like a business class where I had to take—like, you have so much a month on rent and then you have this percent increase. Find out how much the payment is. I did taxes and stuff like that. It was like if you were going to be an accountant or something. It was a great class. I loved it. ...[My Math of Money] teacher taught you it to the point where you understood it, cause like in math, I can't, like in Algebra II and geometry, I can't relate that to anything. (R1.14)

Zach made some interesting comments regarding algebra. He firmly believes that school mathematics should be useful, and he is frustrated that he has not learned how to apply it.

If you don't use [math], you're not going to remember it. It's harder to understand if you don't use it, too, I think. ...It would help a lot if they would pick word problems that you could really relate to—that you actually need to use. These word problems in here are not something you can see yourself needing to do. ...There's so much stuff you can't learn from a book and they expect us to. (Z1.9-10)

Kelsey, Terri, and Zach believe in an inherent ability to do mathematics. Remember that Zach compared it to a machine that *either connects at that circuit or it doesn't* and that Kelsey had very dualistic views of "math" people and "non-math" people. Terri said she did not inherit her mother's ability in mathematics, but she tempers that view in a later interview

> *My mother has that natural knack. Why do they say most Asians are good in math? Is that inborn or is it learned? I honestly think it's both because in my mother's country, they emphasized more on math. So, I think they pushed people to learn math because "this is what you need to know. This is how you need to do it." Whereas here, they don't really push math on the students as much as they do in other countries. I think it's a little bit of both. (T2.16)*

Zach and Terri both picture algebra as "rules" and learning the rules is about getting the right answer.

> *Dana: If there are rules, that implies that you're going to follow them, or that somebody follows them, but also that somebody made them. So why do you have to follow those algebra or grammar rules?*
>
> *Zach: The algebra rules—or I guess both—to get the right answer. With the algebra the rules are there to get you the easiest way to get the answer or the right way to get the right answer, but people who have done math all their life don't even think of them as rules; they think of it as a process, a formula. (Z1.20)*

Sociolinguistic perspectives. In addition to epistemic meaning perspectives, the participants' sociolinguistic perspectives of mathematics and mathematics education were examined. These perspectives relate to social norms and roles, cultural and language codes, and philosophies and theories. Of particular importance to this study were those social perspectives that related to the authority structure that dominates our educational decision-making processes and to the social role of mathematics. In much the same way as their epistemic perspectives, sociolinguistic perspectives of the participants seemed to prohibit more open and empowering points of view.

First, participants have learned over the years to abdicate control to authority, often referring to a vague "they" as they discussed the contradictory status of school mathematics. "They" had no antecedent, no identifier, yet "they" exercised great control over the participants' lives and learning experiences. "They" determined such things as curriculum and hence career:

> *Dana: What would you most like to do?*
>
> *Rachel: I would really like to be a school teacher, but I don't want to do the math. Isn't that awful?*
>
> *Dana: What do you want to teach?*
>
> *Rachel: For a while I really wanted to be a high school teacher, and I really would love to. I would love to teach business, but it has a lot to do with math. And I like math; that's fine as long as I don't have to do it every day and I don't want to have to do it as in depth as they want us to. If I could add numbers, that would be fine. (R2.14)*

"They" also determine class placement with little or no explanation:

Dana: Do you remember your elementary, junior high, high school math? Anything about that?

Zach: I remember when I first started having problems in math and they stuck me in one of those slower classes—special education or something. ...(later) they gave us another test in the class, and we could tell there was a reason they gave it to us because this class wouldn't even do stuff like that. I did really good and he (the teacher) even said something that I was going to get moved back up, and I was the only one. I was really happy about it. Well, it ended up that nothing ever happened. I just stayed in the class and they never said anything else about it. (Z1.26-27).

"They" determine graduation and credit requirements.

James: They should give us some credit for [developmental] classes. (J2.1).

Terri: Requirements. I think honestly they're going to have to raise their standards of requirements and stuff because they tend to be—from what I can see—it's like they're lowering requirements. (T1.21)

The participants have little ownership of their learning materials. They must conform to the hidden "they" of textbooks and computer programs. For example,

Dana: Why do you hate the word problems so bad?

Michael: It's because, you know, the words. It's the way they word it, the way they write it. And the words are so similar that it can mean the same thing, like addition or subtraction—something like that. Just a little word

will throw me off. I guess it's my fault because I don't really pay attention. I read it, and I go to do it, I just don't catch everything. (M1.18)

Terri questions who "they" are—who is making the rules. In discussing who one would ask regarding why algebra is a requirement for a degree, she says

Terri: I have no idea where you would get that answer. I don't know if anyone could answer that question. ...I don't know what you need; I don't know why you need it, but apparently somebody higher up feels that we need to know this stuff.

Dana: That's really part of this study. When you come up with these "why" questions, what do you do with them? And who is it—

Terri: that's making these choices for us? That's where I'm confused. Who is to say that I'm going to need this or use this on my job or the degree that I'm trying to earn? Who sets those standards? (T2.18)

Kelsey offers some suggestions as to who "they" are, but in doing so exhibits a sort of fatalism toward her own educational control.

Kelsey: If I gotta take it I really want the answer to why I have to take it.

Dana: So, who would you ask that question of?

Kelsey: If I knew I'd probably already ask them. I can't ask the algebra teacher because he would say because I need it. Everybody I ask, it's because we need it to get a degree.

Dana: Ok, so one possibility is your instructor or your teacher, but you know what he's gonna say?

Kelsey: Yeah.

Dana: And you don't think that's a good enough answer?

Kelsey: It's not a good enough answer for me. I want to know why. Why do I need it for what I'm going into? I don't think I do.

Dana: Ok. So, who else could you ask?

Kelsey: Um—maybe the head of the college to why they are making us take classes we don't need for a degree.

Dana: Ok, so that's one possibility. Can you think of anybody else?

Kelsey: No, and I probably wouldn't want to ask him anyway, but—

Dana: Why not?

Kelsey: He'd think "Oh, God, why are you asking—". He'd wonder why I was asking such a question.

Dana: But do you think it's a legitimate question?

Kelsey: Probably not. We just take it because we have to take it to get a degree. Even if I asked it's not going to change anything. It's not going to be like "Oh, well, you don't have to take it. Never mind, we'll just go ahead and give you a degree without it." So, regardless, it's not gonna change anything, so why do anything about it? Just do it and go on. (K2.3-4)

Second, limiting perspectives for these participants also related to their conceptions of the role of mathematics in our society. All the participants agreed that what they termed "basic mathematics" played an important and extensive role in society. Whether it was balancing a checkbook, cooking, mixing hair color chemicals, building a structure, working with taxes, or paying bills, all the

participants referred repeatedly to a fundamental role for mathematics in the everyday workings of our society. And as James says

> *There's always the little stuff—your channel numbers when you turn on the tv, I guess that's kind of simple. The amount of beer cans you put in the trash can. How many cigarettes in a pack. (J2.14)*

Though basic mathematics plays an empowering role by allowing us to participate in the day to day workings of society, "school mathematics" has often played a suppressive role. The participants alluded to several different negative roles that mathematics has played in their lives. For example, several participants mentioned the role of mathematics in career selection. Though one is certainly expected to choose a career in keeping with his or her talents and interests, mathematics seemed to play a gate keeping role by preventing access to some of the participants' selected career fields. Zach "washed out" of electronic warfare because of the mathematics. He states

> *it frustrates people. When you know you are not good in math and you look at this thing that says you have to have math, then you might move to a different career field when that was the perfect one for you—or to a different degree and that one might have been perfect for you—or you might be working toward getting that degree and part of the way through you get to the math, walk out and say, "Ok, I've got to switch." That can be a real mistake for a lot of people. (Z2.12)*

Though Terri sees the role of mathematics in career decisions, she is determined that mathematics will not stop her from getting the degree she wants. When asked about the level of control she has over her education, she says

> *With math, my control is if I don't want to go that high up in math, I'm going to try to pick a degree that doesn't require my math skills to go beyond a certain point. Whereas engineering, computer science, business, those are all classes that require math. For me, even though I hate math, I want to learn math because I don't like feeling intimidated by anybody. (T2.19)*

While Terri and Zach alluded to "school" mathematics' gate keeping role, several participants also discussed the use of mathematics to classify and/or value people. Mathematical understanding tended to be equated with above average intelligence and achievement. For example, Kelsey states that

> *I feel like math people are smart just in general throughout society. They're just smarter people, because not only are they dealing with just math, you're dealing with stuff in biology that has to do with math. ...Math is going to make you smarter in chemistry, or you know, other classes you are taking. (K1.16)*

Rachel, too, indicated a belief that mathematics accompanies "being smarter." She sees that one might need a mathematics background to do physical therapy. When questioned as to why, she replied

Well, because you have to be a doctor. I don't know. I would just feel that if you are going to be smart enough to work on people, then you at least need to know math. (R2.8)

The women's group interview also yielded an interesting conversation on this matter. Terri began the discussion by commenting on how she changed her degree field to one that requires more mathematics because she does not want her husband to outdo her. She continues

Terri: It's like you're out to prove something, and for me taking math courses, if I can do well—

Kelsey: It proves your level of success.

Terri: Exactly. Because if [my husband] can pass English, anybody can pass English. (laughter) If he can get an A in English and psychology, I'm thinking, "Shoot, that's easy." But it seems like if you do well in math, it seems like "Wow!" Everyone thinks—

Dana: So there is something different?

Terri: I think so because with me telling people now "I did well on my math test." It seems that it impresses them more when I say I got an A on a math test than when I say I got an A on my English test. For some reason everyone is like "Wow, you're really good in algebra." It makes me feel like "Wow, I'm pretty smart."

Dana: So does everyone have that perception of math, that math is just a little bit—if you do well in math, it is just a little bit different level?

Brenda: Yes.

Kelsey: Yes.

Rachel: I think so. (GW.11-12)

When asked how they thought this came to be, the overwhelming response was the "fear factor."

Kelsey: Math lets you down a lot. And a lot of people don't want to be let down in life, so they would just as soon be scared of it than to face it. ...

Terri: I think with math that people learn it, but unless they use it every day, it's something that is lost and forgotten until you have to use it again and sometimes you'll become re-familiar with it if you were to see it in front of you. But in most cases, people just don't use it anymore. I think people are intimidated because it's not something used by the majority. (GW.12)

In response to the final critical question, why is it important to think about this, Terri replies

So maybe you can encourage people who are intimidated with math. (GW.13)

A conversation involving Paulo Freire, Ubiratan D'Ambrosio, and Maria do Carmo Mendonca (1997) revealed that beliefs regarding the unattainable "nature" of mathematics are not limited to the participants in this study. Freire states

> I have no doubt that inside me there is a mathematician that did not have the opportunity of awakening, and that I will die without having awoken this mathematician, who might have been a good one. Well, I believe one

> thing, that if this mathematician that exists inside me had awoken, I am sure he would have been a good mathematics teacher. But this did not happen and I pay very dearly for this. In my generation of Brazilians from the Northeast, when we referred to mathematics, we were referring to something suited for gods or geniuses. There was a concession for the genius individual who might do mathematics without being a god. As a consequence, how many critical intelligences, how much curiosity, how many enquirers, how many capacities that were abstract in order to become concrete, have we lost? (p. 8)

When asked if there were a mathematical equivalent to the discourse of language, he replied that a "math-literacy" could indeed help with the creation of citizenship.

> This means you democratise the possibility of the naturalness of mathematics, and this is citizenship. ...And why is this democratisation not happening? Because it became accepted that understanding mathematics is something profoundly refined, when indeed it is not, and should not be. (p. 8)

As participants looked through their sociolinguistic lenses, they seemed to see invincible structures of authority and accessibility. The hidden "they" dominated mathematics education decisions with little question or accountability. Equally "hidden," though, were unchallenged assumptions regarding the accessibility of mathematics and mathematics-related (at least on paper) careers to only the "smart" members of society. These sociolinguistic perspectives, just as

the epistemic perspectives, have served for the participants a role far more limiting than empowering. As we turn to the third perspective considered in this study, though, we see something a bit different.

Psychological perspectives. Psychological perspectives are those that address our assumptions about ourselves as individuals. These perspectives include among others self-concept, locus of control, inhibitions, and defense mechanisms. Limiting psychological perspectives for the participants in the study related predominantly to fear of failure and lack of self-confidence. Indeed, every participant in the study referred at some point to a fear of failure in school mathematics. Michael, for example, referred to this fear in a journal entry.

> *What makes math so scary to me? I guess it is the fact or idea of maybe failing. It goes back to when I was in about the 5th grade. I had a math teacher and she could care less whether I passed or understood any of the math that we were doing. From that point on every time that I didn't understand a math problem, I would and still do get very nervous. (MJ.2)*

Terri referred to this fear in the initial group meeting.

> *I tend to do pretty well in math, but I just have a fear of math. Just mention math and a math test and I just break down. (G1.7)*

During her first individual interview, I followed up on this by asking her what it actually was that she feared. She replied, *"I'm afraid of failing." (T1.10)*

More than distorted and disabling psychological perspectives, though, the participants had positive and enabling self-images. Considering the negative

stories told by these participants regarding their mathematical autobiographies, one would imagine persons who had no confidence and little motivation to continue their educational journey. Instead, with one exception, the participants have somehow minimized the damaging effects of their earlier years and developed the positive outlook needed to achieve their goals.

Michael overcame racism, uncaring teachers, and the death of his father. He believes strongly in his ability to succeed and is determined to do whatever it takes to meet his goals.

> *Michael: I'm trying to get this degree. I'll do whatever it takes to get where I want to go. That's what I'm gonna do. No matter what, I'm gonna achieve this goal. It might take me twenty or thirty years, but I'm gonna reach it....*
>
> *Dana: So how did you get that? What have been the forces in your life that have made you like that?*
>
> *Michael: I guess it was my father. ...I think my father was the biggest factor because I don't want to let him down. Even though he's gone, I still feel he's watching over me. (M2.6-7)*

He also speaks of overcoming the negative impact of his teachers.

> *Michael: They'll say stuff that's negative, and then after awhile and after hearing it from this person and that person, you actually start believing it. "Maybe I am stupid; maybe I just can't get this."...Like math, if I were still thinking "I'm stupid; I can't do this" I wouldn't have gone into the electrical field. I wouldn't go into recording and producing. That takes a*

lot of math. I started telling myself, "Hey, you can do this. It's gonna take a little while, but you can do this." (M2.13)

Zach describes his mathematical story as *"very negative"* and says he *"can't think of anything good."* He was placed in special education classes, even though he believed he should not have been there. His mother was convinced of his learning disability and had him tested several times. Despite all this he maintained a view of himself as intelligent, perceptive, athletic, patient—all being aspects of his positive self-image. He says of his school performance:

I was pretty lazy. I hated doing homework, so it's more laziness than a learning disability. It may have been a little of both in those years. (Z1.29)

Remember Brenda's difficult life history—her childhood experiences with her family, the loss of two children, the death of her husband. Before her experience with AA, she believed her voice did not matter and she viewed herself as weak. She now says

I think as I gain and do things for myself and as I walk through fears without using anything, whatever it might be—every time I go through a fear, I feel better about myself and I get to thinking I have worth. I do matter. My self-esteem grows. (B2.17)

She also says of college

[Schoolwork] has become top priority to me. It really has. I love school; I really do. I enjoy it. It's giving me so much. A lot more knowledge of material things, it's given me a lot more knowledge of myself. (B2.19)

Terri overcame her embarrassment of having dropped out of high school and got her GED and started college. Through maturity and a sense of responsibility toward her children, she conquered her fear and is confident in her ability to succeed. Though she still experiences some self-doubt regarding mathematics, she responds to the question of what she has learned about mathematics by writing

> *I give math too much control over me. Basically, if I really wanted to improve my math skills all I would have to do is practice. Math is only as hard as you make it. Before I enrolled in college I didn't understand all the letters and numbers. I couldn't have solved any equation, let alone have told you why we were trying to solve it. Now that I have some basic knowledge about algebra I feel less intimidated. But I still find myself second guessing myself. Go figure! (TM.6)*

James overcame the death of his mother and a rebellious period in his teenage years. He says

> *I really enjoy that [math] was something that I wasn't good at once and now I'm doing good. ...Now I actually care whether I get a good grade or not. (J3.1)*

Rachel overcame negative experiences with teachers and a teenage pregnancy. Like Terri, she has an overall confidence in her ability to succeed in school mathematics, yet that belief is interwoven with self-doubt. In her journal she manifested her confidence:

[My instructor] told me that I am doing well. I got a 100 on my quiz. Some students are holding the class back from learning new material. It is getting so boring relearning things you already know. I think the students that are having problems need to go see the math tutor in the LRC so the rest of us can move on! (RJ.4)

Yet in the last interview she states the following.

I wish I really did have a stronger background in math so I would be able to help [my daughter]. I love English and I can do science. I love history, so those basics are really good. But when it comes to math, I'm a cheese-head. (laughs) I don't understand any of it. (R3.10)

Though most of the participants were experiencing success in developmental mathematics and seemed to have overcome many negative educational and personal experiences, the one exception was Kelsey. She was not experiencing success in college as were the other participants. In general, she simply had not developed a positive self-image to replace the one developed through her elementary and secondary school years.

Kelsey: I can be smart in certain areas. Like if you gave me a psychology book, I could pass it in a breeze, or English or speech—anything like that. ... But this kind of stuff, I can't remember it because I don't like it, I guess.

Dana: So why do you say that makes you not feel smart?

Kelsey: I guess because the grades I'm getting on this stuff isn't good at all. So I just, "God, I'm dumb." Maybe not dumb in general, but dumb to this. I don't pick up real fast on this kind of stuff, so I just feel like why try

to pretend. I used to go to class and everybody used to think I was smart because I would ask a lot of questions and try to be the one that, you know. I'm at the point, why pretend? It's not getting me anywhere. Because even if I did ask all the questions and try to act like I'm really interested, I'm not going to do good anyway. So what's the point in getting my hopes up that I'm going to do good when I'm not. (K2.6)

When considering both the positive and negative perspectives and the question of how the situation came to be, the two overwhelming factors were parents and teachers. The Caniglia and Duranczyk (1999) article referred to in chapter one also bears out the potential influence of family and teachers on developmental students' success in the mathematics classroom as well as on their beliefs about mathematics. In that study, two-thirds of the comments related to family involved negative experiences with tutoring or motivational experiences. Likewise, two-thirds of the comments regarding teachers involved their negative impact on learning. Parents of the participants in this study tended to be either too unsupportive or too demanding. Zach, Kelsey, Brenda, and Michael had parents who, for a variety of reasons, were not very involved in their children's education. While Zach certainly does not blame his parents, he does acknowledge that he was the sixth child and was basically on his own. Kelsey's parents took a laissez faire approach to parenting and encouraged Kelsey in areas unrelated to academics. As Kelsey says, school was not a priority for them. Nor was school a priority for Brenda's parents. The struggles with alcohol and finances, as well as a general cultural belief that school was not for women, contributed to Brenda's

dropping out in the 11th grade. Michael lost his father as a teenager and had a relationship with his mother that was perpetually strained by conflict. She was unable to control him and in later years told him she let him go, knowing he would "come around" someday.

Rachel and Terri had parents who were so demanding that they induced rebellion, and the rebellion manifested itself through schoolwork. Rachel got her freedom during school hours by skipping classes to be with friends and her boyfriend. Terri did likewise, though Terri described her actions as being a deliberate attempt to retaliate against her parents. James parents were not involved in his high school education, but not through choice. He was at such a point of rebellion, he would not allow them access to his life. Being employed during high school, he avoided his parents by arriving home from work after his parents were in bed; he also would leave for school each morning after his parents had gone to work.

We as educators have little influence over parents and home situations, except to try to understand and account for them as we deal with our students. We can, however, influence the role of teachers and the educational system. The disturbing stories told by Zach, Rachel, Kelsey, and Michael point to the tremendous impact of teachers. When Michael was asked what he would most want a reader of this research to get out of it, he replied

> *I would want [teachers] to know that they effect a lot of people's future whether they do good or bad in college or whether they go to college or not. They influence life so much and especially in the younger kids. You*

label somebody stupid and they go to another class and somebody do the same thing, then that person is going to feel like he or she is really stupid. That's got a lot to do with self-confidence and everything else, too. You can build or break a person. (M3.8)

The third area of critical questioning was difficult to address. This research seemed to bear out Mezirow's theory that one way meaning perspectives are addressed is through a series of meaning scheme changes. No major events (disorienting dilemmas) transpired for the participants during the semester, and that leaves, according to Mezirow, smaller meaning scheme changes as the avenue for developing more mature meaning perspectives. Through the process of Cranton's (1994) critical questioning, the participants engaged the questions regarding the situation and even how it came to be. However, the deeper premise reflection addressed by the question of why it is important to think about these issues, received only scant response from most of the participants. It could have been that there was little motivation to question too deeply as most of the participants were currently performing well in the higher education setting. It could have been that one semester was simply not long enough to fully engage in reflective discourse. While there were no "ah, yes" experiences as suggested by Lather's (1991) notion of face validity, the following conversation evidences some changes—maybe meaning scheme changes—that could be the seeds for further reflection. Toward the end of the women's group interview, this question was asked:

Dana: Why is it important to think about teachers and to reflect on your experiences with teachers or different school situations?

Brenda: I think you would get to where you wouldn't blame yourself for a problem that came up. It could have been something else, so if you blame yourself, then you would create a fear in yourself thinking, "I can't do this." But if you can look at it like just a problem with personality or a problem with the teacher not knowing how to teach it. It wasn't you, and to look at it like "I can do this." Not blaming yourself.

Rachel: That's what I get because my teacher was pretty rude. I just took this stuff and I was like "I going to shove this in your face." And that's exactly what I did. ...I know that, even though the teacher at the time didn't know it, that I can actually do this and that I have a brain and I know how to sit down and do it. (GW.21-22)

Zach was one who seemed to fully engage the critical questioning process. Following the men's group discussion regarding why algebra is a requirement for a degree, I asked them why such a discussion was important. Zach replied

Because we assume we're doing things the right way. Is that a paradigm? We assume that whoever came up with the answer to begin with was right and we just follow, and sometimes build on it. Or if you're not building the right way to begin with, what are you building on? If you started out wrong, then building on it improves it, but it may not improve it in the right direction or may not be moving it as far as it could be. (GM.21)

Through the critical questioning process, we have been able to follow as the participants wrestled with their mathematical histories and their efforts to conquer fears and negative experiences. We have seen examples of distorted epistemic, sociolinguistic, and psychological meaning perspectives. The hope that lies in this tale, though, arises from the positive and enabling psychological perspectives that the participants developed in their efforts to reach their goals. Meaning perspectives developed uncritically in childhood can be, and indeed were, transformed into empowering approaches to mathematics education.

Learning as Action

The preceding stories (or tales) could also be considered within Skovsmose' framework of learning as action. Skovsmose goes to great lengths to establish his theory that critical education involves intentional learning. Intentional learning is akin to action, as he defines action, because it presupposes a degree of indeterminism and a degree of awareness. For example, he excludes learning that occurs as a maturational process as well as learning that is basically non-reflective assimilation of culture, what Mezirow refers to as uncritically assimilated ideas from childhood (1994). Learning that is consonant with action springs from intentions, intentions which are grounded in the disposition of the individual. Skovsmose (1994) maintains that a person's disposition is made up of both a background and a foreground.

> A background can be interpreted as that socially constructed network of relationships and meanings which belong to the history of the person.

> When we try to explain the intentions of an individual we often refer to his or her background. But the background is not the only source of intentions. Equally important is the foreground of the person. By this expression I refer to the possibilities which the social situation makes available for the individual to perceive as his or her possibilities. (p. 179)

Once intentions and disposition result in action, this action can modify the dispositions of the individual. This circular relationship reflects the complexity of learning, particularly in a critical context. The question then becomes "how much mathematical learning by the participants is 'learning as action?'" Because action (according to Skovsmose' definition) is dependent upon intention, analysis of intentions in learning mathematics is requisite to answering this question.

This analysis, though, does not depart totally from the analysis based on critical questioning; we now simply broach the subject from a slightly different direction. Rather than seeing the situation as a "blind trust of authority" as we did in the previous section, the situation could be seen as a lack of internalized, purposeful intentions in learning. The prior question of "how did this come to be?" could be reshaped into "from what disposition(s) did these intentions (or lack thereof) arise?" The question of "why is it important to think about this?" becomes "why is it important to learn this?" Following is the analysis of these reshaped questions with particular focus on the participants' "real" intentions in learning mathematics.

Intentions

Why are developmental mathematics students "taking" a mathematics course? To learn mathematics? Maybe. Maybe not. A critical mathematics education, one that develops in students the tools to challenge inequities and misunderstandings, presupposes a reflective awareness and intentionality in the learning process.

> Critique is an action, and cannot be developed in school unless the learner takes some responsibility for the learning process. We can learn many things by command, but critical competence cannot be forced upon a student, and this is the reason that learning as action is an important aspect of a critical education. Intentions in learning help to define learning as a part of a critical enterprise. Routines may be assimilated in an absent-minded way, while a critical awareness cannot be developed as (blind) assimilation or enculturation (Skovsmose, 1994, p. 183).

As evidenced by the statements presented earlier in this chapter, most participants seem to be "blind passengers," lacking the intentionality that would not only boost their mathematical development, but also help them see the broader role of mathematics in society. So, if mathematics and/or its applications are so elusive, why did the participants enroll in a mathematics class? How had they persisted to that point in their mathematics education?

Skovsmose (1994) contends there are different types of intentions. Those that are *shared, modified,* and *integrated* into the learning situation give the students the opportunity to become actors and stakeholders in the learning

process. This opportunity presumes a nontraditional teacher-learner relationship that allows for dialogue and collaboration. Intentions of a second type are called *broken* or *ignored* intentions. The student comes to the learning environment with certain goals, hopes and expectations, but traditional school structuring dictates activity—activity which might or might not fulfill the intentions of the learner. The student must abandon his or her own intentions and internalize those of the institution.

Even in the absence of shared intentions or received intentions, intentions exist nonetheless. Skovmose' third category consists of *underground* intentions. He explains:

> In traditional mathematics education intentions are seldom shared. Negotiations are cut off by: "Today we have to learn about...". Possible intentions behind the series of commands are not made comprehensible. The student is left somewhat as a soldier in a trench at the front, without knowing about his actual position or about the next movement of the army. The soldier has no possibility of getting an overall image of the strategic situation. If he starts to carry on his own warfare in the light of his interpretation of the situation, it will probably not make any sense with respect to the overall strategic situation. The soldier cannot act, only follow commands. However, the soldier may develop his own interpretation of his personal situation. He may develop his own intentions, like keeping himself in the best possible physical condition,

trying to get a better ration of food, improving his ability to play chess, etc. (1994, p. 188).

Underground intentions fill a void where reasons for learning mathematics are absent. They motivate the student to continue in the educational process and can even be quite fulfilling. For students with instrumental purposes, the school setting provides a prime location for advancing their own interests. As the participants talked about themselves and their views of mathematics, this richness of underground intentions became readily apparent.

The complexity of intention, disposition, and action is not readily reduced to simple categories. Similar intentions may be shared by participants, but those intentions do not necessarily arise from similar dispositions. Discussions with the participants were undertaken with an eye (namely my eye) toward seeing their intentions and how social institutions such as school and family influenced their dispositions. Short of a full psychological and social profile, a complete analysis of the relationship between disposition and intentions of each participant is impossible. What follows is intended to exemplify such relationships, but it is far from exhaustive.

Received intentions. The participants' intentions in learning academic mathematics seemed to parallel at least to a degree some of the intentions of the institution. Rachel's current mathematics instructor told her that mathematics *"makes you use a different part of your brain"* and that learning mathematics teaches one patience. Rachel also says that

it's proven somewhere that if you really get down math into your brain, then you can pretty much do a lot of things because it's that logic wheel that's moving in your head. (GW.15)

The most often cited reason given to them by instructors or other educational agents was the need to be a well-rounded person.

Brenda: Do you think it's a reason, too, to make you more well-rounded? I've heard that about a lot of things we're required to take even though we won't probably use them on down the road. It makes us more well-rounded.

Rachel: Like history?

Brenda: I've heard that before.

Kelsey: I believe that. (GW.15)

Michael's intentions most obviously matched those of the institution. His concern was for using mathematics in his electrical engineering degree and in his recording and producing. When asked what his ultimate goal was for his mathematics course, he replied

To get a better foundation for math, structure, and learn all the rules because it has been awhile. Just to give me a better, stronger foundation because I'm going into a lot of math. I need all the backup I can get. (M1.14)

Shared, modified, and integrated intentions were not part of this tale at all, and received intentions were only a small part. Following is a discussion of more powerful and motivating purposes for the participants in this study to learn

mathematics. These purposes are reflected in Skovsmose' third category of intentions.

Underground Intentions. Most common among the intentions for learning academic mathematics were underground intentions—and particularly those that dealt with adjustment to and control of the environment. Because in a traditional educational setting control is elusive, the participants, just as Skovsmose' soldier, developed other intentions that they could control. Not only did these intentions control the present, they also controlled the future. Through time, an educational system has developed that rewards not necessarily learning, but rather it rewards performance and behavior that mimics learning. As is the case with many systems, e.g., the legal system and religion, what starts with good intentions becomes fraught with manipulation to get product and not process. A sort of impurity becomes apparent when the goals of the users of the system do not match the goals of the originators, yet the system is the only way to the end results. What were these goals and products and results that the participants wanted? What were their intentions?

Instrumental intentions often centered around making good grades furthering one's career, and getting a degree. These three, of course, are interconnected. Grades are a way of getting into college—and then a way of staying there until completion.

> Rachel: *My senior year, I took Algebra II, cause I needed Algebra II to get into a good college, and I really wanted to take it. (R1.12)*

James, also, views mathematics as a way of controlling his future.

> *James:* *I really enjoy that [math] was something that I wasn't good at once and now I'm doing good in it.*
>
> *Dana:* *Why do you think you're doing well with it now?*
>
> *James:* *Because now I actually care whether I get a good grade or not. I'm fighting really hard to keep a 4.0 so I can get out of the military and do something. It's really about the only way I can get to a good college from where I'm at now. I'm going to do what I can for that. (J3.1)*

Terri concedes that part of her desire to make good grades is her competitiveness. She very much wants to make A's. Brenda says that getting A's makes her feel good and makes her more excited and more interested. She tempers this, though, with the following.

> *It's not as important to me to make A's anymore as it was at the beginning. It's okay to make a mistake because that's how I am going to learn, but at first it was really important for me to make that A. (B2.20)*

Kelsey and Zach see mathematics as requisite to getting a degree and hence a better career. Both of these participants, though, were not sure a "move up" was what they wanted. Remember that Zach was unwilling to spend the time required to *"make senior."* Kelsey says

> *I've got to (get my degree) if I want to move up in my job field. And I really don't care to move up in my job field because I really like what my job is, but there's just so many people there that say, "Oh, Kelsey, you need to hurry up and get your degree." ...I guess I'm just getting my*

degree because it's the norm in society. If you don't have it, people kind of look at you like, like I said, a waste of life. (laughs) (K2.17-18)

James views his mathematics course as a way to get the credits he needs to *"get out."* Kelsey, in speaking of going away to a "real college," and living the university social life, stated that she would have gladly let a *"smart"* and *"cool"* roommate do her school work for her.

Oh, yeah, I would have done that in a heartbeat. So it's not like I really care to learn; it's just let's get the degree and if I learn it, I learn it, and if I don't, I don't. (K2.14)

Rachel also just wants out.

Rachel: My main objective is just to get school done and over with. I know a lot of people who just want to go to school and get it done. (R2.15)

While the heretofore mentioned intentions centered around grades and jobs and degrees, some intentions surfaced that possibly could be classified as instrumental because the ultimate objective is still control of or adaptation to the environment, but they are much more relational in nature. These intentions are not exactly as Mezirow (1991) described practical interests; I chose the term "relational," instead, to represent these intentions because they correspond to the need to be understood and the need for connection but not in a strictly communicative sense. Rather, the participants often wanted understanding and approval from parents and teachers for emotional and psychological reasons. For example, Rachel told of an incident with her current mathematics instructor in which she failed to get an assignment turned in on time. She was afraid to ask

him if she could turn it in late.

> *Rachel: The reason why I won't ask him is because I'm afraid he is going to judge me. I guess that's the big thing. I'm afraid he's going to look at me and say, "Well, you're just looking for an easy way out because you have a daughter. I know a lot of teachers are like that....*
>
> *Dana: Why does it matter if he thinks that?*
>
> *Rachel: I guess it's because I like him. He's a really good teacher and I don't want him to think anything negative of me. (R2.20-21)*

Kelsey also tied in her disposition of relational thinking with her intentions when she attempted to make sense of mathematics requirements.

> *I started out just really hating [math], but I'm more or less relating it to relating to other people. That's what I like to do—try to relate to other people. By me taking this class I'm looking at it as learning, not just the math subject, but learning how other people see it.... I'm looking at it as understanding other people and using it on the outside world to relate to other people. (K3.15)*

The interplay of disposition with intentions was apparent on several levels. Brenda's difficult life history was connected to her need for approval and her drive to achieve. Kelsey had a very different background from Brenda, yet she, too, developed an unhealthy need for approval. Kelsey, though, acquired an apathy for learning rather than a drive to achieve. Rachel struggled with a demanding father—one whom she could never please. Now she seeks to please her instructors. Though the background tales of the participants told in the

previous chapter are dramatic and compelling, dispositional *foreground* (interpreted before as a positive psychological meaning perspective) appeared to be a more powerful construct than background. Each participant had several background characteristics that could well have prevented achievement of goals. Yet each one has overcome those negative circumstances—to varying degrees—and sees passing that class or making those A's or getting that degree as attainable. Though underground intentions have resulted from lack of negotiated, collaborative goals, it has been those very intentions that have provided motivation for the participants to persist in the educational system.

It is important once again not to create an artificial dualism—this time between background and foreground. Foreground sets up what a person perceives as achievable, yet this cannot be completely divorced from a person's background. The idea that foreground is not completely at the mercy of background, though, should give developmental educators hope and should provide a place to concentrate efforts to help students succeed (and to help students examine what it *really* is in which they want to succeed).

The foregoing consideration of "Deconstructing 'Why?'" allowed both the participants and me to question some deeply held ideas about why academic mathematics is important to a "higher" curriculum. Participants had the opportunity to pose this problem—"to identify it, to try to grasp it, to understand it and to react to it" (Skovsmose, 1994, p. 16) as is the purpose of critical activity. It allowed us to examine beliefs and intentions regarding the learning of mathematics and how the participants have navigated the current educational

system. I now turn attention to a companion perspective on deconstruction and critique.

Deconstructing "How?"

The first part of this chapter considered the problem posed by some of the participants as to why mathematics was a necessary course and the ensuing questioning process. The remainder of this chapter considers a problem I posed to all the participants in an effort to challenge the notion that mathematics serves only a limited role in society and that the role it serves is disconnected and value-neutral. There seemed to be little propensity on the part of the participants to engage in a critique of mathematics and its social role. Around every bend in the road would come a statement that would relegate the role of mathematics to cooks, accountants, and engineers. And every well-intentioned question of mine intended to draw on a broader perspective was a dead-end. Enter Skovsmose again.

Skovsmose (1994) distinguishes between three types of knowing as they relate to mathematics. He uses the term "knowing" rather than "knowledge" to reflect the dynamic nature of these three interrelated concepts. First, *mathematical knowing* refers to what we typically think of as mathematical skills: reproducing mathematical thoughts, theorems, and proofs; performing algorithms for calculations; and inventing/discovering new mathematics. Second, *technological knowing* refers to the ability to apply mathematics and formal methods in technological development and construction. Finally, *reflective*

knowing involves the evaluation and discussion of technological aims and the social and ethical critique of the tools used to pursue those aims. Skovsmose argues that to concentrate solely on mathematical and technological knowing restricts our ability to assess the constructive as well as destructive results of our technological pursuits. Reflective knowing is essential to transcending current meaning structures and developing a broader awareness through which to judge technology. In making this point, he refers to what he terms the "Vico paradox."

He credits the Italian philosopher Giambatista Vico with formulating the idea that human beings can fully grasp only what they have themselves created. Skovsmose challenges that idea by proposing that, viewing technology as a human construction, human beings are unable to establish such an understanding. We have been quite incapable of predicting and controlling the uses of the ever burgeoning production of new technologies, of which mathematics is a "frozen" or "hidden" component. He continues by asserting that from the technological domain, technology can be changed or a technological problem can be solved, but a broader perspective on the consequences of technology is impossible. It is only through reflection and critique that we can grasp the social and ethical ramifications that follow from our own inventions.

Among the tasks of reflective knowing is an awareness of the "language games" involved in the mathematical modeling process. Natural language is based on commonsense interpretations of reality which are not always consistent or well-founded. Systemic language includes technical terms based on a selected theoretical framework. It highlights certain aspects of reality, and they become

part of a system. For example, the "ideal consumer" or "marginal cost" are terms from the systemic language of economics, and they serve to highlight certain aspects of economic life. Mathematical language uses specific mathematical functions to describe relationships between certain parameters. It is a step that formalizes the relationships that are theorized in systemic language. For example, marginal cost becomes formalized as the derivative of a function. Finally, algorithmic language is used to make a model numerically manageable; it is the step from the mathematical language to the actual algorithm for determining a numerical value. For example, it is the very precise formulation of finding a numerical value for the derivative of a function.

Each language is a different type of "game" with its own strengths and weaknesses. While necessary to utilizing the power of mathematics, neither mathematical language nor algorithmic language allow for normative discourse; both the prescription and the process have been formalized, leaving no room for critique beyond that of examining the process against its own criteria of use and precision. The imprecision of natural language is both a strength and a weakness, providing a threshold for critique by non-mathematicians but also limiting the depth of the critique. Skovsmose holds that systemic language maintains a "door" between natural language and mathematical language and provides an opportunity for discourse, overcoming the limitations both of natural language and the more formal languages. The mathematical modeling process can be thought of as a journey between these different languages. The languages, though, influence who has the opportunity to serve as a critic of a particular process; there are limits on

who can "journey" from discussion of a problem area into algorithms and back again. It is precisely this issue that disempowers developmental mathematics students. They generally have neither the mathematical knowledge nor the confidence to engage in a critique of the applications of mathematics.

How do we "get there" in an educational setting? How do we develop a venue for discourse? One potential solution to this dilemma is "scene-setting." Like most project work, scene-setting provides a context in which to make mathematics more meaningful. Scenes set up in a comprehensible way give students the opportunity to navigate the language games and not only gain mathematical and technological competence, but also reflective competence. Skovsmose (1994) maintains that

> there is a web of interrelationship between the types of knowing ...however, the web may easily be destroyed, and this is often done in school mathematics. Reflective elements have been put outside the door of the mathematical classroom and forgotten, and mathematics education has concentrated on the development of a mathematical proficiency. Several epistemologies have served only to emphasize this aspect. The web-structure has been torn apart and mathematical knowledge has been promoted as self-contained. Separation in education destroys the critical potential of mathematics education. Although a scene-setting may be artificial, it still may provide a natural way to develop mathematical, technological and reflective knowing as an integrated structure which it is possible to identify as the competence of mathemacy (p. 123).

To deal with the "dead-ends" and to promote reflection, I selected a "scene" to set up for the participants. Keeping in mind the limitations associated with language games for the participants, I chose this "scene" in particular because all the participants could relate to it and it had very obvious social ramifications. The level of mathematics required was manageable so that the participants could travel through the different types of language as they chose. It was based on an incident that had happened in our area about one year prior to the study.

The Scene

> A farmer/rancher from this county was driving on a certain highway. As he was preparing to turn left, he turned on his signal and began to slow down. Behind him was a trucker hauling jet fuel (remember the Air Force base in this area) who was speeding just a bit. When the trucker saw the man in front of him, he applied his brakes but did not have time to come to a complete stop. He went to the left because going to the right would have resulted in overturning the truck and probably a massive explosion. Just as the farmer turned left, the truck hit him on the driver's side. The truck had slowed sufficiently that the farmer was not hurt in the incident. However, a short time later the farmer suffered a stroke and was permanently disabled. He experienced a loss of speech, loss of short-term memory, and loss of certain motor functions. He could no longer work and his wife resigned from her job to care for him. The subsequent court case was

about determining an award for "loss of enjoyment of life." Agreement had already been reached on medical payments and compensation for lost wages. The plaintiff brought in an expert witness who was an economist at a west coast university. He had devised a mathematical approach to figuring the value of a person's life. He told them to imagine that there is something in the water in this town that is going to kill three people. No one knows which three it will be. What one-time contribution would one be willing to make to decrease the number from three to two? Multiply that contribution amount by the number of residents in the town and that will be an estimate of the monetary value put on a person's life.

In keeping with Skovsmose' entry points into reflective knowing, we considered the issues of whether this is an appropriate use of mathematics and what are the consequences of such formulations. The transitions through the different languages were just as Skovsmose suggested: neither sequential nor complete. Nonetheless, the journey was very fruitful in terms of illuminating "unconventional" uses of mathematics and the ethical considerations the participants referenced to evaluate those uses.

We discussed this "scene" during group interviews and during the final individual interview. I had also discussed it with Terri in her second individual interview. Though the original intention was to have three groups, the loss of two of the participants made that plan less than desirable. In keeping with Morgan's (1997) suggestion of having a minimum of three participants per group, we formed two groups: one group was composed of women; the other was composed

of men. Though I had not intended to separate the groups by gender, this was the best way to accommodate the participants' schedules.

I was amazed to see the difference in how the groups operated. The group composed entirely of women related well to each other. They were very supportive and relaxed. Basically, we had fun. The group composed of men and me was another story. It was characterized by tension and competition. Differences of opinion became staunch positions to be defended. Tempers even flared a bit. Rather than being a participant in the discussions, I felt I had to be the referee and be very careful to orchestrate questions and comments in such a way as to maintain control—which is not the epitome of critical research.

For the women's group, value of relationship, life, fairness, and mercy is woven in with mathematical understandings and avoidances. Following is the uninterrupted conversation regarding the scene.

Dana: What do you think? And how much would you contribute?

Kelsey: I wouldn't do no thousand or hundred. (laughter)

Terri: You're like me. It's like, do we know these people?

Kelsey: Yeah. If I knew it wasn't anybody I really knew and cared about—I don't want anybody to die. I just would go buy bottled water. (laughter)

Brenda: I'm sitting here soaking all this in.

Rachel: I know when we lived in Del Rio, their water is really, really bad. You could get colds and viruses, so we drank bottled water. So I think I would do the same thing. I'd just buy bottled water. (laughter)

Terri: But there is no bottled water.

Kelsey: It's in all the world, right? But only 3 people in Altus will die. (laughter) I would think about my kids and stuff.

Rachel: There would be some things I would have to know first. Like, if they really knew contributing money would stop the cause, and what—

Terri: But remember, they're using this equation to help figure out what they're going to give this farmer for loss of quality of life. This is what this scientist from San Francisco is saying. This is a hypothetical question.

Kelsey: If you couldn't drink water and you knew three people were going to die, and there's nothing you can do about it but give money, you'd probably think "Okay, it's my life; it's my kid's life; it's my neighbors life." You'd think of it that way, so you would probably just think of it as being a bill.

Terri: But it's just a one-time contribution, though. It's not like you're giving it monthly.

Kelsey: Oh, okay. I think maybe $50.

Terri: But if you knew it was one of your kids, you would give all the money in the world that you had. But just knowing it could be anybody out of 25,000 or 30,000 people, with it being that many, you think, "Gee, what are the odds of it being somebody I know."

Kelsey: But what if it is?

Terri: Exactly, do you want to take that gamble. There's a lot that you

have to really think about. It's not just—

Rachel: I'd move. (laughter)

Dana: You're not going to cooperate, are you? (laughter) Brenda? You haven't spoken.

Brenda: I'd take a gamble on it. ...It would also be compared to how much you make. If you don't make very much, you can't contribute as much as John Doe down the street that maybe has more, so I think it goes according to what you make. (GW.6-8)

Terri and I visited about this "scene" more in depth in an individual interview, and her remarks bear repeating here. Remember that Terri gets frustrated with math because it is ambiguous. There is *"no black and white."*

Terri: In our algebra books, somebody has pre-made the equation. We're not the ones who put those little problems in that book, and yeah, with these equations there is only one answer, but when you take what you just gave me—here I am, put in a situation to sit here and put a price on someone's life I don't even know. I'm supposed to figure out how much this person deserves. If you give me a problem with the numbers already in it—like okay, I have to find the area of this room. That's kind of different. But when you are putting human lives into the equation, I just don't see how—there is no set right or wrong answer. ...You've got too many areas that you can really touch with, and it's not as simple as doing a problem out of the book. ...(T2.12-13)

Upon learning of the $24 million award, she criticizes the court system and

greedy lawyers. She believes the size of the award is unjustified, and she *"just can't see putting a price on someone's life." (T2.14)*

Dana: Compare the math that was used in that case with school math.

Terri: Well, that math, you've got different factors that can change the outcome. There is no one set answer because you've got different factors playing a role in figuring out that total, and that can change. What you do in math class, when you are given a problem or an equation to solve, you've got the factors already plugged in for you. There are no other outside roles that can change it. If you've got 5 – 3, it is always going to be 2. ...In math class, it's like the teacher is giving you the rules. He's giving you the number to put in. Over here in this court case, they're having you decide what to put in. They're having you decide how to put a value on certain things. (T2.14-15)

The men's conversation was different. The transitions between the languages were still there, as were the ethical considerations; but the ethical considerations seemed to relate to fairness, rights, and independence. Relationship and connection were not as prominent.

Michael: I don't know. That would be very difficult to figure because you really can't put a value on anyone's life and take away their ability to do different things. He might like to hunt and fish...you really can't put a value on it.

Dana: But if you're on the jury, you've got to do something.

James: I think if that guy's entitled to anything at all in that situation, it

would be medical bills, I guess. But poor guy that just drove his truck the wrong direction.

Michael: I think he's entitled to more than just hospital bills and lost wages.

Zach: Well, it will be insurance or the Air Force that pays for it anyway. I would never give them what the attorneys want. At most I would give them ½. They come up with some of the craziest numbers because they get 1/3. The attorneys that come up with these numbers only worry about themselves. You would have to give him a monthly or yearly payment instead of saying to give him half a million or a million now. (GM.24)

When asked how much they would contribute to reduce the number of deaths from 3 to 2, they replied

James: The way my lucks been going, I'll pitch in 5 bucks.

Zach: That don't seem like a very good argument to me. It's probably right with all the nitrates we have in the water right now. To me that's not an argument.

Michael: Yeah, it's really not that good.

James: You have to understand the city itself, all the bureaucratic stuff they'd have to go through to spend money on this anyway.

Dana: Think of it like this. Three people here as compared to three people in New York City. The odds are obviously different. How much would you chip in?

Michael: It would just give me incentive to move.

Zach: Is this per year?

Dana: No, this is just a one time deal. You're paying to reduce the odds.

Zach: And it's not even a sure thing.

Dana: It's a sure thing that three people are going to die, you're just trying to reduce it down to two people.

Zach: It's a sure thing, or the odds are that it will reduce it to two.

Dana: It's a sure thing that you can reduce it to two.

Zach: It's such a weird argument because how could you reduce it to two? Our money out of our pocket?

Dana: How much would you chip it?

Zach: 100 or 200.

Dana: (talking to James) You'd do five.

Michael: I wouldn't do nothing, man. If I die, I die. The way I figure it, if it's gonna happen, it's gonna happen. (GM.27-28)

The majority of the discussion for both the men and women stayed within the domain of natural language. Both groups bantered around issues such as the water in the city and moving to another location, thus avoiding the more difficult matter of settling on a value for the man's loss of enjoyment of life. Natural language allowed the participants to approach the problem from within their own realms of experience, e.g., Zach's experiences with attorneys and Rachel's experiences in Del Rio. Though all the issues discussed by means of natural language were not obviously germane to the topic at hand, they provided a way for the participants to situate the "scene" in terms of their own views of reality.

Natural language is thus familiar and comfortable, making it easy to avoid the transition to a more mathematically challenging language game.

Terri was willing to enter a bit more formal language game as evidenced by her analysis of the "equation" offered by the economist and the steps involved in its use. Considering Terri's competence in school mathematics, I am not surprised by her willingness to transition to a different level. Skovsmose (1994) discusses the limitation on the number of persons able to follow the modeling process from natural language into algorithmic language and back to natural language. He bases this limitation on the mathematical, technological, and reflective competence of those involved in critique. I see, though, the added effect of affective factors such as confidence. Remember that Terri discussed not only her surprise at her level of understanding of the material taught in her algebra class, but also her increasing level of confidence in her abilities.

I also see a social dimension involved in the transitions between the different types of languages. Within the men's group, the level of comfort and trust were simply not adequate to encourage deeper discussion of both the mathematical and ethical issues regarding the scene. The participants were guarded with their responses in contrast to the women's group where views were openly expressed and accepted.

In addition to the restrictive effects of group dynamics were the restrictive effects of the algorithmic manner in which the "equation" was presented (as it was to the jury). The simplicity of picking a dollar value one would be willing to contribute to reduce the number of deaths from three to two and then multiplying

it by the number of residents in the town seemed to hide the intent of the equation and the assumptions underlying it. Within the women's group, Terri played a role in highlighting the effects of the parts of the algorithm. Within the men's group, I played that role. Specifically, Terri and I both alluded to the purpose of multiplying by the number of residents in the city and the effect population might have on one's decision as to an amount to contribute. Simply "following the directions"—whether determining the value of a person's life or figuring one's taxes or calculating funding for a school district—allows a consumer of mathematics to slip into complacency and unquestioningly participate in mathematical formattings. A case in point is the federal income tax forms in which the dissected and simplified algorithms hide the subjective decisions made regarding who benefits from various tax credits and deductions. However, mathematical formulations of social processes are not problematic in and of themselves; it is the lack of scrutiny, and indeed the inability to subject formulations to scrutiny, that endow them with the potential to become oppressive.

The point of scene-setting was to introduce an unconventional use of mathematics and challenge the participants to grapple with social and ethical ramifications seldom portrayed in a traditional classroom. The participants did indeed wrestle with the idea of using mathematics to assign value to a person's life and with a level of subjectivity not often associated with mathematics. School mathematics may in some ways be frustrating, intimidating, and alienating, but it is also comfortable because of its sterility and familiarity. This comfort level,

though, can prevent an *initiated* critique from becoming a *sustained* critique. The next section illustrates the fate of the participants' critique of mathematics' social role.

Participant Conclusions

During the final individual interviews participants were asked to discuss what they had learned about themselves, about mathematics, and about the role of mathematics in society. It was quite interesting to see what affect, if any, considering math in these unconventional ways had on the participants.

The participants gave a variety of answers to the question of what they had learned about themselves after having discussed all these issues. Michael said that through the study he has gotten more confidence. Rachel and Terri were glad to learn they were not the only ones who struggled with algebra and making sense of it. Terri also said she now realizes that she worries too much and does not give herself enough credit when it comes to doing math. When asked if he had learned anything about himself, James—true to form—replied

> *About myself? Uh—I would love to say yes, but I just can't think of anything. (J3.4)*

When answering the question regarding what they had learned about mathematics, their answers seemed to relate more to their mathematics courses than to the study. For example, Michael said he has learned that mathematics is not as hard as he thought it was, and Rachel learned that you must practice to

understand it. Brenda still likes it, and Kelsey still hates it.

The question regarding what they had learned about the role of mathematics in society yielded some very interesting, and in some cases discouraging, answers. All of the excerpts included below came from the participants' final interviews.

> *Dana: What do you think about using math in that way (the court case)?*
>
> *James: I don't know. I don't think about math in those things.*
>
> *Dana: How do you usually think of math? Describe math to me.*
>
> *James: My mind works on math in class and for half an hour after class when I do my homework and maybe a little bit before a test, but other than that, it just—(voice trails off) (J3.3)*

Michael likewise returns to his pre-study conceptions.

> *Dana: Thinking back over the study, all the things we've thought about, what have you learned about the role math plays in our lives as people?*
>
> *Michael: It plays a great, great part from balancing your checkbook to taking classes. (M3.10)*

Brenda took two approaches to answering this question.

> *Brenda: Like I said before, I really think that everybody deals with math every day. Every day there is something. Like with me, when I look at something I see angles, I see dimension—everything has something to it. Everything does. I think it plays a big part.*
>
> *Dana: ...Do you see any political uses or cultural uses?*
>
> *Brenda: No. (B3.3)*

Later in the interview, though, when asked if thinking through some of the issues had helped her, she replied

> *It did. I never thought about things like that. Even though I knew math was in everyday things, I never quite put it in those areas. It made me stop and think. (B3.5)*

I also asked the participants what effect the study would have on their future actions. Though Zach had been so introspective and willing to engage in critique during the interviews, his resignation to the status quo became apparent. He wrote that he would *"try to accept the need and move on to the next course." (ZM.3)* Michael and Kelsey both plan to take a more proactive stance in getting help when they need it. Michael specifically mentioned resources on the internet, and in fact had already explored this by going into chat rooms and asking for help with his homework. Kelsey planned to go to her teachers more when experiencing difficulty. Being a mom myself, I was particularly touched by Rachel's answer to this question.

> *I'm definitely going to be involved in [my baby's] math career—how she's doing, and I really want to be there if anything goes bad. My dad was always gone in the military, and when he was there, it was fifty questions about all my schooling, and then he was gone again, and then he was back. And for [my baby], I want to be there all the time. (R3.8)*

Brenda says she will not do anything different, though she will probably look at mathematics differently. Terri plans to try and trust herself more. She wrote

> *I will try to look at math as a tool that may or may not help me in my daily*

life. I won't be so quick to say that I can't do something because it involves math either. I think that I will be more understanding to other people and their abilities when it comes to doing math or understanding it. I know that my fears and anxiety won't go away overnight. I also know that having a bad teacher can put me right back to where I was at the beginning of these interviews. Should that ever happen, well, I guess that I will have to call you, Dana, and have you reassure me and remind me of what I am saying now. (TM.6)

Throughout this chapter we have analyzed the participants' views of mathematics and mathematics education. We have considered the problem they posed regarding the requirement of academic mathematics in the curriculum, as well as the problem I posed regarding an unconventional use of mathematics. The deconstructive process revealed both distorted and enabling meaning perspectives; it also revealed a lack of purposeful, internalized intentions. Deconstructing "how" allowed us to follow as participants engaged a subjective application of mathematics with obvious ethical implications. The discussion demonstrated both positive and negative aspects of the language games involved in critique of the uses of mathematics in society.

CHAPTER 6

REFLECTIONS AND CHALLENGES

Having woven the tale of the participants and their views regarding the deconstructive process, I now turn to my own conclusions and the implications I see for developmental mathematics education and beyond. I begin with a summary of the original research questions and preliminary answers.

Summary

The first question, that of the participants' initial conceptions of the role of mathematics in society, revealed that most of the participants saw a very limited role for mathematics in society. The usual checkbooks, cooking, and engineering predominated their thinking—of course, this was "basic mathematics" rather than the "academic mathematics" expected of them in the higher education setting. Academic mathematics was just that—academic. Mathematics in the form of algebra was about school and had little relevance to the lives of the participants.

The second question asked how this initial conception of mathematics in society changed over the course of the study. Without the scene-setting, the participants would probably have experienced no change at all. Remember that the purpose of the scene-setting was to encourage deeper reflection on less obvious uses of mathematics. During the group interviews, the conversation led me to believe that the participants did indeed have an "edge of chaos" (Waldrop, 1992) experience. Momentarily they were cast into a miry mix of old views, new views, and an uncomfortable incongruity between the two. Ethics, feelings, and

ambiguity typically not associated with mathematics suddenly confronted the participants. As evidenced in the preceding chapter, though, the "moment" was short-lived. The participants seemed to come full-circle back to their initial views of mathematics as utilitarian and disconnected from subjectivity. Or maybe not. Maybe the journey through the study was more of a spiral in which the participants came close to what they were before, but with a small change that has the potential to feed back on itself and eventually result in transcendence. After all, the Butterfly has no idea she will shortly be transforming a storm in New York.

The third question dealt with what the participants questioned about mathematics and mathematics education. Most of the participants conceived of academic mathematics as being disconnected from their experiences. It was this sense of disconnection that led to the deconstructive questioning of mathematics requirements in higher education. Terri, Zach, Rachel, and Kelsey were searching for an answer as to why mathematics—such a useless subject—was included in the curriculum. Particularly for Kelsey, the requirement was not simply an annoyance, it was a barrier to achieving her goals. Though these four participants questioned the inclusion of algebra in the curriculum, they had no one of whom they could ask the question. Someone, somewhere had decided its importance for them and the invisible nature of this someone held their critical questions at bay.

The fourth question of how the critique differed for the various types of students participating in the study was answered in only a limited way. Gender differences became apparent, but those differences seemed to be as much related

to interpersonal dynamics of the research process as they were to ideology. Political correctness shielded the participants from having to fully engage this question. Traditional stratifications by such constructs as age, gender, and enrollment status seemed not to have the explanatory power of less common constructs such as disposition and intentionality. Those whose goals were most thwarted by mathematics were the ones who most vehemently questioned its inclusion in the curriculum, yet it seemed to be those same people who were willing to explore a role of mathematics deeper than the proverbial checkbook.

Fifth, in keeping with the seemingly spiral effect of the problem-posing process, the participants' predictions of future actions mirrored their past actions—with minor changes. Whether it was Brenda saying she would look at things a bit differently now or Kelsey determining to proactively seek help when she has a problem, the seeds of change have been planted and have the potential to grow. Rather than a traditional feedback loop in which the object is to correct deficiencies, I view this process as positive feedback in a dynamic system. Future action is not a one time event. Rather, it is many events in succession, each one or each series of events affecting the next.

Further Reflections

Where does this leave us—the triad of the researched, the researcher, and the reader? What meaning does this project have for future theory development and practice? How do we continue from here? Having reported some basic answers to the research questions, I now address these challenges. I do so still

adhering to the theoretical and philosophical framework for this study. I maintain my emphasis on connection, relationship, and interaction. For purposes of organization, I will address each member of the triad separately, but I recognize in actuality the overlapping roles, responsibilities, and relationships among the three entities. Each has played a role in shaping the direction of this study and will continue to play a role, even though maybe implicitly, in meeting the challenges set forth.

The researched

The participants in the study had the opportunity to engage in problem posing, to explore more deeply questions about mathematics and its uses. They were able to deal with the question of why school mathematics is important and to do so seriously. But to what end? It was not the mathematics nor the requirements that changed in this project, it was the participants. The critique was left incomplete. The participants were able to define the object of critique and articulate their issues with mathematics as it is currently defined in most educational institutions, but they were frozen in their efforts to move beyond their initial critique. I think back to Zach's metaphor for mathematics and consider its applicability here. Zach stated that doing mathematics is like *pushing a cart uphill. If you don't keep going forward, you might slide back. If you don't keep learning or using it, you might forget what you've learned.* Is critique somewhat like Zach's mathematical cart? If you do not continue pushing it up the hill, do you slide back?

A different possibility, though, is the chilling effect of fear—a fear of what is on the other side of the hill. What happens to students who fully engage critique, who go beyond the definitional phase? What is it they are giving up? What happens if they reject current prescriptions for mathematics education? What are their options? Simplistic notions of emancipation overemphasize the reasoning powers of subjects to achieve full consciousness (Lather, 1991). Such notions also fail to account for the ensuing risks associated with rejection of ideology. "The synergism of the conversation between resistance postmodernism and critical theory involves an interplay between the praxis of the critical and the radical uncertainty of the postmodern" (Kincheloe & McClaren, 1994, p. 144). As those participating in critique address the attendant crisis, they face "structures of risk" (Skovsmose, 1994, p. 20). In other words, prediction of the "outcome" of critique is tenable at best. A solution to one crisis could indeed lead to another.

For our particular situation, if the "crisis" of an irrelevant mathematics is solved by rejecting the status quo, where do the participants turn? The ideology of school mathematics pervades our educational systems. Concepts such as a "seamless education," whether referring to vertical moves between providers as in advancing from public school to higher education or to horizontal moves as in transfer among colleges and universities, force a uniformity of curriculum so that a rejection of one means a rejection of all. Imagine also the implications of a national curriculum and the overwhelming power vested in the chosen program of mathematics. Possibilities for critique would be even more daunting and the assumptions underlying mathematics education buried further. The resolution of

the first crisis by rejection of an irrelevant curriculum leads to the crisis of no opportunity for education at all.

A second situation exists for the participants of this study that relates to the tentative nature of the critical process. Not only are the participants faced with a decision regarding a mathematics curriculum, they must also deal with an invisible authority structure—a nameless, faceless entity to whom they defer in judgments regarding their educational decisions. Suppose through the critical process the entity becomes visible and the participants have a name and face to associate with curriculum decisions, class placement, graduation requirements, etc. What becomes the logical end? Remember that Kelsey offered a suggestion as to who "they" might be, but even in recognizing the "head of the college" as one possibility, she was unwilling to go to that person and pursue the critique. Her own powerlessness was only made more apparent.

Suppose, though, that someone had been willing to press ahead, to go to the identified "they" and work toward a more appropriate curriculum. What would they find? On the one hand, the possibility exists for a viable solution; but the possibility also exists that the participants would only exchange one "hidden they" for another. Education does not exist in a vacuum, being affected by such establishments as government, business, and religion. The overwhelming prospect of uncovering one "they" after another could discourage the critical process, or it could shift the direction to the search for the fundamental "they" who seems to have power over all.

Skovsmose (1994) addresses a similar issue as he discusses the search for

a fundamental crisis that, if solved, would automatically solve all others. He maintains, though, that "because the main problem is so fundamental and the solution so difficult to imagine, the consequence easily becomes fatalistic" (p. 21). What he advocates instead is a "grey dialectics" approach in which even small responses to a crisis have the possibility of bringing about change.

> Crises may interact because they belong to reality, but because the interaction is stochastic it is impossible to predict the consequences of these interactions, and therefore it becomes impossible to predict the consequence of any 'management of crises' (p. 21)

When we view critical change from this vantage point, we see possibilities in uncovering at least one layer of the "hidden they" because we cannot predict the iterating and interacting effects of even minor change. Remember the Butterfly.

The researcher

The second part of the triad with whom I must deal is me. In evaluating the research process, I must subject my own assumptions and actions to scrutiny. I must examine more deeply the role I played in shaping the direction and results of this project. In the previous section, I addressed the incomplete critique as it related to the participants, but what role did I as the researcher play in limiting the critique?

The first possibility lies in my exaggerated avoidance of imposition. I had difficulty at some points evaluating whether I could and indeed, should, nudge the participants further. As reported in the "considerations" section of chapter 3, I

have a propensity to question the status quo from my own perspective, but I hesitate to challenge others. My own background and disposition is one of tolerance and acceptance—to an extreme. I enjoy theoretical engagement, but the face-to-face, "real-world" challenge to another to change their beliefs is very uncomfortable for me. Though the point of critical research is not to force a change, it *is* the point to present a strong challenge to act on inequities and misunderstandings. The researcher in a critical research project has an awesome responsibility to avoid the extremes. On the one hand my careful avoidance of imposition is to be applauded because of my sincere respect for the views of the participants and my aversion to objectification of others. On the other hand, though, an unwillingness to act on uncovered "crises" leaves the status quo as the only option—but possibly with a greater dissatisfaction.

I have learned that a critical researcher does not simply hold open the door of critique as a "gentleman" or "gentlewoman;" the researcher must adopt a stance of "I'll go with you"—not "after you" or "before you," but "with you." I made the offer to Kelsey to literally go with her to question the *head of the college* regarding curricular requirements for her degree. She declined and suggested I go in her place. Looking back, that might not have been a bad idea, at least to start the process, but my timidity about risking a "mistake" in conducting the research kept me bound in the chains of "proper" and "untainted" research. In so doing, I held open the door, but no one went through.

One of the strengths of the research process was the ease with which the participants and I connected, making it possible for us to cover a great deal of

ground in a relatively short amount of time. The limited time frame (four months) probably affected the depth of the critique, but given the exploratory nature of this project, I see hope that with more experience and a narrower focus, future critical research need not take greatly extended periods of time. I believe it is called a "learning curve."

In addition to the research process itself, I must also consider my own reaction to mathematics as it is currently structured in the educational system. For years students have asked me why they must "take" academic mathematics and when they would ever use it. I must admit my own frustration at the lack of good answers to their questions. Though I could list many areas of application, each area appealed to only a few students. I suppose I have been looking for that "universal" application to which everyone could relate. Though I am certainly not naïve enough to think I have found *the* application, I do think critical mathematics education has the potential to allow students to find their own areas of relevance. Shared, modified, and integrated intentions (Skovsmose, 1994) give students a degree of control, as well as responsibility, in their learning. When directed activity becomes meaningful, purposeful activity, students are empowered to make the mathematics their own and need not rely on my explication of the importance and usefulness of mathematics.

I question the wisdom of requiring remediation in "algebra." Indeed, most developmental mathematics courses center around basic mathematics and algebraic symbol manipulation. The goal is to make up for lost time, to teach students in one or two semesters what they "should have" learned in two or three

years in high school. Besides the shallowness of this rationale, it is also doomed to failure in many cases unless the student *did* learn to do algebra in high school and simply needs a refresher. Even at this, what is the point? Is it to prepare the student for more symbol manipulation in trigonometry and calculus? Is it to check off a requirement so one can say he or she is "generally" educated, to boast that he or she "made it through" college algebra? I agree with the participants that much of what traditional mathematics has been about *is* a waste of time and energy. It does not prepare them for critical, quantitative reasoning; it just prepares them for the next course.

So, did I plant these words and thoughts into the minds of the participants? I think not. I have no reason to question the status quo; in such I excelled. I can manipulate symbols with the best of them. Through listening to my students and the participants in this study and through reading the influencing literature, I faced my own disorienting dilemma. Beliefs about mathematics as objective and value-neutral no longer fit with my experiences. I saw something new. Mathematics and mathematical learning are now more powerful constructs, affected by a broader social context, no longer self-contained and self-important. It is precisely this idea I hope to convey to future students and to continue to research.

Having considered the researched and the researcher, I now focus on the reader—the collective audience. What challenges are there in this research? What implications for theory and practice? I assume the audience to be students, teachers, administrators, or more generally, anyone interested in developmental or critical mathematics education. What are some possible ways for the audience to

make meaning of this research and to take it to the next level?

The reader

Perpetual critique is the primary call that arises from this research. Whether "deconstructing 'why?'" or "deconstructing 'how?'" the questioning process is essential to transformation of personal and social perspectives, two perspectives which are inextricably integrated and affect one another profoundly. The critique should address at least the issues that were developed in this study, specifically intentionality of learners and uses of mathematics not commonly acknowledged in the traditional classroom.

The intentions of the participants were primarily underground intentions. Learning mathematics is about degrees, grades, and "getting out." The participants seldom acknowledged a role of mathematics in their lives beyond basic processes of arithmetic. Remember, though, that these instrumental intentions provided motivation to persevere through the irrelevance. Instrumental intentions provided power and control to the participants, but we must ask what is lost when students simply close their eyes and grit their teeth and exist for that moment when they turn in their final exams and walk out of the classroom to never think about school mathematics again. Our students miss the deeper opportunities for personal and social growth as well as the opportunity to develop a critical competence regarding the uses of mathematics in society.

Most of the participants in this study had strong instrumental intentions, but developmental educators know that there are many students—like Kelsey—

who do not possess this strong motivation. Underground intentions need not be instrumental; the participants in this study also had relational intentions regarding their learning. These are the intentions evidenced in this research, but what are other possibilities? What intentions exist for the student who chronically misses class? for the student who fails to turn in assignments? for the student who sleeps in the back of the room? Maybe such behaviors are defense mechanisms or maybe a student is experiencing an incongruity between expectations about college and what he or she has actually found. We are not the saviors of developmental students, but as educators we do have a responsibility to help them uncover their intentions and deal with those intentions in an appropriate way.

We must also reflect on what ways the educational system perpetuates and encourages underground intentions. What answers are given when students ask why they have to "take" a particular mathematics course? When they are told "it is to prepare you for the next course" year after year after year, they have actually been told that the mathematics is not important—only progressing through the system is important. Do we as educators and parents promote grades or learning? As a mom, do I ask my son what he learned or do I ask what grade he received? As employers, do we ask about competencies or do we ask about grade point average? Remember Terri's complaint about how many people she knew who were working outside their major area. Knowledge was not important, only a piece of paper certifying that they were indeed "educated."

Formalization, whether in curriculum or mathematical formulations or religious ceremony or tax systems or legal codes, etc., makes for efficiency, but

without a continual revisiting of the foundational framework from which it was developed, intentionality becomes superficial. The door to the room for improvement remains closed. An ideology evolves that hides inequities or incongruities as common sense, and questions are dismissed either out of a fatalism that says "nothing will change anyway" or out of a self-denial that says "I must be the one who doesn't 'get it.'"

In addition to reflections regarding intentionality, the reader should consider the role of educators in developing an awareness of the uses of mathematics in society that go beyond checkbooks, cooking, and engineering. The uses to which I am referring are not simply additional sterile applications typical of current curriculum. Mathematics has ethical and political dimensions essentially ignored in traditional education. This research utilized scene-setting as a way to introduce the participants to subjective uses of mathematics. Though scenes are contrived, they have the potential to bring out features of reality which students may subject to critique. Given the age and experience of most developmental mathematics students, critical project work need not be fictitious. The media, government, legal issues, political campaigns, etc. are replete with issues that could be useful for developing not only mathematical and technological competence, but also a reflective, critical competence.

More is not always better. To increase an awareness of the uses of mathematics in society, we need not develop more mathematics courses. We need rather to diffuse its influence and application to the broader curriculum. Does it make sense to discuss mathematics in a history or government class?

Should we consider the use of mathematics in the advertising media? If we agree that mathematics is one of the tools we use to organize and make sense of our world, we could also agree that its influence pervades much more of the overall curriculum than formal mathematics courses. Greater knowledge of symbol manipulation is not a sufficient condition to develop critical competence; we need a more encompassing platform from which to evaluate the effects of mathematics in our lives.

Much of the formal mathematics in our world has become buried. I saw this with the participants. They knew mathematics was important, but articulating exactly why seemed to escape them. The concept I used to address this issue was deconstruction. Skovsmose (1994) suggests another concept: mathematical archaeology.

> An aim of a mathematical archaeology is to make explicit the actual use of mathematics hidden in social structures and routines. It is the process of digging mathematics out and drawing attention to how mathematics moves from being an explicit guide to becoming a grey eminence underlying, for instance, social and economic management....It is a response to the integration of mathematics into our second nature (p. 95).

A first step toward developing a mathematical archaeology is to create opportunities to talk *about* mathematics, whether this comes in the form of scene-settings, journal writing, group discussions, or some other format and whether the opportunities are in mathematics or history or economics or some other classroom. The scene-setting in this project was of my device, but this need not

be the case. Students may choose their own areas of interest to subject to scrutiny. The options are limitless if we consider the possibility that within every ethical consideration there is a mathematical component. The participants in this study all had some connection with the Air Force; an example of a mathematical archaeology that might interest them is the mathematics of war. What mathematical considerations go into determining an "acceptable" number of casualties? What mathematics is used to develop weapon systems?

To arrive at this point of talking *about* mathematics, we must abandon the linearity with which we approach mathematics education. We have adopted the idea that symbol manipulation and algorithmic method must come first, then application, and if we accept the challenge of this study, then critique. Not only is this questionable epistemology, it also risks "running out of time" and giving short shrift to application and critique. If we embrace the interconnection and interaction among mathematical, technological, and reflective knowing, we may address critique in tandem with skills and application.

We are no longer equipping students for a stable world in which each day is much like the one before and the one after. We must give them tools to deal with change; we must give them a broader scope of reference to recognize when old structures and beliefs no longer adequately address social problems. Remember the Vico Paradox (Skovsmose, 1994); we cannot predict the consequences of our technologies, nor can we predict the world for which we are preparing our students (Davis, 1995). Giving them a foundation to deal with rapid change is inconsistent with old methods for mathematics education designed

to produce uniformity of product and knowledge. To adequately deal with change, we must be able to subject current social structures to scrutiny and to create strategies for adapting to new contexts. Mathematical critique is an essential element in this process.

Recommendations for Future Research

Development of critical mathematics education requires more research and more theoretical engagement. An area that at this point is quite esoteric needs much study about how to make it practical. What does this approach mean for the classroom teacher who has 150 students each day and a family to care for each evening? Researchers who appear from the university long enough to gather some data and then rush back to the office to write and publish in journals never read by "real world" teachers do little good. It is collaboration between teachers in the field and professional researchers that holds the most promise. Only in remaining grounded to the lived experiences of mathematics teachers and their students does this educational approach have any hope of surviving and making a contribution.

I see the need to focus on those who lack an articulated intentionality—shared, received, instrumental, relational or otherwise. Even in the absence of shared intentions, most of the participants in this study were motivated to overcome barriers and to persist in their education. What are the perspectives, though, of those who choose to leave? What is the relationship between their background and foreground? What areas of critical questioning or deconstruction

would be helpful in their development?

It would also be helpful to extend this type of study to include mathematics educators (at any level, developmental or otherwise)—to give instructors and other professionals the opportunity to critique their own assumptions regarding the role of mathematics in society. Because their mathematical and technological knowing is more extensive than developmental students, they have the keys to travel more easily and more deeply through the language games (natural, systemic, mathematical, and algorithmic).

As educators and students engage in mathematical archaeology, it will be important to document not only their changing views of mathematics, but to document critical action so that it can be diffused to other schools and colleges. Though a prescription for critical mathematics education is antithetical to the concept, it does not preclude the possibility of sharing processes and ideas in an effort to expand the dialogue. As we deal with the "structures of risk" (Skovsmose, 1994), we should share with colleagues whether crises were solved or new ones created as we engaged the critical process. For example, did the participants find another "hidden they" to replace the one revealed? Did they exhibit fatalistic tendencies or did they experience empowerment?

I also see a need for studies that examine how our educational system and our media perpetuate current ideologies regarding mathematics. What phrases and practices promote instrumentalism? How do teaching methods and materials contribute to the idea that mathematics is both irrelevant and value-neutral? What role should educators play in deconstructing current ideology? These concepts

have been addressed to a degree in the field of ethnomathematics, but they have not made their way into the classrooms of our schools and colleges. I repeat my call to work closely with those in the trenches (if there is indeed a war going on) and bridge the gap between research and practice.

When a positive, purposeful view of self interacts with a deeper recognition of the role of mathematics in our society, mathematics learning takes on a dimension of consequence and empowerment. "I can" and "I need to" provide a strong motivation to learn mathematics—and not just any mathematics, but rather that which provides power to engage social processes critically and with an air of confidence. If we are to make mathematics natural (Freire, D'Ambrosio, do Carmo Mendonca, 1997), we must reveal its uses and ensure that every citizen has the competencies needed to make informed decisions, to evaluate claims, to reveal inequities, and to participate in the creation of new social structures. We do not simply need a more mathematically capable society, we need a more mathematically critical society.

References

Abraham, A. A. (1991). They came to college? A remedial/developmental profile of first-time freshman in SREB states. Issues in higher education no. 25. Atlanta, GA: Southern Region Education Board.

Abraham, A. A. , Jr. (1992). College remedial studies: Institutional practices in the SREB states. Atlanta, GA: Southern Region Education Board.

Almeida, D. A. (1991). Do underprepared students and those with lower academic skills belong in the community college? A question of policy in light of the "mission." Community College Review, 18(4), 28-32.

American Mathematical Association of Two-Year Colleges. (1995). Crossroads in mathematics: Standards for introductory college mathematics before calculus. Memphis, TN: Author.

Barker, J. L. (1994). Selected factors related to academic achievement of developmental introductory algebra students at the two-year college level. (Doctoral dissertation, University of Oklahoma, 1994).

Barr, R.B., & Tagg, J. (1995). From teaching to learning—A new paradigm for undergraduate education. Change, 27(6), 13-25.

Berenson, S. B., Carter, G., & Norwood, K. S. (1992). The at-risk student in college developmental algebra. School Science and Mathematics, 92, 55-58.

Betts, F. (1992). How systems thinking applies to education. Educational Leadership, 50(3), 38-41.

Board on Mathematical Sciences (1989). Everybody counts: A report to the nation on the future of mathematics education. Washington, DC: National

Academy Press.

Bogdan, R. C., & Biklen, S. K. (1992). Qualitative research for education: An introduction to theory and methods. Boston: Allyn and Bacon.

Borg, W. R., & Gall, M. D. (1989). Education research: An introduction (5th Ed.). White Plains, NY: Longman.

Boylan, H. R. (1999). Exploring alternatives to remediation. Journal of Developmental Education, 22(3), 2-10.

Boylan, H. R., Bonham, B. S., & White, S. R. (1999). Developmental and remedial education in postsecondary education. New Directions for Higher Education, no. 108, 87-127.

Buerk, D. (1994). Broadening students' conceptions of mathematics: Theory into action. In D. Buerk (Ed.), Empowering students by promoting active learning in mathematics: Teachers speak to teachers (pp. 45-48). Reston, VA: National Council of Teachers of Mathematics.

Burton, L. (1987). From failure to success: Changing the experiences of adult learners of mathematics. Educational Studies in Mathematics, 18, 305-316.

Caniglia, J., & Duranczyk, I. M. (1999). Understanding mathematics backwards: A qualitative analysis of students' mathematical beliefs through autobiographies. In J. L. Higbee & P. L. Dwinell (Eds.), The expanding role of developmental education (pp. 43-55). [On-line]. Available: www.umkc.edu/cad/nade/nadedocs/99monpap/tcmonp99.htm.

Capra, F. (1983). The turning point: Science, society, and the rising culture. New York: Bantam Books.

Casazza, M. E., & Silverman, S. L. (1996). Learning assistance and developmental education: A guide for effective practice. San Francisco: Jossey-Bass.

Code, L. (1991). What can she know? Feminist theory and the construction of knowledge. Ithaca, NY: Cornell University Press.

Commission on the Future of Community Colleges. (1988). Building communities: A vision for a new century. Washington, DC: American Association of Community Colleges.

Comstock, D. E. (1982). A method for critical research. In E. Bredo & W. Feinberg (Eds.), Knowledge and values in social and educational research (pp. 370-390). Philadelphia: Temple University.

Cranton, P. (1994). Understanding and promoting transformative learning: A guide for educators of adults. San Francisco: Jossey-Bass.

Cross, K. P. (1974). Beyond the open door: New students to higher education. San Francisco: Jossey-Bass.

Cross, K. P. (1975). The elusive goal of educational equality. In J. F. Hughes & O. Mills (Eds.), Formulating policy in postsecondary education (pp. 191-201). Washington, DC: American Council on Education.

Cross, K. P. (1976). Accent on learning: Improving instruction and reshaping the curriculum. San Francisco: Jossey-Bass.

Cross, K. P. (1993). Closing the gaps between teaching and learning. Journal of College Reading and Learning, 26(1), 1-10.

Darby, D. D. (1996). The new science: Connections with developmental

education. In J. L. Higbee & P. L. Dwinell (Eds.), Defining developmental education: Theory, research, and pedagogy (pp. 5-10). Cold Stream, IL: National Association for Developmental Education.

Darken, B. (1991). Arithmetic + calculators + college students = ? Journal of Developmental Education, 15(2), 6-8, 10, 12, 35.

Davis, B. (1995). Why teach mathematics? Mathematics education and enactivist theory. For the learning of mathematics, 15(2), 2-9.

Depree, J. (1998). Small-group instruction: Impact on basic algebra students. Journal of Developmental Education, 22(1), 2-6.

Doll, W. E., Jr. (1989). Foundations for a post-modern curriculum. Journal of Curriculum Studies, 21, 243-253.

Ernest, P. (1996). Varieties of constructivism: A framework for comparison. In L. P. Steffe, & P. Nesher (Eds.), Theories of mathematical learning (pp. 335-350). Mahwah, NJ: Lawrence Erlbaum Associates.

Even, M. J. (1987). Why adults learn in different ways. Lifelong Learning, 10(8), 22-25, 27.

Flynn, W. J. (1999). Rethinking teaching and learning. Community College Journal, 70(1), 8-13.

Frankenstein, M. (1987). Critical mathematics education: An application of Paulo Freire's epistemology. In I. Shor (Ed.), Freire for the classroom: A sourcebook for liberatory teaching (pp. 180-210). Portsmouth, NH: Boynton/Cook.

Frankenstein, M. (1990). Incorporating race, gender, and class issues into

a critical mathematical literacy curriculum. Journal of Negro Education, 59, 336-347.

Frankenstein. M., & Powell, A. B. (1989). Empowering non-traditional college students. Science and Nature, 9/10, 100-112.

Frankenstein, M., & Powell, A. B. (1994). Toward liberatory mathematics: Paulo Freire's epistemology and ethnomathematics. In P. McLaren, & C. Lankshear (Eds.), Politics of liberation: Paths from Freire (pp. 74-99). London: Routledge.

Freire, P. (1970). Pedagogy of the oppressed. New York: Seabury.

Freire, P., D'Ambrosio, U., & do Carmo Mendonca, M. (1997). A conversation with Paulo Freire. For the Learning of Mathematics, 17(3), 7-10.

Glaser, B., & Strauss, A. (1967). The discovery of grounded theory: Strategies for qualitative research. Chicago: Aldine.

Gleick, J. (1987). Chaos: Making a new science. New York: Viking.

Glesne, C., & Peshkin, A. (1992). Becoming qualitative researchers: An introduction. White Plains, NY: Longman.

Gourgey, A. F. (1992). Tutoring developmental mathematics: Overcoming anxiety and fostering independent learning. Journal of Developmental Education, 15(3), 10-12, 14.

Gray, S. S. (1991). Ideas in practice: Metacognition and mathematical problem solving. Journal of Developmental Education, 14(3), 24-26, 28.

Grumet, M. (1990). Show-and-tell: A response to the value issue in alternative paradigms for inquiry. In E. G. Guba (Ed.), The paradigm dialog (pp.

333-342). Newbury Park, CA: Sage.

Guba, E. G. (1990). The alternative paradigm dialog. In E. G. Guba (Ed.), The paradigm dialog (pp. 17-27). Newbury Park, CA: Sage.

Habermas, J. (1971). Knowledge and human interests. Boston: Beacon Press.

Hagedorn, L. S., Siadat, M. V., Fogel, S. F., Nora, A., & Pascarella, E. T. (1999). Success in collegiate mathematics: Comparisons between remedial and non-remedial first-year college students. Research in Higher Education, 40, 261-284.

Harper, L. C. (1995). The re-entry female student in mathematics: A study of affective variables that contribute to persistence and success. (Doctoral dissertation, Temple University, 1995).

Hartz, V. (1990). Mathematics teaching and democracy: A real problem. Mathematics Teaching, 133, 3-7.

Higbee, J. L. (1996). Defining developmental education: A commentary. In J. L. Higbee, & P. L. Dwinell (Eds.), Defining developmental education: Theory, research, and pedagogy (pp. 63-66). Cold Stream, IL: National Association for Developmental Education.

Higbee, J. L., Dwinell, P. L., McAdams, C. R., GoldbergBelle, E., & Tardola, M. E. (1991). Serving underprepared students in institutions of higher education. Journal of Humanistic Education and Development, 30, 73-80.

Huberman, A. M., & Miles, M. B. (1994). Data management and analysis methods. In N. K. Denzin, & Y. S. Lincoln (Eds.), Handbook of qualitative

research (pp. 428-444). Thousand Oaks, CA: Sage.

Jarvis, P. (1987). Adult learning in the social context. London: Croom Helm.

Kincheloe, J. L., & McLaren, P. L. (1994). Rethinking critical theory and qualitative research. In N. K. Denzin, & Y. S. Lincoln (Eds.), Handbook of qualitative research (pp. 138-157). Thousand Oaks, CA: Sage.

King, J. (1992). The art of mathematics. New York: Plenum Press.

King, M. C., & Crouse, T. T. (1997). Opening the bottleneck: Using computer-mediated learning to increase success and productivity in developmental algebra. Community College Journal, 68(1), 18-22.

Knopp, L. (1995). Remedial education: An undergraduate student profile. Research Briefs, 6(8). Washington, DC: American Council on Education.

Koch, L. (1993). Writing for reasoning in mathematics. Research and Teaching in Developmental Education, 9(2), 87-93.

Koch, L. (1994). Reform in college mathematics. Research and Teaching in Developmental Education, 10(2), 101-108.

Langenbach, M., Vaughn, C., & Aagaard, L. (1994). An introduction to educational research. Boston: Allyn and Bacon.

Lather, P. (1991). Getting smart: Feminist research and pedagogy with/in the postmodern. New York: Routledge.

Lazarick, L. (1997). Back to the basics: Remedial education. Community College Journal, 68(2), 11-15.

Lively, K. (1993). States step up efforts to end remedial courses at 4-year

colleges. Chronicle of Higher Education, 39(25), A28.

Matthews, R. S. (1994). Enriching teaching and learning through learning communities. In T. O'Banion & Associates (Eds.), Teaching and learning in the community college (pp. 179-200). Washington, DC: American Association of Community Colleges.

Mau, M. S. T. (1993). Ways of knowing and ways of teaching: Conflicting expectations in a developmental mathematics classroom on a college campus. (Doctoral dissertation, Indiana University, 1993).

Maxwell, M. (1994). From access to success: A book of readings on college developmental education and learning assistance programs. Clearwater, FL: H & H Publishing.

Merriam, S. B. (1993). Taking stock. In S. B. Merriam (Ed.), An update on adult learning theory (pp. 105-110). San Francisco: Jossey-Bass.

Merriam, S. B., & Caffarella, R. S. (1991). Learning in adulthood: A comprehensive guide. San Francisco: Jossey-Bass.

Mezirow, J. (1990). A transformation theory of adult learning. 31st Annual Adult Education Research Conference (pp. 141-146). Athens, GA: University of Georgia.

Mezirow, J. (1991). Transformative dimensions of adult learning. San Francisco: Jossey-Bass.

Mezirow, J. (1994). Understanding transformation theory. Adult Education Quarterly, 44, 222-232.

Mezirow, J. (1998). On critical reflection. Adult Education Quarterly, 48,

185-198.

Morgan, D. L. (1997). Focus groups as qualitative research (2nd ed.). Thousand Oaks, CA: Sage.

Myers, E. (1996). Enhancing education through cooperative learning. In J. L. Higbee & P. L. Dwinell (Eds.), Defining developmental education: Theory, research, and pedagogy (pp. 21-28). Cold Stream, IL: National Association for Developmental Education.*

National Center for Education Statistics. (1996). Remedial education at higher education institutions in fall 1995. [On-line]. Available: www.ed.gov/NCES/pubs/97584.html

National Council of Teachers of Mathematics. (1989). Curriculum and evaluation standards for school mathematics. Reston, VA: Author.

Oaks, A. (1994). Conflicting goals in the mathematics classroom. In D. Buerk (Ed.), Empowering students by promoting active learning in mathematics: Teachers speak to teachers (pp. 37-44). Reston, VA: National Council of Teachers of Mathematics.

O'Banion, T. (1995-96). A learning college for the 21st century. Community College Journal, 66(3), 18-23.

Oklahoma State Regents for Higher Education. (1993). Student remediation study. Oklahoma City, OK: Author. (ERIC Document Reproduction Service No. ED 364 297)

Oklahoma State Regents for Higher Education. (1997). Annual student assessment report. Oklahoma City, OK: Author.

Payne, E. M., & Lyman, B. G. (1996). Issues affecting the definition of developmental education. In J. L. Higbee, & P. L. Dwinell (Eds.), Defining developmental education: Theory, research, and pedagogy (pp. 11-20). Cold Stream, IL: National Association for Developmental Education.

Richardson, R. C., Jr., & Elliott, D. B. (1994). Improving opportunities for underprepared students. In T. O'Banion, & Associates (Eds.), Teaching and learning in the community college (pp. 97-114). Washington, DC: American Association of Community Colleges.

Roueche, J. (1968). Salvage, redirection, or custody: Remedial education in the community junior college. Washington, DC: Association of Community Junior Colleges.

Roueche, J., & Kirk, R. W. (1974). Catching up: Remedial education. San Francisco: Jossey-Bass.

Roueche, J. E., & Roueche, S. D. (1993). Has the friendship cooled and the love affair ended? Responding to the realities of at-risk students. The College Board Review, (167),12-17, 26.

Roueche, J. E., & Roueche, S. D. (1999). Keeping the promise: Remedial education revisited. Community College Journal, 69(5), 12-18.

Roueche, S. D., & Roueche, J. E. (1993). Making good on the promise: The view from between a rock and a hard place. Community College Journal, 63(5), 18-23.

Roueche, J. E., & Snow, J. J. (1977). Overcoming learning problems: A guide to developmental education in colleges. San Francisco: Jossey-Bass.

Sawada, D., & Caley, M. T. (1985). Dissipative structures: New metaphors for becoming in education. Educational Researcher, 14(3), 13-19.

Skovsmose, O. (1990). Mathematical education and democracy. Educational Studies in Mathematics, 21, 109-128.

Skovsmose, O. (1992). Democratic competence and reflective knowing in mathematics. For the Learning of Mathematics, 12(2), 2-11.

Skovsmose, O. (1994). Towards a philosophy of critical mathematics education. Dordrecht, The Netherlands: Kluwer.

Stage, F. K., & Kloosterman, P. (1995). Gender, beliefs, and achievement in remedial college-level mathematics. Journal of Higher Education, 66, 294-311.

Tate, W. F. (1994). Race, retrenchment, and the reform of school mathematics. Phi Delta Kappan, 75, 477-480, 482-484.

Testone, S. (1999). Mathematics support services—tutoring and beyond. Research and Teaching in Developmental Education, 15(2), 93-96.

Umoh, U. J., Eddy, J., & Spaulding, D. J. (1994). Factors related to student retention in community college developmental education mathematics. Community College Review, 22(2), 37-47.

Van Maanen, J. (1988). Tales of the field: On writing ethnography. Chicago: University of Chicago Press.

von Glasersfeld, E. (1996). Aspects of radical constructivism and its educational recommendations. In L. P. Steffe, & P. Nesher (Eds.), Theories of mathematical learning (pp. 307-314). Mahwah, NJ: Lawrence Erlbaum Associates.

Waldrop, M. M. (1992). Complexity: The emerging science at the edge of order and chaos. New York: Simon & Schuster.

Western Oklahoma State College. (1996). Institutional assessment report. Altus, OK: Author.

Western Oklahoma State College. (1997). WINDS project. Altus, OK: Author.

Western Oklahoma State College. (1998). North Central Association Self-study. Altus, OK: Author.

Wheatley, M. J. (1992). Leadership and the new science: Learning about organization from an orderly universe. San Francisco: Berrett-Koehler.

Wilcox, K. J., delMas, R. C., Stewart, B., Johnson, A. B., & Ghere, D. (1997). The "package course" experience and developmental education. Journal of Developmental Education, 20(3), 18-26.

APPENDIX A

EXPLANATION OF DATA CITATIONS

Data for the study came from interviews, journals, and miscellaneous items such as participant questionnaires. In order to reference these materials efficiently and accurately, I developed the followed numbering system.

Individual interview transcripts:

Each page of transcript data was labeled with the appropriate participant's initial, the number of the interview, and the page number of the transcript. For example

T1.15 refers to page 15 of Terri's first interview
Z2.8 refers to page 8 of Zach's second interview.

Group interview transcripts:

Each page of the initial group interview transcript was labeled with a "G1" and the appropriate page number. For example

G1.13 refers to page 13 of the initial group interview.

Women's and men's group interview transcripts:

Each page of these interview transcripts was labeled first with a "G" to indicate a group interview, and then a "W" or an "M" to indicate the women's group and men's group, respectively. This was followed by the appropriate page number. For example,

GW.12 indicates page 12 of the women's group interview
GM.6 indicates page 6 of the men's group interview.

Journals:

Each page of journal entries was labeled with the participant's initial, a "J" representing "journal," and the number of the page containing the journal entry. For example

MJ.5 refers to page 5 of Michael's journal
BJ. 2 refers to page 2 of Brenda's journal.

Miscellaneous:

Such items as participant questionnaires, correspondence, and notes I made regarding interviews were categorized as miscellaneous. These were labeled with the appropriate participant's first initial followed by "M" for miscellaneous and the page number. For example,

KM.3 refers to page 3 of Kelsey's miscellaneous materials
JM.2 refers to page 2 of James' miscellaneous materials.

APPENDIX B

You're Invited!

I am looking for a few good people to participate in a research study here at Western. The proposed study is a bit different; instead of me asking all the questions, students in mathematics courses (such as Beginning Algebra and Intermediate Algebra) will have an opportunity to ask the questions. I will be like the "guide on the side" helping you explore possible answers. I am interested in learning what you question about mathematics and its role in society.

Participation will take a bit of time, but not anything too overwhelming. The participants will first meet as a group to decide on issues to explore. Each person will keep a log of their thoughts on the issues, and then I will interview each person individually about the topics. We will meet again as a group to see the different points of view. We will do this for two different issues.

Because your time is valuable, I am prepared to pay each participant an amount equal to half of the general fees and tuition for their next math course (which is approximately $58). This will be payable upon completion of all interviews and meetings. I anticipate that the project will be completed before Thanksgiving break.

If you are interested in participating, please complete the attached form. I will return to your classroom during your next class session to collect the forms (or you are welcome to bring it to my office in the LRC). If you are selected to participate in the study, I will call you shortly thereafter. Please call with any questions you might have; my number is 477-7766.

Thanks for your consideration!

Dana Darby

Participant Questions

Please complete both sides of this form.

1. Name:

2. Address:	3. Phone number:

4. Course name and instructor	5. Time course meets

6. Are you a traditional student (22 or under and a full-time student) or a non-traditional student?

7. Male or female?	8. Race/ethnicity:

9. Are you the first generation in your family to attend college?

10. Mathematics courses taken in high school:

11. Give me a picture of your view of mathematics by completing the following statement: Mathematics is like... (Alternatively, use the statement "Doing mathematics is like...")

12. Reason(s) for wanting to participate in the study:

APPENDIX C

September 22, 1997

Participant,

Thank you very much for volunteering to participate in my research study. I am looking forward to the project, and I hope that together we can generate some very valuable ideas.

The first thing we need to do is find out exactly what you think about mathematics (yes, I can hear the jokes flying now!). Seriously, please think about the following questions and respond in writing to each one. You can make your answers as long or short as you wish. I am not concerned with grammar or spelling—just with what you really think.

1. What do you think mathematics is all about?

2. Describe yourself as a person.

3. Describe yourself as a person doing mathematics.

Please have this ready for our first meeting (all participants will meet together the first time so that we can get a feel for what we will be doing). To help with scheduling this meeting, please check which of the following times you absolutely *cannot* meet. After I get everyone's feedback, I will call you to let you know when and where the meeting will be held.

_____ Thursday, September 25, 1997 at 7:00 p.m.

_____ Friday, September 26, 1997 at 7:00 p.m.

_____ Saturday, September 27, 1997 at 10:00 a.m.

_____ Sunday, September 28, 1997 at 2:00 p.m.

Again, I must tell you how much I appreciate your willingness to participate. If you have any questions or comments, please call me at 477-7766 or come by my office in the LRC.

Sincerely,

Dana Darby

APPENDIX D

Research Participation Agreement
University of Oklahoma – Norman Campus

I agree to participate in the research study being conducted by Dana Darby as part of the requirements for her doctoral degree. The purpose of the study is to explore my and the other participants' views of mathematics and its role in society. I understand that I will be participating in both individual interviews and group interviews. I understand that I will be keeping a journal of my thoughts about the issues the group decides to explore.

I understand that as the study progresses the design might change. I also know that I have the right to stop participating at any time. Furthermore, I will have the opportunity to verify the accuracy of interpretation of statements I make during the interviews.

I have the right to privacy. Within the body of the research report, my name will be changed to a fictitious name and my identity protected, but I have the option of including my name in the forward of the study as a research participant. I have indicated at the bottom of this form my preference. I also know that tapes, transcripts, and journals will be kept confidential and that no part may be shared with other research participants without my consent.

I agree to the terms of payment for participation in the study. I will receive half the amount of general fees and tuition for my next mathematics course. I understand that this amount will be $58. I further understand that I can elect to receive the payment personally upon completion of all interviews and meetings or have the payment delivered to the Western Oklahoma State College business office to be applied directly to my account. I further agree to forfeit my claim to any payment if I choose to stop participating at any time before the completion of the study.

If I have any questions concerning this research project, I may contact Dana at (405) 477-7766.

X_____
(signature)

X_____
(date)

(initial one)
_____ I prefer to remain completely anonymous.

_____ I prefer to have my name included in the forward of the study designating me as a research participant.

APPENDIX E

September 2, 1997

Dr. Ron Kern
Vice President for Academic Affairs
Western Oklahoma State College
2801 N. Main
Altus, OK 73521

Dr. Kern,

I request permission to conduct the research for my dissertation on the WOSC campus with WOSC students as participants. The project focuses on the conceptions developmental mathematics students have of mathematics and its role in society. The design of the study is qualitative and involves journal writing, individual interviews, and group interviews. The participatory nature of the design will allow participants the flexibility of selecting issues to explore with my primary role being that of facilitator. Using the criteria of the University of Oklahoma's Institutional Review Board (IRB), the study is exempt from review because it does not pose a threat to the well-being of participants. A copy of the IRB form is attached to this letter.

I anticipate that data collection will begin in early September and end before Thanksgiving break. I have arranged my office hours so that conducting this study will not interfere with my regularly assigned duties at Western. I ask that I be allowed to occasionally use study rooms and the conference room in the LRTC to conduct interviews. I will also discuss this possibility with Julie Brooks and coordinate scheduling with her. If you have any questions or concerns, please contact me at extension 7766.

Thank you.

Dana Darby

APPENDIX F



The University of Oklahoma

OFFICE OF RESEARCH ADMINISTRATION

September 10, 1997

Ms. Dana Darby
2509 Apache Pass
Altus, OK 73521

Dear Ms. Darby:

Your research proposal, "A Critical Exploration of Development Mathematics Students' Conceptions of the Role of Mathematics in Society," has been reviewed by Dr. E. Laurette Taylor, Chair of the Institutional Review Board, and found to be exempt from the requirements for full board review and approval under the regulations of the University of Oklahoma-Norman Campus Policies and Procedures for the Protection of Human Subjects in Research Activities.

Should you wish to deviate from the described protocol, you must notify me and obtain prior approval from the Board for the changes. If the research is to extend beyond twelve months, you must contact this office, in writing, noting any changes or revisions in the protocol and/or informed consent form, and request an extension of this ruling.

If you have any questions, please contact me.

Sincerely yours,

Karen M. Petry

Karen M. Petry
Administrative Officer
Institutional Review Board

KMP:pw
98-036

cc: Dr. E. Laurette Taylor, Chair, IRB
Dr. Jayne Fleener, Faculty Sponsor, Education-ILAC

1000 Asp Avenue, Suite 314, Norman, Oklahoma 73019-0430 PHONE: (405) 325-4757 FAX: (405) 325-6029

APPENDIX G

Interview Timetable
Beginning with the week of September 28, 1997

	Group Wom.	Group Men	Terri	Kelsey	Zach	Rachel	Michael	Brenda	James
Week 1			1st	1st		1st			1st
Week 2					1st		1st	1st	
Week 3									
Week 4				2nd					
Week 5						2nd			
Week 6					2nd		2nd	2nd	
Week 7			2nd						
Week 8									2nd
Week 9	X	X							
Week 10									
Week 11						3rd	3rd		
Week 12								3rd	
Week 13				3rd					
Week 14									
Week 15									
Week 16									3rd

APPENDIX H

Field Log

September 4, 1997

My first experience "in the field" was going to Dr. Stephanie Kern's Beginning Algebra class to ask for volunteers. I was immediately faced with the difficulty of conducting this type of research project. The students expressed absolutely no interest in participating in the project. Stephanie is supportive and has indicated that she knows of two or three students in that class that would be able to contribute a great deal to the project. She is going to encourage them to participate.

I must admit that my first reaction was sheer panic :^). As I reflected, though, I began to realize that this is totally consistent with my reasons for doing this particular project. Critique is a foreign concept to most developmental mathematics students. Status quo is comfortable and familiar. We need to gain some insight as to the entry points to critique in developmental mathematics.

I also caught a glimpse of my immersion in "the ivory tower." Have I become so "theoretical" that I have lost sight of the possible (or at least the practical)? It makes me think of a cite I wanted to work into my prospectus, but there just didn't seem to be an appropriate place. In *The Paradigm Dialog*, Grumet attacks a debate on values in research for its separation of intellectualism from the "embodied world." While the papers that were a part of the alternative paradigms conference recognized that "research is situated, shaped by the lived experience, concerns, and interests of the researchers," they hardly mention "the world that [the research] was, is, might be about" (p. 335). In considering value an impediment to proper research, "we succeed in doing studies that neither we nor anybody else cares about" (p. 337). "In order for our work to have value, it must maintain and acknowledge its vital connection to the world" (p. 337). This research is where the theory I have been learning, constructing, reflecting on, meets with the lived experiences of the participants. It must take on a dimension of "realness" or as Grumet said, neither we nor anybody else will care about it.

September 20, 1997

I needn't have panicked. As I went to the other developmental mathematics classes to seek participants, I became much more relaxed, and as it turned out, had twice as many volunteers as I needed. Today I faced the difficult task of picking participants. As I read each participant questionnaire, I could see so many possibilities. I finally landed on 9 participants: 5 women and four men. I wanted diversity and certainly found it. Their answers to the final two questions on the questionnaire were very interesting. Most seem to be seeking answers to the

question of why they have so much trouble with mathematics. I hope the process helps them answer the question and helps them overcome the barriers.

September 28, 1997

Today was the first group meeting. All but two of the participants were able to make it. We began with introductions. This was followed by everyone addressing the question of "how do you feel about mathematics?" Two said they liked mathematics and the other five said they definitely do not. It will be interesting to see how this evolves.

I believe I must have had supernatural intervention in the selection process. I can't imagine having better participants. They are all so pleasant, bright, and articulate. They don't seem to mind expressing their opinions, but they also seem open to new ideas. I feel very blessed, indeed. We were able to "click" during this first meeting. There is no strain or nervousness. I realize that these characteristics are part of why they volunteered in the first place, but I don't want to take any of this for granted.

I must mention a thought that ran across my mind. We met in the college parking lot (this was a Sunday afternoon, so the building was locked). Without thinking, I pulled in to a faculty parking space and immediately wished I hadn't. I wasn't thinking about relinquishing position power. Though this was not a big deal, I must be careful in the future to avoid those little things that separate me from the participants. One person called me "Mrs. Darby" right after the meeting broke up. I quickly requested that she call me Dana. Maybe this is a 'little thing' that can help diminish the position power.

I asked them to begin keeping a log or journal about their mathematical autobiography. These will serve as a basis for our first individual interview (we are calling them 'visits'). We scheduled a time for the first 'visit.' I will need to contact the other two participants as soon as possible to set up meeting times with them.

October 2, 1997

I just finished with Rachel's first interview. She is a beautiful, sweet, bright girl. She is very charming and loves to talk. The majority of the interview moved swiftly. As she talked about previous experiences with math, she talked very freely about teachers, etc. Toward the end of the interview, when I started asking deeper questions, such as 'why do you think these people chose to be teachers' and 'describe a typical math teacher' and 'do you think it is reasonable that math determines your career choice' etc., she began to struggle with her answers and I began to struggle with my questions. The "critical" part is difficult. Getting the

participants beyond the surface will be a challenge—just as it is a challenge for all of us to question assumptions.

I sat across the table from Rachel and felt that it conveyed a more formal relationship than I wanted. I will try to remember in future interviews to not arrange the seating that way.

As I read the transcript of the group interview, I saw more of myself than I should have. I planted too many seeds of things "I" wanted them to address. Patty Lather's admonition to avoid being impositional is becoming more real to me. Academically, I know to avoid it, but in the setting of the interview, it is so easy to become anxious to keep things moving, and I overstepped my bounds. I must watch this closely.

The participants seem to have the usual view of math as completely external to themselves and as being about right or wrong answers. I must remember that my goal is not to change that view with a good math lesson, but rather to help them see the world "out there" and how math affects them socially and personally.

The second interview today was with Kelsey. She is delightful. She is fun, a bit fiery, and loves to talk. She came closer than Rachel to beginning the questioning process. She was asking the "why" question of "why do we have to take these mathematics classes?". Though I am not sure whether it will be a fruitful pursuit, I will encourage her to go ahead and explore this issue.

She, too, had a bad experience with a teacher. I wonder if this will be lead into deeper questioning. I am anxious to see if this comes up with other participants.

I am beginning to understand, not to control, the impulse to 'impose' my questions. It is difficult to strike a balance between encouraging questions with a gentle 'nudge' and leading them to my conclusions. It is even difficult to express.

October 3, 1997

James' interview was this morning. I cannot believe how much I am enjoying this. The interviews are extremely interesting and challenging. The participants in this study are unbelievable. They are quite willing to share and are willing to think outside the box. Of course, just the fact that they volunteered to participate in the study is an indication that they are outgoing and willing to express their opinions. I guess I just didn't anticipate how quickly the discussions would yield such interesting information. So far, we have "clicked" and the interviews flow smoothly.

October 4, 1997

What a fun interview! Today I met with Terri. We actually stayed 30 minutes longer than we intended because we just kept visiting. Terri is incredibly bright and articulate. She is confident even though she says she is not when it comes to mathematics. Her story is as interesting as the others have been. The subject of poor teachers again came up. But even more interesting than that is her family background. Her mother is Vietnamese and her father is American. Her parents met during the Vietnam war. She describes her mother as like most Asians, with an incredible work ethic. Grades and school were extremely important. Terri was in advanced classes through school, but in the 11^{th} grade dropped out because of the pressure. Her work never seemed to meet the expectations of her parents.

October 6, 1997

I overdid it today. I did three interviews, two classes, and a meeting. Too much for one day! The first two interviews went well. Robert's was really just an orientation because he had to miss the group meeting. Michael's interview went well. He, like the others, is very outgoing. He knows what he wants from life and is willing to do what it takes to get it.

My interview with Brenda did not go as well as the others. She doesn't really remember much about her school years, particularly mathematics classes. She is a bright and very nice person. She is not, however, quite as open as the other participants have been. I'm not sure what it will take to get through the exterior. She is also different from the other participants in that she likes mathematics and always has. She doesn't really share their fears and is not willing, at least yet, to critique something that seems black and white to her.

October 8, 1997

I met with Zach today. The interview went well, though we never got around to talking about his mathematical autobiography. He did get very close to breaking the "critique" barrier. Though he thinks he doesn't have a mathematical mind, he is very introspective and quite willing to think more deeply. I think I went too far, though, in challenging him. I again allowed myself to do too much leading. That "impositional" thing, again!

October 23, 1997

My first piece of advice for any doctoral student is don't try this while working. I have had limited time over the past two weeks to even think about data collection. I am waiting for the interviews to be transcribed so I can do a preliminary analysis

and get some themes back to the participants. I hope the group interviews will be helpful. I think it will be interesting for the participants to hear other people who share similar views.

Today I did a follow-up interview with Kelsey. I was particularly disturbed to read her journal. She is losing even more confidence in herself. It is, however, a prime example of Mezirow. She has come face-to-face with her 'disorienting dilemma.' She stated that she is not smart and tired of pretending that she *is* smart. She is considering quitting college. I know our time together today just stirred it up more for her, but I hope she went away with some things to think about. I believe the groups will be good for her.

Today, I asked Kelsey why she was so concerned with what people think of her. Without thinking, as I asked the question I shared that I, too, struggle with fearing what people think of me. She in turn asked why I had this struggle. This made me think of Lather's suggestion for "interviews conducted in an interactive, dialogic manner that *requires self-disclosure on the part of the researcher*". Part of me felt uncomfortable sharing this information about myself, but another part really enjoyed the connection I felt with Kelsey. The difficulty lies, *again,* in finding balance.

Kelsey is so close to making some major decisions in her life. She might or might not remain in college. She is taking a deep look at herself and her life situation. I fight myself to not offer advice, to simply encourage the questioning process. The questioning process is uncomfortable, but so crucial. If there is no other purpose for my doing this dissertation than to help Kelsey through this time, it will be worth it.

October 25, 1997

As I sit here transcribing Kelsey's second interview, I see so many directions this study could take. The tremendous impact of worrying about what other people think is starting to hit home with me. School is about so many things other than learning. It is about prestige, power, and competition. It is about survival of the fittest, and the fittest are those that have characteristics that make them easy to teach, whether that be a quiet disposition, or a logical, analytical, rational approach to learning. I have also been thinking about the horror stories that have surfaced about math teachers. The teachers described in the interviews seem to hold the traditional idea that a person either has "a math mind" or doesn't. I also envision these teachers as "crusty." By this, I mean that as the paradoxes of teaching (e.g., students learning at different rates, yet having to "cover" the material in a fixed period of time) wear on a teacher, out of self-preservation they develop indifferent attitudes. This could be an interesting future study.

November 1, 1997

This is the first day I have had to spend just rereading the transcripts and reflecting. I am beginning to see themes emerging as to possible reasons for the participants' dislike of math. We have not delved deeply enough into "why" yet for any true critical theory to emerge.

I see the following issues as being important to these people. First (not necessarily in order of importance) is the issue of poor elementary and secondary school teachers. Almost every participant has had a story to tell about a teacher. They have done so with a sense of frustration, but without a sense of empowerment. It seems that it is a "fact of life" that math teachers are bad, and that it is something to be overlooked. No thought is given to "what can be done." In other words, action is frozen. Several have expressed dislike or frustration, but then turned around and said the teacher was good. It's as if the critique can only go so far.
Another issue that has emerged is "why do we have to have this stuff?" When pressed, the participants always fall back on "an institutional requirement" (except for Michael—who plans to major in engineering). They also don't really want to ask the question. They "fear" administration. I am anxious to see if they can find someone they are willing to ask.

Another issue is "fearing what other people think." This is one I can relate to quite well. Since I was small, I have worried about impressing other people—wanting them to think I was bright or fun or .... It is only recently that I have begun to come to grips with this and to understand its source and its power over me. This new revelation for me is probably why I saw the issue, initially in Kelsey. It is a very powerful force, motivating extreme behavior. In my case, I had the traditional abilities so that I was able to rise to the occasion and make good grades, etc. But the participants in some cases have not had those traditional academic abilities, and the pressure made them shut down. I wonder about math anxiety and test anxiety. I need to take a look at that literature and see if this has been explored. This ties in with the issue of parental pressure. A couple of the participants dealt with extreme pressure from parents. The fear factor made them also shut down.

An interesting observation is the adolescent rebellion evidenced by several participants. This is a normal developmental stage, but in a couple of the participants, the extreme nature of their rebellion caused them to miss out on learning. And just as interesting is the fact that parents and teachers didn't see it.

These issues are entwined and interactive. As I do more reading, I will be anxiously looking for how they have worked together. I am also anxious to begin delving a little more deeply into the "why" questions and see how the participants react. I struggled for a while about whether to go straight from here to the group interviews, but I have decided to do another individual interview. I knew I would

need to do another interview with both Kelsey and Rachel, but I wasn't sure about the others. I finally decided that one more time together would really set in their minds that the issue is about questioning—about becoming critical. I think it will make the group interview process move more quickly and thoroughly.

November 6, 1997

This evening I visited with Zach again. I don't think this meeting was quite as productive as the first. He wasn't as willing to reflect and question. I think it was because it was more personal this time. Last time math was a shield. This time I just asked about his view of himself. He really struggled to answer this; he related it back to sports over and over. He wouldn't let himself go any deeper. I found this interesting. Based on the last interview, I would have expected him to be at ease discussing personality, values, etc. Maybe he just wasn't sure of the question.

I continually notice my own biases coming out. For example, I have asked a few of the participants about their stereotypes about math people. They express the (as one person put it) the Hollywood version of a math person, but their personal view does not reflect the nutty professor type. I expected that they would have a negative view of "math" people, and describe them as completely opposite themselves. The Hollywood description is opposite, but that is not really their personal description. I further expected that they believed in "math" people; they do. Several have expressed the belief that "you either have a math mind, or you don't." Is this a socially constructed belief? I need to explore this further with them.

November 15, 1997

I have realized two more areas of bias. First is my equating math with algebra. I have been in the developmental education setting at my college for so long, I have forgotten that math does not necessarily equal algebra. I have found myself not wanting to "count" basic mathematics into our discussion—dismissing it as trivial. After all, everyone sees the role of arithmetic in our society—not! This very issue came up in an interview with Zach, and I did not examine my own biases and beliefs.

The second area of bias is in my questioning strategies. As I have stated several times before, the fine line between being impositional and being thought-provoking is difficult to maintain. I have realized, though, this is the same line I walk in the classroom: teaching, yet trying to help them construct their own knowledge. My teaching method is often this: ask a leading question. This is my compromise; it is this method that lets me live in the two conflicting worlds of structure and discovery. I have unknowingly adopted the same strategy in my

interviews. I have tried to gently "lead" the participants down the road to discovery. This is not a new revelation, nor is it bad—unless I "lead" them down a one-way road toward my personal views and biases. I had not made the connection between the research and the teaching.

November 15, 1997

Today I met with Terri for a second time. What an interview! I was beginning to get discouraged, feeling the study was not making much progress toward answering the questions. I had asked Terri to read some excerpts from a book by Jerry King entitled *The Art of Mathematics*. She didn't connect with everything she read, but one story sparked her interest. It was about a mathematician who intentionally used mathematics to intimidate a colleague who was not a mathematician. This spawned a discussion about the power that math affords. Later, I summarized a lawsuit in which the plaintiff was awarded a 24 million dollar judgment. The plaintiff suffered a stroke as a result of an accident that was not his fault. An "expert" witness testified as to a formula he had developed that would allow an "objective" way to place a value on a person's loss of enjoyment of life. We spent some time discussing the validity of such an approach and the possible effect it had on the jury. Excellent discussion!

I also received some feedback that reinforced my approach in the interviews. Terri told her husband that talking to me wasn't at all like talking to an instructor. She said, "Dana is just one of us." When talking to her algebra instructor, she felt intimidated—like she was back in jr. high. While I don't applaud her relationship with her instructor, I am *very* pleased that even though I am an instructor in the institution, I have been able to diminish the position power that Cranton talks about.

November 22, 1997

I held a group interview today with James, Michael, and Zach. I determined the groups based on schedules and similarity of issues. It turned out that the groups were split between male and female. I really had not intended this as gender issues had not been an obvious factor. The effect was quite interesting, though. I will be anxious to see how the interview with the women goes.

I was hesitant about meeting with all men. I was concerned that the level of interaction would be shallow because of a reluctance on their part to share their ideas with each other and with me. For whatever reason, I had fought the idea of gender being an issue in this study. However, as I look at the whole point of the study, it cannot be avoided. We are social beings, and gender is a social force that shapes our experiences. This process has begun to enlighten me as to the issues Lorraine Code discussed in her work on feminist epistemology. I construct my

knowledge as a woman. I conduct my research as a woman. There is no escaping this; there is no reason to escape this. I simply must acknowledge the role it plays.

I find myself anticipating tomorrow's interview with "the girls." I look forward to it and expect it to yield data to which I can relate. I struggled in the interview with the men. The confrontation (mild as it was) was uncomfortable to me. I found myself trying too hard. I am nearing the end of data collection and am concerned that the participants are going to walk away without having gained anything of significance. After all, that's what makes a critical study good (*smile*).

Part of the difficulty today was that two of the participants like the status quo; it is working nicely for them. They were therefore unable to relate to the questions of the third. This made it difficult to really start off in a direction and stick with it. I was constantly having to reevaluate whether I was putting words into their mouths or simply giving the issue a little prod.

Overall, the study has been fun and fascinating. I wonder, though, if I am really finding something significant—the "so what" question. Am I coming close to answering my research questions? Does everyone experience these doubts?

November 23, 1997

Today I met with the second group which consisted of all women. It was the complete opposite of yesterday. I felt completely at ease and related readily with the participants. Everyone shared openly and was accepting of other's opinions. There was little competition among the participants, and they seemed to genuinely enjoy the experience. (I did, too.)

Brenda and I had a chance to visit before the others arrived. She shared with me that she had taken steps to deal with the situation we had discussed in the previous interview. She had an instructor who she felt had dealt with her unfairly. After earlier discussion, she went to the college counselor to discuss her options. She also has sought counseling regarding some issues that occurred early in her life that she has never fully faced. I would like to think that our visit and our reflecting on issues of empowerment helped her take action.

January 7, 1999

One year later! I had a small diversion—a baby. We adopted a baby, but had only about one week's notice. What a great blessing he has been and what a wonderful year. But now, it is back to the grind. I felt the need to include this in my field log because of the effect it has had on my very being. Though we

change daily in response to our worlds, we sometimes face those "disorienting dilemmas" that Jack Mezirow discusses, and we change dramatically. The baby was my "disorienting dilemma" (smile). I now move more slowly, drinking in every moment. I lost some of my egocentrism, competitiveness, and selfish ambition. I believe I have a healthier view of myself and of this research project. I am anxious to dig into the data once again and look at it through new "lenses." I have a feeling I will see things I didn't see before.

March 11, 1999

I just finished transcribing the last interview. I really thought I was going to lose my mind. This is a very slow process with just a couple of days a week to work on my dissertation, besides the fact that I am a very slow typist. It feels good to vent.

March 25, 1999

"The analytic task...appears monumental when one is involved in a first research project. For those who have never undertaken it, analysis looms large, something one can avoid, at first glance, by remaining in the field, collecting data when that period should have ended. Anxiety mounts: 'I didn't get anything good.' 'I've wasted my time.' 'This job is impossible.'" (Bogdan & Biklen, 1992, p. 153)

I am so glad I am not alone!!!!!

April 1, 1999

Another tidbit I reread in Bogdan and Biklin was the advice to ask myself "What does this remind me of?" I have thought of three things so far. First, I was listening to my oldest son practice his piano lesson and I noticed that as he learned a new piece, when he would encounter difficulty he would start playing a song that he has known backward and forward for months. It was like a retreat to the familiar. Second, I watched my youngest son as he was trying to figure out a new toy. As you push a button or twist a key, etc., little animal characters pop up. He figured out the push button very quickly. When he would try a different pop-up and could not get it to work, he would go back and do the push button several times. Again, it was like a retreat to the familiar. Third, I was remembering the church my family was a part of in years past. It was *extremely* conservative with many members believing it was the only group of people who were truly Christian. I remember being in Bible classes my husband was teaching. As he would challenge this belief, members of the class would seem to come right the point of also calling the belief into question, but at the last moment would go back to a familiar cliché or simply check out. It wasn't that they were rejecting or

accepting the belief; rather, they would never truly examine and question it. It was too uncomfortable.

I saw this in my study's participants. They would start to call into question math and math education, but in the end would go back to "checkbooks" and "engineering" and "school" as examples of the roles math plays in our society. And as I sit here and think about all this, I realize how I was pushing for some big revelation of the hegemonic power relations that mathematics supports, yet that is not it. It doesn't have to be a global, subsuming revelation or theory. It can be the simple realization that "I had a really bad teacher, and I thought I couldn't do mathematics. But now I know I can." What a wonderful beginning for learning to use a tool or a language or whatever metaphor you want to use for mathematics—a beginning that can lead to the power to use mathematics to be a more informed citizen, to critique the established uses of mathematics, to see in themselves the power to conquer a great fear.

I remember when I began to change my religious beliefs. It was one small conversation, and yes, I retreated many times after that, but it was the beginning.

May 17, 1999

I *have* worked since April 1!!! I just haven't written anything in my field log. I have been analyzing—reading through the transcripts and developing themes. Several of the themes are those that I had already taken back to the participants for deeper discussion, but I have found several that I didn't see before. One in particular is the issue of different methods for doing a math problem. Because the view the participants have of math as correct and sterile and lacking in creativity, it is confusing to them that there might be a different way of solving a problem. You can see in their teachers the same dilemma. They demand that the students solve a problem in only one way. The parents demand that the students solve a problem in only one way. When those ways are not exactly the same in the eyes of the students, the frustration of the students is enormous. I am reading Rachel's transcript right now, but I remember Terri talking about the same issue. The lecture method of teaching lines up perfectly with this view of math—and is a major contributor to the frustration.

Another very big theme is the lack of relevance of math. I am not talking about application problems. I am talking about the participants having no sense that math is anywhere "out there" except at school. In fact, I am calling one of the themes "Math = School." I need to look up some of Willard Daggett's work in this area. We do school to get ready for more school. Because younger students lack experience, it is almost understandable that they might develop this view, but the older participants in the study seem to have the same view.

June 10, 1999

Big revelation. In different ways for different participants, learning is irrelevant. School/college is about grades and degrees and other purposes—but not learning. Even the adult returning students, for all their motivation, are not interested in learning math (except maybe Brenda). Is this an indictment on our system, or is it "just the way it is?" Has it always been this way or has mass education created this particular "butterfly effect?" But then again, how much of anything we do is "real?" Do we do research truly for the search of knowledge, or is it about degrees or tenure or prestige? How many lawyers and judges really want truth? How many doctors really want to heal? Or at least for all these, how many is it the primary motivation? Actions are the same, motives are different. Maybe this is where ethics enters the picture. How many teachers teach not for learning, but to get students through the system? When students ask why they have to take algebra and the answer is "to prepare them for geometry," we have perpetuated the system. We have reinforced the belief that learning is irrelevant.

June 17, 1999

Over the past couple of weeks, I have gotten away from the transcripts and have been re-reading Skovsmose' philosophy of critical mathematics education. It has helped me to rethink codes I have developed so far. It has also illuminated issues I hadn't noticed—which is Skovsmose' purpose in developing the philosophy.

Right now I am reading about the formatting power of mathematics. His contention is that mathematics (in the form of formulas, algorithms, computer programming logic, etc.) becomes "realised," i.e. that these abstractions become a part of our "reality" and hence shape society and the way it functions. While I agree to a point, I think it is misguided to ascribe the power to mathematics. The power is still in the hands of people. When a mathematical formulation becomes "realized," it is because we choose it—sometimes knowingly and sometimes unknowingly. The power to exert influence using mathematics belongs to those who understand how to use it and how to interpret its use. Those who know neither how to use it nor how to interpret it seem to worship at the feet of the god of mathematics. In a sense, they ascribe a power and mysticism to mathematics much as oppressed people ascribe to their oppressors--somewhat like participating in their own oppression. When the connection is analyzed one step further, the oppressor becomes those who use and interpret mathematics competently. I guess what I am trying to say is that I see mathematics as a tool or a technology in itself. It is an "inanimate" language or process or ???. It has no power in and of itself. It is no different than formal language or education or socioeconomic position or any other construct that is used by the elite to maintain "control" over the disenfranchised. No, I do not believe in most cases that it is intentional control. I suppose a better wording is that these constructs are used by the elite (or the powerful or the educated) to advance or protect their own interests which in turn

can harm the interests of the disenfranchised.

I want to avoid the use of words like "oppression" because even in my own mind they incite visions of radical and bitter people who sometimes do more harm than good for the very people they are trying to help. Sometimes these "buzz words" inflame and alienate and widen the chasm between theorists and practitioners. I must be very conscious of my own conservative tendencies and analyze very carefully and honestly why I hold such views of "radical and bitter people." In what ways am I a part of the mainstream that is in power and is protecting its interests at the expense of others?

July 6, 1999

I took some time to go back to the literature. After taking a year off, I needed to refresh my memory. I went back to Philosophy of Critical Mathematics Education by Skovsmose and found some great stuff. It made more sense this time, after having done the interviews. I recognized natural language versus more formal types of language. I recognized the crucial role of scene-setting. Etc. It helped me develop a new and improved understanding of the relationship between theory and data. I "saw" the data in a new light when I went back to this particular work. I "saw" things I hadn't seen before. It also helped me put names to things I had "seen." The data, though, still has a life of its own, for me. I still see (no quotations) the participants and hear them. I know what they meant, but will I be able to convey this in a research report? Another way to look at it is the theory or philosophy gives a way to organize the data. For example, part of my research is to ask how the participants view themselves and how do they view mathematics. Skovsmose discusses "disposition" for learning. It involves both background and foreground. So, while I was going to discuss the students view of themselves and of math in general, I can now organize it in terms of background and foreground. It is the same thing, but through using Skovsmose' framework, I can discuss it with more depth and provide a greater coherence to the rest of the theory that I will use to interpret the findings. (Did any of that make sense?)

July 9, 1999

What does this remind me of? People (teachers, lawyers, etc.) use screens to protect themselves. For example, preachers talk about people who complain and cast these people in a very bad light. This discourages criticism. People who might have a legitimate complaint will not bring it up because they don't want to be one of those "complainers." In this way, preachers insulate themselves from being scrutinized. Math teachers do the same thing. If they make students feel stupid for asking questions, they will not have to answer many questions. But the follow-up to that is, why don't they want to answer questions? Is it fear of not being able to answer, or is it impatience, or is it intolerance? What is it? Why do

they need to insulate themselves?

July 22, 1999

When the participants worked through having to take algebra, was it a circle, i.e., right back where they were, or was it a spiral, i.e. you come back to something similar, but on a higher level (better understood, more integrated). So rather than a complete perspective shift, maybe they took "baby steps" or meaning scheme shifts. Transformation seems too dramatic, though.