# Views of mathematics of women restarting their education : looking for safety in numbers.

VIEWS OF MATHEMATICS OF WOMEN RESTARTING THEIR EDUCATION:

LOOKING FOR SAFETY IN NUMBERS

A Dissertation Presented

by

SUSAN H. MACLEOD

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I could not have been involved with a more interested, encouraging, and helpful group of people. They even provided some obstacles and adversity at times and in quantities that resulted in growth and improvement. Thank you, all.

ABSTRACT

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FEBRUARY 1996

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Inclusiveness and usefulness are principles underlying community college education and reform in mathematics teaching. But adults restarting their education may view mathematics as inaccessible, threatening, and of limited personal use.

The purpose of this study was to gain awareness and appreciation of the beliefs about mathematics and attitudes about themselves as learners of mathematics of a group of financially and educationally disadvantaged women preparing to enter community college and technical occupations. In the event that these beliefs and attitudes seemed to be counter productive to the effective mathematics education of the students, the study considered how they changed in a learning community where science, mathematics, communication, and career development skills were integrated and learned experientially.

The methods used were qualitative and interpretive. The researcher interviewed six women at the beginning and end of the semester, and talked with the math/science instructors about their objectives and methods. She observed the students in the classroom and laboratory and administered an attitude questionnaire. Literature from the fields of human development, teaching and learning, and mathematics education formed the background for the study.

The study found that the students varied in their attitudes and in their responses to the learning experiences. Students perceived little change in their own attitudes during the program, but the instructors and researcher observed positive change in the group, with the least change

occurring in those expressing most resistance to the methods. The researcher found that the program was evolving from a learning community into a more traditional collection of subjects, that assessment methods conflicted with the experiential and integrated model, and that there was poor communication within the program. These problems seemed to work against some of the anticipated changes in attitude toward mathematics of the students and highlighted difficulties of putting theory into practice.

The study verified that the relationship between attitudes and a program designed to affect them is complex and sensitive to many factors including the dynamics within the program itself and the developmental characteristics of the student.

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# PURPOSE AND CONTEXT

## Introduction

For many people, mathematics is a foreign and forbidding realm. Some avoid the area and have no contact with its inhabitants and their language or culture. Others try to enter but fail the tests — they do not understand or do not conform; mathematics blocks the road to their goals. A select few are allowed to enter and they seem to be granted keys to power and the secrets of the universe.

The current view predominant in mathematics education is that more people should have access to this power and understanding. Our world needs and expects a higher degree of quantitative competency and reproducible reasoning from more people than in the past. A greater number of jobs and promotions require math qualifications. Everybody counts. Anyone who wants to should be allowed into the land of numbers, patterns, and problem-solving.

A wider gate to knowledge through education and thus to mathematics is provided by the community colleges, referred to by Vaughan (1983) as "The Ellis Island of Higher Education." More people have access to mathematics via this gate, but processing the immigrants is not always easy, efficient, or even successful. Whether a person approaches this gate, persists in his or her efforts to get in, and becomes a part of the culture of mathematics depends on many factors. Some of these factors have to do with opportunities and ability to perform as required on certain tasks; others have to do with how the person views the world of mathematics and his or her relationship with it.

This study involves a group of women approaching the community college gate to mathematics. They take part in a program which seeks to form a learning community to develop their technological understanding and communication skills and to begin the process of preparation for jobs in technological areas. How do they view what is before them? What are they thinking and feeling? As they proceed, do their interpretations of the situation or their feelings change? I talk with these women as they enter, as they take part in the program, and as they emerge after fifteen weeks either to matriculate as community college students, or turn from the gate on other paths. It is their beliefs and attitudes toward mathematics that are of particular interest to me, but I am aware that I cannot isolate a single aspect from them as changing, complex beings who think as well as feel, learn as well as know, who act, react, and sometimes choose not to act. They are human beings involved in the human enterprize of education.

These people have some obvious things in common. They come together at the same time, January 1995, in the same place, Greenfield Community College. They have decided to take advantage of the same opportunity, and they fit the same criteria for acceptance by the program. They are all women, financially disadvantaged, thinking about a career which involves technology. They have chosen to come together to learn about math, science, and communication.

As with any group of people, they also have differences. They have converged on this place by varied routes. They are likely to have different responses to the same situations because of what they bring with them and where they plan to go next. Each one has her own knowledge, goals, expectations, philosophy of education, and thinking style. Each one has a lifeful of experiences and the residue of her culture's messages about what is expected of her and who it is who goes to college and learns science and mathematics.

I can gain an awareness and appreciation of other similarities and differences only by looking closer, listening to individual voices, and getting to know these people. I do not want to simplify them, cut them into pieces, or ignore their pasts, futures, cultures, homes and families. I do not want to reduce them to numbers or to multiple choice answers. I do not want to pull them out of context and look only at their measurements, their behavior, or their products. My research method is qualitative and interpretive — as open-ended and conversational as I can manage yet always drawn by the magnet question: How do you perceive mathematics and your relationship to it?

## Research Problem

The philosophy underlying community college education and current reform proposals in mathematics education is characterized by openness, inclusiveness, usefulness, and equal opportunities. Research into people's attitudes about learning mathematics and my personal experience as a teacher of adult students indicate that many students have a different view. Particularly students who have avoided math, have been unsuccessful in past math classes, or are members of groups who traditionally have been under-represented in the field, may see mathematics as inaccessible, exclusive, threatening, and of limited personal use (Buerk, 1985). They may have dysfunctional beliefs about the scope of mathematics, the nature of mathematical knowledge and activity, and the origin of mathematical knowledge (Borasi, 1990). These beliefs and attitudes interact with the students' learning, personal development, and achievement. A change in students' personal philosophies is an important part of their effective mathematics education (Borasi, 1990).

## Research Questions

The big questions which frame my study are not necessarily the specific ones I ask in the interviews.

### Global Questions

What are the students' beliefs about mathematics and their attitudes about themselves as learners of mathematics? Do these change in the course of the program? What is the nature of that change? What are the implications for mathematics education?

### General (Regional) Questions

How does the student view mathematics? In the introduction I used the metaphor of mathematics as a place (a world or a realm) with a culture. This metaphor emerged from a small, preliminary qualitative study I did in 1993 with three community college students in a mathematical problem solving course. What will be the metaphors for mathematics from this study? Is mathematics external, absolute, fixed, unchanging? or is it socially constructed, negotiable, dynamic? or something else?

How does the student view herself relative to mathematics? Is the student confident in her ability to succeed in math courses, or anxious, ...? Is math a necessary or useful part of her future? Does she feel comfortable working in a technological environment?

How does the student perceive the learning process? Does one receive knowledge from an outside source? or is knowledge internally constructed?, or negotiated with others in the community...? What is the location of authority? Internal, external,...? Absolute, negotiable, ...? Who is responsible for the student's learning? Student, teacher, ...?

What factors might affect these attitudes and beliefs? What might have contributed to their formation? How stable are they? What in the learning environment might encourage change?

### Local Questions

The local questions form the framework for the interviews and the themes for the observations. They are particular questions or areas of interest designed to elicit answers to the regional and global questions, and can be grouped according to the information they are meant to draw forth. Some ask for general information about the student, for example, "Describe yourself to me." Others try to get at the student's beliefs and perceptions about mathematics — "When I say the word 'mathematics,' what is the first thing that comes to mind?" and "How is math different from other subjects?" A third group is concerned with learning in general — "What do you expect from a teacher?' and "What do you do when you get stuck?" A complete list of these local questions and themes for observations can be found in Chapter 3 in the discussion of the methods of the study.

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## Context of the Study

There is a common alignment of values and visions of the recent wave of mathematics education reform and a community college's mission, both of which see the goal of education to be personal fulfillment, preparation for effective citizenship, and useful employment in a democracy. Consistent with these values and visions is Women in Technology: Project Jump Start, a college preparatory program designed to start a group of educationally and economically disadvantaged women toward careers in technological fields by providing basic academic skills, communication skills, counseling, and career awareness activities. Before I describe Project Jump Start, let me sketch the streams on which it rides.

Mathematics Education Reform

Reports prepared in the late 1980's and early 1990's by the National Research Council (Everybody Counts, 1989; Reshaping School Mathematics, 1990; Moving Beyond Myths, 1991) conclude that mathematics education needs to facilitate the development of mathematical concepts and analytical skills in a wider spectrum of the population. In a world that is becoming increasingly dependent on mathematics because of increased use of technology, the explosive growth of information, and sophisticated communication systems serving a global economy, it is important for everyone to have a fair chance to attain basic competency in mathematics, to satisfy his or her interests, and to reach his or her potential in the field. "Fair opportunity" includes equal access to education services and learning experiences designed for a diversity of thinking styles, ways of knowing, rates of learning, interests and goals. Denial of access to the field of mathematics blocks the entrance to many occupations and advancement in many others. Mathematics education has been perpetuating social inequity when it has the power to equalize opportunities. Moving beyond Myths: Revitalizing Undergraduate Mathematics (National Research Council,1991) sums up the social need for reform.

> In a technologically driven economy, mathematically literate employees more readily achieve positions of influence whereas those who remain innumerate are often denied the economic and social benefits of productive jobs and stable employment. Far from achieving its ideal as an agent for social equalization, undergraduate mathematics education as currently practiced bestows uneven benefits on different groups within our society — white males learn much more, women and many minorities much less. The result has been a growing

> polarization of society along the dimension of mathematical power that will, if left unchecked exacerbate social and economic tensions by widening disparities in opportunities and earning capacities. (p. 2)

The mathematical information and skills that are taught and assessed in schools and colleges also need to be reconsidered. Calculators and computers are such an integral part of the home and workplace that the routine calculation skills which, in the past, made up most of the mathematics curriculum, are not nearly as important as the ability to solve problems in different contexts, to communicate mathematical ideas effectively, and to think analytically. The minimum proficiency is no longer arithmetic skills so that one can "make change" or know which quantity is larger. Making sense of newspaper articles and government programs requires a grasp of statistics, probability, and calculus concepts such as rates of change and maximization.

Perhaps the greatest challenge to educators results from the growing realization by many of them that knowledge is constructed, not received. For constant and varied application of mathematics everyday by anyone, unless the knowledge is rooted in experience, personalized, reflected upon, talked about, and applied, it is easily forgotten or is useless. Reform in mathematics education in the direction of more active learning and increased emphasis on problem solving has led to increased emotion in the classroom.

> Traditionally, teachers have tried to control or eliminate emotional responses in mathematics classrooms, and traditional content, with its emphasis on learning low level skills, tended to minimize the opportunities for more emotional involvement in learning. Now, however, the emphasis on higher order thinking and problem solving makes the classroom a more exciting and emotional place to be. (McLeod, 1989, p. 251)

The fundamental principle of mathematics education reform is that, for everyone to operate effectively and reach his or her potential, it is economically and morally imperative that the public concept of mathematics, the range of mathematical ideas taught, the way in which they are presented, and the opportunities for learning mathematics be broadened to reflect the needs of society and the diversity of students.

Greenfield Community College

In general, the community college system focuses on diffusion. Each college attends to the diverse needs of its home region, its employers and its people (Rouche & Baker, 1987). Most have doors open to anyone who approaches and, combined with the selectivity of other post-secondary educational institutions, this results in a high concentration of students from lower socio-economic backgrounds, lower academic achievement, and from a wide range of social origins and cultures (Roueche & Baker, 1987).

A particular example of the community college system is Greenfield Community College (GCC), where this study will take place. GCC is one of the smallest of the Massachusetts State Community Colleges, located in a rural area at the intersection of two major highways at the edge of a county town. The Greenfield Community College Mission Statement (1993), the result of an intensive collaborative writing project begins with the commitment

- To be the primary source of adult education in the northern half of the Pioneer Valley [The Connecticut River Valley in western Massachusetts]
- To provide low cost, high-quality open-admission education in a small college environment
- To participate in transforming our region to a knowledge-based economy and to prepare students to live and work in the emerging global society. (p. 2)

The GCC Mission Statement starts its section "Our Values" with the paragraph

> Greenfield Community College is defined by its commitment to helping every student succeed. Our faculty are, above all, teachers. They and our staff cooperate to provide strong academic programs and support services that are responsive to student needs and assist them in reaching their goals.(p. 4)

Along with descriptions of specific departments and academic and community programs, the Mission Statement adds to the flow established by the principles behind mathematics education reform with statements such as these:

> Our academic programs prepare students to be flexible and innovative in our ever-changing environment. (p. 3)
>
> GCC is committed to empowering people. Through education we provide a means for people to lead more productive lives and enhance their economic futures. (p. 4)
>
> [W]e are committed to addressing directly and forcefully the enduring legacy of oppression so firmly rooted in our society. Above all, we — students, faculty, and staff — are a community working together in a climate in which learning is recognized as intrinsically valuable. (p. 4)
>
> We believe that the times call for dramatic change and creative approaches to the delivery and structure of higher education in Massachusetts and in the United States. (p. 5)
>
> We cherish [our] growing diversity and are committed to recruiting and serving these and other groups who are under-represented in higher education. ... To meet the needs of this diverse population, the College actively promotes innovative and experienced-based approaches to instruction. (p. 4)

In this climate of serving the needs of local and global communities by providing not just physical access to an educational institution, but by reexamining fundamental attitudes, principles, instructional methods, and goals, Project Jump Start was created.

Women in Technology: Project Jump Start

Women in Technology: Project Jump Start is a semester-long college preparatory program, created and initiated by Charlotte Rahaim, an educator of more than thrity years of varied experience. The program admitted its fourth cohort in January, 1995. Participants do not matriculate at GCC until possibly the semester after the program takes place. GCC provides the setting, some of the staff, and many of the services. Project Jump Start is funded by the Jobs Training Partner Act (JTPA ) through the Franklin/Hampshire Employment and Training Consortium. The Project goal is "to prepare 40 [20 per semester] economically and educationally disadvantaged women for entry into Associates degree technologically-based programs that are non-traditional for their gender" (Women in Technology Grant proposal, 1994, see Appendix A). The proposal goes on to explain that

> The model expands upon the concept of a learning community where team-teaching, an integrated curriculum comprised of [math, communications, computer usage, principles of science and technology], contextual learning, and individualized students' unique learning styles and needs are all brought to bear in a mutually supportive and student-centered environment. (p. 8)

Participants must meet Franklin/Hampshire Employment and Training Consortium, JTPA criteria of residency (local), age (over 16), citizenship (authorized to work in the U. S.), and economical disadvantage (less than $17, 880 annualized income for a family of four, for example). Complete criteria are given in detail in Appendix A. Participants are recruited in collaboration with the Department of Public Welfare, Franklin/Hampshire Employment Training Consortium, and other social service agencies and women's organizations with references from GCC's Admissions Office, the GED (General Educational Development) program, and existing programs at GCC serving a similar population. There are twenty participants per session (the sessions follow the college semester calendar) and they have twenty hours per week of classroom experiences and career exploration. The first eight weeks are spent in the classroom, computer room, and science lab working with a regionally designed Applied Academic Curriculum. This curriculum was written as part of the Tech-Prep program bridging the last two years of technical school with the first two years of college, and has been adapted for the Jump Start Program by a Franklin County Technical School science teacher and a member of the GCC mathematics faculty. These two people are also the instructors for the science and math component of the Jump Start Program.

> Developed to recognize and respond to the needs of students with non-auditory learning styles, this competency-based curriculum is consistently hands-on yet nonetheless rigorous, requiring a high degree of student involvement in labs and special projects, exploring, experimenting, measuring, testing and building a variety of participatory teamwork and critical thinking skills. (Women in Technology Grant Proposal, p. 6)

In addition, there are classroom experiences designed to develop effective study skills and investigate career options. The final seven weeks continue classroom interaction with "job-shadowing" placements in existing and emerging critical industries. Individual counselors help identify needs, form personal learning plans, and provide follow-up advising to ease the transition into college or employment. Performance outcomes include

> 1) raising awareness of mid-level technical careers, 2) increasing the attainment of math/science/communications and computer usage competencies..., and 3) establishing a comprehensive system of technical education in the region which includes specific outreach and support mechanisms for a variety of special populations. ... Primary positive outcomes expected are competency gains in math/science areas, increases in self-confidence/self-esteem in these academic areas, and increased awareness/interest in Associate Degree career options and pathways toward reaching them (Women in Technology Grant Proposal, p. 10).

Specific competencies (listed in excerpts of the Program Document in Appendix A) are measured by pre- and post-tests. Awareness, interest, and attitudinal changes are "measured by the counselor via pre and post surveys and development of individual career plans and portfolios by students" (p. 11). [This information is independent of my research.] Writers of the grant make it clear that success should not to be measured solely by quantitative gains or high percentages enrolled in college or embarked on mid-level technical careers. The project is "directed primarily at increasing general academic competencies and encouraging the exploration of alternative career options" (p. 11). A student who comes to know herself and her goals and has the self-confidence and basic skills to work toward any career is a positive outcome.

## Purpose of Study

The purpose of my study is to gain awareness, appreciation, and understanding of the beliefs about mathematics and the attitudes about themselves as learners of mathematics of a group of women preparing to enter community college and technical occupations. In the event that their beliefs and attitudes are initially restrictive or seem to be counter-productive to the effective mathematics education of the students, this study considers if and how those beliefs and attitudes change in a context designed to increase the students' access to and comfort with the mathematics they need to enter a technical field.

## Definitions

Within the context of Greenfield Community College's mission, mathematics education reform, and Women in Technology: Project Jump Start, mathematics takes on a broader and more forgiving meaning than it traditionally has had in university education and areas of fine specialization. Although there are pinnacles of pureness where researchers work rigorously within a formal framework, there is also a wide apron of everyday, applied, human mathematics extending to children, students, workers, and citizens — to all who seek to understand and utilize the concepts of shape, pattern, and number. Mathematics is defined, for my purposes here, to include quantitative literacy —and, come to think of it, qualitative numeracy.

Throughout the statement and discussion of my research problem and research questions, I use the terms affect, beliefs, and attitudes. Psychologists often subdivide learning into three dimensions: affect, cognition, and behavior (or conation). My primary interest in this research is the affective dimension. Affect, a noun, accent on the first syllable, is defined by The Dictionary of Psychology by J. P. Chaplin, to be "a broad class of mental processes including feeling, emotion, moods and temperament." Cognition , on the other hand, is "a general concept embracing all forms of knowing. It includes perceiving, imagining, reasoning, and judgment." Conation or behavior involves action or impulse to act.

The affective dimension can be subdivided in various ways. I use Douglas McLeod's (1989) classifications from the context of mathematical problem solving of beliefs, attitudes, and emotions. These are not separate provinces of the affective domain, however, just as affect, cognition, and behavior are not independent dimensions of learning. On the border of the cognitive and affective domains, the more cognitive of affective factors is beliefs (Schoenfeld, 1985). Beliefs describe the way a person views mathematics, education, and oneself. Moving away from the head toward the heart, we come to attitudes. Attitudes are related to beliefs but they have a positive or negative polarity and more personal objects. Beliefs and attitudes are long-term and stable; they are traits of the individual. One may believe that mathematics is a collection of rules to be memorized and have the attitude that personal mastery of those rules is pointless or impossible.

At the episodic level, we come to the gut reactions — emotions. These are short term affective variables. They are temporary states, but repeated occurrence of an emotion in similar situations can lead to attitudes about the general context (Mandler, 1989). If one is repeatedly frustrated by word problems, he or she develops the attitude "I can't do word problems." If a student repeatedly feels the emotion of joy at using visualization to make connections between mathematical concepts, that student develops the attitude of being capable of making sense of mathematics and alters his or her belief to include the possibility that mathematics is dynamic and accessible. I look for signs of emotion in my classroom observations, but my primary focus is on the longer term beliefs and attitudes.

## Assumptions

I start my study assuming the following:

- Students' views about the nature of mathematics are discernible.
- One can get an indication of a student's beliefs and attitudes by open-ended interviews, student writing, and classroom observation.

- The development or encouragement of productive beliefs and favorable attitudes about mathematics and learning is an important part of effective mathematics education.
- Productive beliefs about mathematics and learning include:
  - mathematics is a broad and useful field accessible to everyone,
  - much of mathematical knowledge is contextual and socially negotiated,
  - there may be more than one answer or method,
  - wrong answers are often valuable,
  - collaboration and reflection are valuable ways to form and refine concepts,
  - language and communication play an essential role in getting to know mathematics.
- Favorable attitudes and emotions include feeling safe about the process of constructing knowledge, having self-confidence, feeling capable, being curious and interested, enjoying the learning process, having a sense of accomplishment when a problem is solved or a concept grasped, making productive use of frustration, and experiencing the joy of discovery.

## Process and Goals

In this study, I select six members of Project Jump Start and interview them individually at the beginning of the program and after the program has ended. I observe them regularly in the classroom and ask them to respond to a short questionnaire about beliefs about mathematics. At the initial interview, I ask them about their past experiences with mathematics, their expectations of the program, their instructors, and themselves, how they regard the subject of mathematics and their relationship to it, and their perception of the learning process. At the end, I get them to talk about their experiences during the course, whether they think their beliefs or attitudes have changed, and what they think an ideal environment would be for learning math. Early in the session, I ask all of the students present to indicate their degree of agreement with a series of statements about mathematics derived from the National Research Council report (1991), Moving Beyond Myths: Revitalizing Undergraduate Mathematics. During the semester, I am a regular participant-observer in the learning community, paying special attention to these six students, how they respond to their science and math experiences and exercises, and how they interact with their instructors, fellow students, printed materials, and tutors. During some of the observation sessions, I concentrate on specific themes, for example, the extent and kind of collaboration between students, the nature of the questions asked, and anomalies to dualistic thought.

The methods of the math/science portion of Project Jump Start aim to develop the mathematics necessary to understand a particular phenomenon as it is encountered. Math is presented as pertinent, interesting, and useful — part of a larger experience. I look for signs that student beliefs are changing and for experiences which maybe nudging this change.

My goals are to have an awareness of each of the six students' initial beliefs and attitudes about mathematics and learning mathematics and how they change in a four month period during what may well be to be a transition in their lives. I consider the beliefs and attitudes and any change using the ideas and language of human development and effective mathematics education as established in the literature review in Chapter 2.

## Theoretical Frameworks

The theoretical frameworks for the analysis of this study are human development and effective teaching and learning, including current mathematics education reform and its underlying philosophy. As I am investigating the attitudes and beliefs of women taking part in a program designed to prepare women for fields in which their sex has traditionally been under-represented, wherever possible I consider gender differences in the theories. Throughout the study, I try to keep the larger picture in mind and appreciate the fact that people are complex, that learning is a complicated process, and that rarely are descriptions unbiased, explanations complete, or causes and effects linear.

## CHAPTER 2

## A REVIEW OF THE LITERATURE

### Introduction

The world is a noisy place. There are shifting paradigms, clashing metaphors, alternative viewpoints, agreement and argument. In the midst of an abundance of information and multiple perspectives, my purpose, methods, and goals are simple: I want to help students become comfortable and competent in mathematics; to accomplish this, I become involved with them and their classroom environment and consider possible beneficial curricular and pedagogical options.

I am steeped in what others have thought and said, and know that there is a giant reservoir of untapped sources. Human development, teaching and learning, mathematics education reform, and the evolution of the philosophy of mathematics provide background, insight, vocabulary, stimuli, and conceptualizations for my study. Woven through these frameworks are overlapping concerns of social equity, realizing individual potential, capitalizing on gender differences, and meeting the social and economic needs of the future. Because women are the stars of the study, sources which reconsider prior studies this time with women particularly in mind are included when the earlier studies might not be. Some of my sources are well known and widely accepted in their areas. Others are more obscure; with this study on my mind, articles that I read or conversations I have on subjects not intentionally related seem to shed new light on my analysis.

### Altermative Perspectives

In this study I investigate the state and change of students' beliefs and attitudes about mathematics and learning. There are overlapping fields in which I stand to watch these changes:

1. Individual students are observed in their journeys of *human development*.

2. Sometimes, the context is reduced to a particular group of students in a specific classroom with set instructional goals. Here the field of reference is *teaching and learning* , with

particular emphasis on affect in the sub-fields of teaching and learning mathematics, adult education, and collaborative learning.

3. The program and its participants are seen as an implementation of the current wave of *mathematics and science education reform* within the community college mission.

The fact that I am concerned with beliefs and attitudes about mathematics is a complicating factor. I do not think that human development theories alone have a wide enough perspective for my purpose. Many people's development in mathematics is different from their overall development; some never move beyond the lowest stages of cognitive development in mathematics in spite of their growth in other areas. Students' views of mathematics may be more taught than developed. Teaching and Learning literature, however, seems to benefit from the enrichment of a human development approach. Mathematics has a tradition and reputation of being absolute, dualistic, and impersonal. The mathematics education reform movement bases its version of effective teaching and learning of the subject on a philosophy that mathematics is relative, fallible, and socially constructed. In a sense, the philosophy of the subject has evolved along a path comparable to a developing human. Mathematics education is only now slowly reforming to recognize that historical evolution.

## Adult Development

Each person has a unique way of experiencing the world and learning about it, and this way of knowing is likely to change with time. Theories of human development try to make sense of how a person changes in the way he or she conceives of the world and his or her relationship to it. They try to explain where people are and where they are going on a metaphorical journey through life. Because my study involves adult women in an educational setting, I am drawn toward researchers and practitioners who describe the adult condition and pay particular attention to women and to learning. In addition, to get an idea of possible future sources, I look at works which summarize and compare some of the research findings and theories.

Foundations — Perry

The work of William Perry forms part of my foundation in adult human development. His book Forms of Intellectual and Ethical Growth in the College Years (1970) is based on a longitudinal study of young men at Harvard around 1960. This is quite a different population and setting from middle-aged welfare women coming to a community college in the mid 1990's, but his purpose was very similar to mine: to investigate the "evolution of students' beliefs about the nature of knowledge, truth, and fact, and the role of authorities in defining and conveying knowledge" (Kurfiss, undated).

The skeleton of Perry's scheme provides both vocabulary and a coarse framework to use as a reference point for other theories and empirical data. He described the development of the young men of his study as being a continuum with mileposts along the way starting with *Dualism*, moving through *Multiplicity* to *Relativism* and eventually *Commitment in Relativism*. These terms are defined below.

> *Dualism*. Division of meaning into two realms — Good versus Bad, Right versus Wrong, We versus They, all that is not Success is Failure, and the like. Right Answers exist somewhere for every problem, and authorities know them. Right Answers are to be memorized by hard work. Knowledge is quantitative. Agency is experienced as "out there" in Authority, test scores, the Right job.
> *Multiplicity*. Diversity of opinion and values is recognized as legitimate in areas where right answers are not yet known. Opinions remain atomistic without pattern or system. No judgments can be made among them so "everyone has a right to his own opinion; none can be called wrong."
> *Relativism.* Diversity of opinion, values, and judgment derived from coherent sources, evidence, logics, systems, and patterns allowing for analysis and comparison. Some opinions may be found worthless, while there will remain matters about which reasonable people will reasonably disagree. Knowledge is qualitative, dependent on contexts.
> *Commitment*. An affirmation, choice, or decision (career, values, politics, personal relationship) made in the awareness of Relativism. ... Agency is experienced as within the individual. (1970, p. 80)

This continuum is more finely marked by nine positions where each position includes and transcends earlier ones. Perry's scheme is an example of what Lillian Troll (1985) called Stage Theories, with characteristics that everyone goes through the same stages, in the same order (no short cuts), with a predetermined endpoint. Even though everyone's route is the same, there is variability in rate and length of stalls and (according to Troll) an underlying assumption that there is a good way and a bad way, the good way being the one in tune with middle class values. As well as the position period names *Dualism*, *Multiplicity*, and *Relativism*, Perry provides some verbs for lack of progress: *temporize, escape,* and *retreat*.

In a chapter written by Perry in The Modern American College (1981), he looked back twenty years to this first study, back ten years to the publication of Forms of Intellectual and Ethical Growth in the College Years and a second study, and at the time he was writing, he had data from a third study. He explained his theory and answered questions, rethought some points, and made some adjustments and refinements. He commented that perhaps transitions between positions are more important and interesting than the positions. He acknowledged that development may be recursive rather than two-dimensionally linear — a helix with an ever expanding radius — but this still is a continuous linear hierarchy. He recognized that individuals mature in their cognitive structures at different rates in different areas or contexts. His original view was that development should not be forced, but allowed to take its natural course; his scheme was primarily descriptive. Lee Knefelkamp convinced him of the feasibility of developmental instruction where "teaching and curriculum could be optimally designed to invite, encourage, challenge, and support students in their development" (Perry, 1981, p. 107) — a more prescriptive use of his scheme. Knefelkamp found intervention particularly effective for encouraging movement from dualism to multiplicity (Knefelkamp, 1978). Joanne Kurfiss discussed further implications of developmental theory to classroom instruction. Characteristics of college settings which appear to encourage epistemological development include faculty expressing doubt about information or results, de-emphasis on rote learning, lecture, and objective tests, faculty available for interaction, and encouragement of disagreement and active debate (Kurfiss, 1975). In this 1981 chapter, Perry also considered the relationship between cognitive development and cognitive styles, and, basically, saw his earlier work in a broader context.

Reading Perry, I sensed not a detached observer but an experienced teacher, in touch with his students and aware of the actual complexity interplaying with the simplicity of his scheme. Daloz (1986) noted that Perry's interest in development was aroused when he asked students in his literature class what they believed he wanted from them, and was surprised by the variation in their answers. Even though many instruments have been created to measure position in Perry's scheme more efficiently (questionnaires, essay tests, etc.), Perry preferred open and leisurely interviews, relying on rapport with the student and the judgment of the interviewer for positioning (Kurfiss, undated).

The work of William Perry and his associates has formed the basis or stimulus for other studies of more direct relevance to my research, notably Dorothy Buerk's doctoral dissertation (1981), Belenky, Clinchy, Goldberger, and Tarule in Women's Ways of Knowing (1986), and Marcia Baxter Magolda in Knowing and Reasoning in College (1992).

Women's Cognitive Development

Dorothy Buerk (1981) worked with a small group of college women who were at lower positions by Perry's scheme in mathematics than in other subjects. These women were articulate and intelligent, but were avoiders or low achievers in mathematics. She tried to raise her subjects' math developmental level using specially designed individual and small group instructional methods.

Mary Belenky, Blythe Clinchy, Nancy Goldberger, and Jill Tarule (too often referred to as Belenky et al, the alphabetical listing of the names gives Belenky uncalled for predominance in this collaborative project) in their investigation resulting in the book Women's Ways of Knowing (1986) were inspired and informed by Perry. They too worked from the premise that "our basic assumptions about the nature of truth and reality and the origins of knowledge shape the way we see the world and ourselves as participants in it" (p. 3). Rather than accepting the practice of squeezing women into the development pattern that emerged from an empirical study on men, they immersed themselves in the individual stories of 135 "rural and urban American women of different ages, class and ethnic backgrounds and educational histories" (p. 4) to allow women to form their own pattern. To have a connection with (or roots in) previous theory, they included in their interview questions specially coded questions designed to indicate Perry positions. The Women's Ways of Knowing study resulted in a number of "perspectives" from which women know and view the world: *silence, received knowledge, subjective knowledge, procedural knowledge,* and *constructed knowledge.*

> Building on Perry's scheme, we grouped women's perspectives on knowing into five major epistemological categories: *silence*, a position in which women experience themselves as mindless and voiceless and subject to the whims of external authority; *received knowledge*, a perspective from which women conceive of themselves as capable of receiving, even reproducing, knowledge from the all-knowing external authorities but not capable or creating knowledge on their own; *subjective knowledge*, a perspective from which truth and knowledge are conceived of as personal, private, and subjectively known or intuited; *procedural knowledge*, a position in which women are invested in learning and applying objective procedures for obtaining and communicating knowledge; and *constructed knowledge*, a position in which women view all knowledge as contextual, experience themselves as creators of knowledge, and value both subjective and objective strategies for knowing. (p. 15)

Being more cross-sectional than longitudinal, Women's Ways of Knowing resulted in a snapshot of perspectives or states of development rather than a video clip that shows movement between positions or the process of development. The authors acknowledged that how people progress, the order in which the perspectives are attained, and why and when women shift were not well-addressed. What Women's Ways of Knowing did was break the tradition of perceiving women as aberrant men and question many long-held assumptions about learning and human development. Unlike Bloom's Taxonomy (1954) which worked from the outside in and established the "proper" direction in which a student's mind should move, Perry and the Women's

Ways of Knowing group worked from the inside out, watching and asking how people's minds do work and establishing a pattern later (Hogsett, 1993).

Another contribution of Women's Ways of Knowing to the investigation of epistemology was the awareness and the reinforcement of an alternative metaphor for knowledge. It is of voice rather than vision that the women spoke. This echoes a theme of earlier feminist scholars including Carol Gilligan who, in her book, *In a Different Voice* (1982) examined Kohlberg's theory of moral development from the female perspective. According to Gilligan, women speak with the voice of care and responsibility; men prefer the voice of justice. The Women's Ways of Knowing group noted the usual visual language for knowledge and its connotations of disengagement and objectification — standing apart from knowledge. Speaking and listening, on the other hand, suggest dialogue and interaction. To speak, one must be the agent; the voice comes from within. To see, one is the receiver, passive; the scene exists outside. The English language does not have enough common aural descriptors however — or perhaps habits are just too hard to overcome. In spite of their convincing case for voice rather than sight, they called their ways of knowing "perspectives" and referred to the women's "views," "insight," and "reflection."

In "Women's Development Across the Life Span" (Evans, 1985) Nancy Evans gave an overview of developmental theories and their implications with regards to women. Evans and Troll (1985) recognized that historical events and change may have an effect on how a person sees the world, that development is neither culture nor context free. Evans grouped theories into three perspectives: *Life Span, Life Events*, and *Individual Timing*. The *Life Span* perspective is least influenced by environmental factors. One goes through a sequence of age-related steps or tasks. Erikson (1968), Levinson (1978), and Gould (1978), all of whom studied men, are examples of Life Span theorists. Evans noted that women do not seem to fit well into these molds. Women's development seemed to be more context, event, and timing related. Instead of parallel strands leading up standard steps, there are intertwining and inter-influential dimensions of family, career, and interpersonal relationships with their accompanying variable self-concept and sense of well-being. Women's development has been described as a "braid of threads in which colors appear, disappear, and reappear" (McGuigan quoted in Evans, 1985, p. 20). The two other perspectives, *Life Events* and *Individual Timing,* are more sensitive to the outside world and individual paths through it. From the *Life Events* perspective the timing, duration, and ordering of major sustained activities are important factors in determining one's world-view and identity. Women are more likely than men to allow one area of their lives to affect other areas. From the *Individual Timing* perspective, particular events like divorce, death of spouse or parents, children going to school or leaving home, and career plateaus or opportunities affect one's development. Against the backdrop of male developmental theories, Evans saw women as more complex, less predictable, and more context-sensitive.

Chickering and Havighurst (1981) noted reverse tendencies for men and women. Women move from "being" toward "doing" whereas men move from "doing" toward "being." Troll (1985) perceived men going from active-mastery to passive-mastery, meeting women traveling in the opposite direction (from passive-mastery to active-mastery). Similarly Baxter Magolda (1992) described a difference between students of the receiving, interpersonal pattern (more likely to be women), who demonstrated communion and gained agency, and those of the mastery, impersonal pattern (more likely to be men), who demonstrated agency and gained communion. Maybe men and women have some effect on each other. Daloz (1986) has a different take on this two-way traffic for men and women. Interpreting Levinson (1978) and Sheehy (1976), he suggested that in our 40's we reappraise life and seek to redress imbalances. "Neglected parts of ourselves call out more loudly to be heard" and a "longing for wholeness begins to replace the ideal of perfection" (Chickering & Havighurst, 1981, p.56). Perhaps we shall meet in the middle.

Chickering and Havighurst (1981) integrated and synthesized various theories and came up with movement along seven vectors, cycles of differentiation and integration, men and women moving differently, and repetitions of tasks. "Complex development tasks are never achieved once and for all. Shifting circumstances and new challenges may require tackling them again at other levels of complexity and sophistication" (p. 30).

Lillian Troll (1985) also presented an overview of adulthood, looking at both state and process, indicating contradictions, raising questions, showing complexity. An important dualism for her was open/closed. Is human development pre-programmed (closed) or are we open to changing conditions? She saw two kinds of models: the open-ended learning theories and the structured stage theories. Evan's Life Events and Individual Timing classifications are open-ended as is Riegel's (1975) dialectic theory which stated that human development is a result of opposition between a pre-existing state and a new condition, with the resolution being a new structure which incorporates both into a qualitatively different form. For intellectual development, closed versus open systems relates to biological versus social determinism and competence versus performance.

A Developmental Scheme for Both Sexes

Marcia Baxter Magolda, in Knowing and Reasoning in College (1992) synthesized Perry's Scheme and Women's Ways of Knowing. She too was concerned with students' perceptions of the nature of knowledge. Like Perry, she conducted a five year longitudinal study of college students. Unlike Perry she investigated men and women and had the benefit of a broader paradigm for learning that included connected as well as separate knowing, concern for others as well as self, and collaboration as well as competition. Her resulting four vertical ways of knowing with two horizontal gender-related patterns interwove Perry's Dualism to Multiplicity to Relativistism to Commitment progression of positions with Women's Ways of Knowing received or subjective or procedural or constructed perspectives. Students in Baxter Magolda's study were found to progress generally from *absolute knowing*, where certain knowledge is the domain of the instructor, to *transitional knowing*, where authorities are not all-knowing and there is increased importance of others' insights, to *independent knowing*, where most things are uncertain and each person has his or her own beliefs, and finally to *contextual knowing*, where it is possible to make a judgment in a particular situation. In addition Baxter Magolda showed the following tendencies of student development in college: Authority and reward move from the outside in; knowledge is acquired then understood and eventually integrated, applied, and evaluated;

relationship with peers evolves from isolated units looking out at authority to parallel units glancing at and aware of each other but still looking outward, to communicating group members checking with the instructor for verification, to fully a collaborative group constructing meaning and providing its own authority.

Each way of knowing has two gender-related patterns which link (loosely) into a receiving - interpersonal - interindividual chain and a mastery - impersonal - individual chain. More women showed the former pattern chain, and more men the latter, but this was neither a strict classification nor invariable. Some people switch pattern chains when they move from one way of knowing to another.

There are two features of Baxter Magolda's formula that are of particular interest to me as I prepare to get to know individuals within a learning community. The first is the importance of context when considering knowledge, and the second is the growth of the relational aspect of learning as one develops.

Social Construction of Knowledge

Berger and Luckmann in The Social Construction of Reality (1980) established the theoretical basis for sociology that reality and knowledge are dynamic and socially constructed, the result of an ongoing dialectical process between the individual his or her environment, socially formed institutions, and intersections of relevancies with other individuals. This dialectical process has three moments: externalization, objectivization, and internalization, which do not occur in a temporal sequence but are simultaneously characterized for each individual. There is, however, a temporal sequence for a person's induction into participation in the social dialectic. According to Berger and Luckmann, isolated individuals do not make meaning autonomously but must interact with significant and generalized others. Everyone has a different reality, but there is an ongoing correspondence, a shared common sense which is constantly being adjusted and, at the same time, influences each individual reality. Language is of paramount importance for this correspondence, for crystallizing and stabilizing subjectivities, for focusing, anonymizing and detaching experiences — making them generally available — and for linking past, present, and future events. Knowledge is socially distributed, possessed differently by different individuals. It is a real-ization in two senses of the word: "apprehending an objectivated social reality" and "ongoingly producing this reality" (p. 62). One "knows" (or is successfully socialized) when there is a symmetry between subjective and objective reality.

Built into Baxter Magolda's ways of knowing is the growth of interpersonal reasoning. Learning is a relational activity that thrives in a communal atmosphere. It "requires a continual cycle of discussion, disagreement, and consensus" (p. 223). There are two aspects of peer involvement: talking to understand and talking to hear others' views. Rogers (1990) similarly differentiated between communication as sharing and communication as performance. Collaboration improves both communion and agency. Depending on the gender-related pattern, working with others either helps a student strong in agency to gain communion or encourages a student comfortable in communion gather agency.

Non-uniform Development

Kolb (1981) called attention to the socio-cultural variation of subject areas and the effect of this on student development.

> ...we have often emphasized the unitary linear trend of human growth and development at the expense of acknowledging and managing the diverse developmental pathways that exist within different disciplines and professions. (p. 233)

Each student integrates cognitive and socio-emotional factors to create his or her own way of viewing the world and coping with it. Kolb characterized learning styles by a four stage cycle on two axes: concrete ⇔abstract and active ⇔reflective, with all of the quadrants a part of the learning process. Heredity, experience, and environment result in learning styles that emphasize some learning abilities over others. There may be "fundamental mismatches between personal learning styles and learning demands of different disciplines" (p. 233).

> The scientific professions and basic disciplines are predominantly analytical, seeking to understand wholes by identifying their component parts, whereas the socio-humanistic fields tend to be synthetic, believing that the whole can never be explained solely by its component parts. (Kolb, 1981, p. 243-244)

How well a students "fits" with the dominant style may affect the student's achievement and persistence. Failure to match the dominant style of the field may result in the student being "weeded out." Effective education in a "mismatched" field may require deliberate efforts to strengthen weaker spokes and moderate the field's dominant style.

Kolb's theory allows for a dimension of development as well as the two-dimensional learning cycle. Each student develops cognitively in three stages: acquisition, specialization, and integration. Kolb pictured this growth out of the plane of the learning cycle in the shape of a cone, with complexity, relativism, and integration increasing toward an apex.

Kolb (1981) asked the question, "Should we continue to follow the trend toward increasingly specialized education or should we be creating new educational programs that reassert the integrative emphasis lost in the demise of classical education?" (p. 251). The answer suggested by mathematics education reform, the GCC mission, and Kolb is that we should "reassert the integrative emphasis, developing appreciation of and competence in diverse approaches to creating, manipulating, and communicating knowledge" (Kolb, 1981, p. 252).

Application of Development Theories to Adult Students

Laurent Daloz in his book Effective Teaching and Mentoring (1986) drew human development and adult condition literature into consideration of effective teaching. As a teacher and mentor who worked with adult students in a non-traditional educational setting, he showed how developmental theory can be applied and how particular students fit into various schemes. He also provided additional insight derived from teaching students about development rather than just observing their development. He found that some students have trouble acknowledging that there are positions different from their own. In a study published in 1981, Daloz found that most adults returning to college arrived carrying some degree of dualism.

Gabelnick, MacGregor, Matthews, and Smith (1990), in their investigation of learning communities, also observed that the majority of students could be classified as dualistic at the beginning of their college learning community experience. Piaget (1964) noted that being able to think about thinking is itself a stage of development.

Daloz' perspective was that of a practitioner, and he highlighted mentor-student interaction, attaching less importance than Baxter Magolda to student-student interaction. Daloz sustained the metaphor for education of a transformational journey — not a continuous gradual progression but leaps, slips, and catastrophes. Developmental theories provide various maps for this journey. Daloz held great stock in Kegan. Kegan (1982), in The Evolving Self posited an upwardly spiraling helix of evolutionary truces alternating between independence and inclusion. Life is a continuing struggle between self and other. Kegan saw development as self-authorship — one achieves new power and expands his inner self. This is quite different from the importance Friere (1985), Baxter Magolda (1992), Gilligan (1982), and Berger & Luckmann (1980) attach to interaction, communication, relationships and social construction. According to Kegan, a teacher or mentor can help the student reach and let go, balance and then get to a stage of imbalance before balancing at a higher level by variably and sensitively providing *confirmation, contradiction,* and *continuity.* Balance-imbalance seems like a two step process, but the three external factors are comparable to a dialectical process where the student's thesis meets an antithesis resulting in a synthesis. From the student's viewpoint, this is a three-fold process of accepting, rejecting, and reconstructing.

## Teaching and Learning

### Developmental Education

Effective Teaching and Mentoring (Daloz, 1986) was based on development but focused on teaching. Daloz emphasized that the main purpose of teaching is to engender trust, not to bestow knowledge. Knowledge grows rather than accumulates. "The role of a teacher is to help students increase the complexity of their world by exposing them to a world bigger than they know in a gentle and supportive way" (p. 97). Teachers and mentors can foster student learning, by showing not their knowledge but their curiosity, excitement, interest, willingness to connect and modeling how they operate, solve problems, and approach new situations.

Weathersby (1981), writing in Chickering's The Modern American College, viewed education as encouraged development.

> Exposure to higher level reasoning, opportunities to take others' roles and perspectives, discomforting discrepancies between one's actual experiences in a situation and one's current explanations and beliefs — these are the basic elements of the transition process ...(pp. 71-72)

The role of the teacher in facilitating student development was seen by Widick, Parker and Knefelkamp (1978) to be providing the appropriate amounts and balance of *challenge* and *support*. But this is not as simple as adjusting hot and cold taps. Challenge and support have different sources depending on the student's developmental level. According to Widick, Parker, and Knefelkamp, Dualistic students found support in structure and challenge in diversity, whereas Relativistic students found support in multiple perspectives and challenge in the necessity to commit. A teacher can provide support by listening, empathizing, assigning achievable tasks, having positive expectations and by being accessible. Challenge can be provided by questioning and calling attention to contradictions and other perspectives, having high standards, setting tasks which stretch one's abilities, and stepping back (Widick, Parker, & Knefelkamp1978).

The challenge and support balance goes along with Kegan's confirmation, contradiction and continuity. Learning makes the world more complicated; thinking becomes more complex. The student loses his or her balance and then struggles to regain it. According to Piaget and Perry, when we feel safe, we reach out. Under stress or in new situations, we may slip back. "Success at the educational venture is less a function of brains than of balance and courage" (Daloz, 1986, p. 236).

These suggestions for effective teaching emerge from balancing challenge and support, or confirmation, contradiction, and continuity:

1. Call attention to multiple methods, assumptions, conclusions, models and perspectives.
2. Provide a context for your subject. It has a history, rests on a web of assumptions, and has implications and applications.
3. Give students the opportunity to discuss, debate, play roles, to use language both to form and to share knowledge.
4. Know your students and the tasks which they are confronted by.
5. Ask a student to reflect and then help move the reflections to a level where meanings are made. Fowler (1981) said that a mentor's task is to "nurture us into new metaphors" (Daloz, 1986, p. 235).

Chickering also held the interactionist's view that education and student development are in conversation. "[C]ertain activities will by their very nature provide information, demand different behavior, and provoke introspection — all elements which bring about developmental changes in attitudes and behavior" (Widick, Parker, & Knefelkamp, 1978, p. 19) Some tasks ask students to make choices, require interaction with diverse ideas, involve students in solving complex intellectual and social problems without demanding conformity to an authority's view, and involve receiving feedback and making objective self-assessments.

Adult Education

Several scholars of adults and adult education (Brookfield, 1986; Cross, 1982; Knowles, 1984) wrote about the state of adulthood in its variety, without considering it specifically as a process of development. They agreed generally that adult learners are characterized by the amount and variety of their experiences, by their autonomy, their orientation toward learning, particular physical and attitudinal patterns, and the complexity of their lives. Brookfield (1986) saw the role of educators to be to challenge students. "As adults, we are enclosed within our own self histories. Unless an external source places before us alternative ways of thinking, behaving, and living, we are comfortable with our familiar value systems, beliefs, and behaviors" (p. 19). A facilitator's job is to present alternatives. Knowles (1984) stressed that adults are different from children and should be taught differently, and that one of the differences is in the location of authority. There is no place for authoritative teaching. "The role of the teacher is to engage in a process of mutual inquiry with them rather than to transmit his or her knowledge to them and then evaluate their conformity to it" (p. 31). Cognitive learning theorists provided the following principles of teaching:

> 1. *The perceptual features* of the problem given the learner are important conditions of learning — figure-ground relations, directional signs, sequence, organic inter relatedness. Hence a learning problem should be so structured and presented that the essential features are open to the inspection of the learner.
> 2. The *organization of knowledge* should be an essential concern of the teacher or educational planner so that the direction from simple to complex is *not* from arbitrary, meaningless parts to meaningful wholes, but instead from *simplified wholes to more complex wholes.*
> 3. Learning is *culturally relative*, and both the wider culture and the subculture to which the learner belongs may affect his learning.
> 4. *Cognitive feedback* confirms correct knowledge and corrects faulty learning.
> 5. *Goal-setting* by the learner is important as motivation for learning and his successes and failures determine how he sets future goals.
> 6. *Divergent thinking*, which leads to inventive problem solving or the creation of novel and valued products is to be nurtured along with convergent thinking, which leads to logically correct answers. (Knowles, 1984, pp. 65-66)

## Collaborative Learning

A recurring theme in adult education literature, feminist education, mathematics and science education reform and effective teaching, is collaborative learning. Brookfield (1986) wrote, "Collaborative modes of teaching and learning will enhance the self concepts of those involved and will result in more meaningful and effective learning" (p. 29). Johnson & Johnson (1988), Davidson (1990), Webb (1989), and others who studied collaborative learning presented small group interaction as a safe, viable, effective way to encourage development. Instead of receiving knowledge, students are given the opportunity to construct it. They negotiate meanings, find authority and voice in themselves and classmates, and consider alternative solutions. In a small group, students become aware of diverse thinking styles, cultural perspectives, experiences, and ideas. Students as well as teachers can provide the model, encouragement, and support for development.

Forman (1989) in an article entitled "The Role of Peer Interaction in the Social Construction of Mathematical Knowledge" attributed negative attitudes toward mathematics to the fact that it is often not taught the way it is practiced. Whole class instruction and drill communicates the idea that the subject is the property of experts. Collaborative learning allows a more constructivist approach. Students assume more responsibility for defining goals and strategies, and constantly refine their understanding in light of discussion and other's perspectives. Schoenfeld (1985) combined his interests in graduate research and undergraduate problem solving in math. He stressed the importance of social interaction and believed that meanings and ideas are negotiated — that there are ideas in the air, generated by group interaction. There is a big difference between knowing how to do a problem and understanding its significance or real meaning. Mathematics must be generated. The teacher helps the students find fertile ground for exploration and makes sure appropriate values are respected. Legere (1991), a college math teacher, came to the conclusion that "no matter how good a teacher you are, how clear your presentations and good the dialogue with your students, collaboration and writing offer essential opportunity for students to learn" (p. 166).

Learning Communities

Collaborative learning within a traditional classroom setting is one way of encouraging social construction of knowledge, using language to form and to share knowledge, and providing the support and challenge for individual development. Learning communities accomplish these and other ends on a larger scale. According to Gabelnick, MacGregor, Matthews, and Smith (1990) "learning communities constitute an unusual reform effort because of their focus on the structural features of our institutions and our curriculum as both the problem and the solution" (p. 5). "Learning communities are validated by recent pedagogical theory and research on collaborative and cooperative learning, writing, critical thinking across the curriculum, and feminist theory" (p. 10). Courses are linked together with team teaching and interdisciplinary themes to provide greater coherence and increased intellectual interaction with faculty and fellow students. The theoretical basis for learning communities comes from Alexander Mieklejohn and John Dewey in the 1920's and 30's. Both considered education's role to be preparation of students to be responsible citizens. Mieklejohn (1932) started Experimental College at the University of Wisconsin (1927-1932) and stimulated later learning community experiments. Dewey (1938) established the theoretical framework for experiential, active, student-centered learning, inherently social but individually based.

Effective Mathematics Teaching

Effective mathematics teaching overlaps developmental teaching (Buerk, 1985) and collaborative learning (Davidson, 1990; Webb, 1989; Forman, 1989), already discussed, and recommendations of mathematics reform discussed in the next section. Other areas of research of interest to me for my study are construction of mathematical knowledge, writing to learn math, affective teaching, and making mathematics more accessible to women.

Paul Cobb (1988) and Cobb, Yaekel, & Wood (1991) considered the tension between the view that students construct their mathematical knowledge and the goal of mathematical instruction to initiate students into a culture of the wider community. "Individuals each construct their individual mathematical worlds by reorganizing their experiences in an attempt to resolve their problems" (Cobb, Yaekel, and Wood, 1991, p. 4). "As cultural knowledge, mathematics is continually regenerated and modified by the coordinated actions of members of a community" (Cobb, Yaekel, & Wood, 1991, p. 92). Cobb regarded this to be fundamental dilemma of teaching: should a teacher push to cover the curriculum or provide a comfortable learning environment for individual understanding? He saw individual and community, cognitive development and acculturation as non-intersecting areas which must be coordinated, not integrated, by the teacher. Teachers and students need to redefine mathematical knowledge as socially constructed and learning as both interactive and constructive. "They learn by reorganizing their experiences of interacting with others in an attempt to construct a consensual domain within which to communicate about mathematics" (Cobb, Yaekel, and Wood, p. 93-94). "Choosing and using 'good problems' and instituting appropriate means of classroom communication can be thought of as two of the tasks that teachers need to do to teach mathematics" (Cobb, Yaekel, and Wood, p. 125).

Constructivism is widely, but not universally, recognized as a valid theory of learning, particularly in recent mathematics education reform literature. In an article in the Journal for Research in Mathematics Education (1995), Cobb rebutted an accompanying article by Robert Orton. These two articles present two sides of the representational/constructivist debate. An educator's basic philosophy, in this case whether mathematical knowledge pre-exists outside or is constructed by each individual, is fundamental to his or her concept of effective teaching.

Writing to learn has an extensive literature for all subjects. Language is important in knowing (Berger & Luckmann, 1980) and finding voice is essential to development (Belenky, Clinchy, Goldberger, & Tarule, 1986; Baxter Magolda, 1992). In The Craft of Teaching, (1988) Kenneth Eble suggested free writing as an avenue for capturing student's random thoughts. Brown and Walter in The Art of Problem Posing (1990) proposed problem posing by students as a way of to shift control to the student, and develop problem solving skills. It helps students to "own" the subject, to reduce the distance between themselves and mathematics and become creators rather than recipients. Problem posing allows for differences in student interest and ability and helps them learn to work more productively and less competitively with others. There is a similar theme of empowerment in Hoffman & Powell (1989). The under-prepared math student in college may believe that mathematics is not a thoughtful activity — that it is a static collection of facts to be memorized. Being asked to write allows the students to practice the language, to reflect on mathematical experiences, to externalize their thoughts so they can "examine their conceptualisations and revise them in light of further or contradictory evidence" (p. 57). Diane Vukovich (1985) suggested journal writing for both learning and sharing, and sees the additional function of writing to communicate with the teacher — to express concerns and confess confusion.

Affective teaching refers to teaching which is sensitive to the students beliefs, attitudes, and emotions. Douglas McLeod (1989) and Alan Schoenfeld (1985) have published extensively about the role of affect in problem solving, where problem solving refers to considering and analyzing situations and questions which do not have clear or specified algorithmic or procedural solutions. When solving non routine problems, students are more apt to feel higher degrees of both frustration and joy. Verna Adams (1989) suggested that math teachers should consider affective components when planning instruction, be sensitive to student attitudes and beliefs, and help the students become aware of their feelings. Students need to learn that frustration is part of the problem-solving process, and that it is not a signal to quit (McLeod, 1989). The teacher should start with easy non-routine problems that provide plenty of opportunity for success. The whole curriculum should be constructed to reduce the frequency of panic response. Group work is useful in providing social rewards and helping students enjoy the challenge. McLeod (1993) suggested that teachers model the problem solving process, working with the class on problems to which no one knows the answer. Acting against social construction of knowledge is the practice of teachers preparing their thoughts in private prior to class; students do not see the thinking process (Tucker, 1994). Teachers should call attention to limitations of the tools of mathematics as well as their power. Students should be given credit for explanations, strategies, and alternative methods.

Much has been written in the past twenty years about mathematics and gender. Only a small segment of this is concerned with classroom teaching. Suzanne Damarin (1990) campaigned for feminizing the subject, particularly the language, types of problems, and classroom techniques. Others (<u>Essays in Humanistic Mathematics</u>, 1993), called for *humanizing* the subject by placing the student more centrally in the position of inquirer and acknowledging the emotional climate of the activity of learning mathematics . The SummerMath Program for young women at Mt. Holyoke College "emphasizes greater conceptual understanding, affirmation of young women as capable members of a learning community, and the importance of construction one's own understanding of complex ideas" (Morrow, J. 1992). They take into account the following research findings

- Females prefer an environment where students are not working alone and in isolation.
- Knowing the utility of mathematics and its connectedness to other areas seems critically important to females.
- Females are frequently allowed to be more passive than males in school and are less often asked to develop justifications for their ideas.
- Opportunities to explore the world spatially occur less often for females than males.
- Feeling confident in mathematical ability is more predictive of course taking for females than males.
- The computer culture outside of the classroom is predominantly male.
(Morrow, C, 1992, p. 182)

Classroom methods based on these principles include providing exercises for which no method or answer is given, having students work in pairs or groups, asking for pictorial representation of solutions, and facilitating learning rather than leading the student or transmitting knowledge. The SummerMath program emphasizes process over product and tries to provide both context and connections for the mathematical knowledge which is being constructed and discussed. Deborah Schifter and Catherine Twomey Fosnot (1991) applied these principles to teachers, giving them the opportunity to experience mathematics as something human beings do so they can teach in a way other than the way they were taught. Joan Countryman, a math teacher, daughter of a math teacher, and mother of a math teacher agreed that the under-representation of women in mathematics is not because women are deficient, but that, as she said in the title of an article, "perhaps it is time to change the subject" (1992). It is her hope that mathematics classes will engage emotion and rationality, intuition and logic. Jungwirth (1993) agreed.

> Maybe there are different approaches to math, different ways to experience math as meaningful, different aspects of math that make or do not make sense; and maybe mainly those ways are ignored and those aspects are emphasized in the

mathematics classroom that make females rather than males feel uncomfortable because of lack of meaning. To turn away from math in this view would be a decision of females who make fruitless efforts to create meaning out of what is going on. They would not be victims of gender role expectations. They would like to live in worlds that make sense. (pp. 141-142)

## Mathematics and Science Education Reform

### Current Reform Movements

Virtually all current reform movements in mathematics and science education in the United States are in the direction of broadening the subject matter and making the fields accessible to more diverse learners. In the development or evolution of education, the call is for relativism and social construction to replace dualism and absolutism.

The 1980's was a very active decade for education reform. Because of changing demographics and increasing use of technology, preparation for life and work needed to change as well. A Nation at Risk : The Imperative for Educational Reform (National Commission on Excellence in Education,1983) painted a grim picture of the state of education in the U. S. including a "crisis" in the teaching and learning of math. This was followed, for the field of mathematics, by Everybody Counts: A Report to the Nation on the Future of Mathematics Education (National Research Council, 1989), The Curriculum and Evaluation Standards for School Mathematics (National Council of Teachers of Mathematics, 1989), Reshaping School Mathematics : A Philosophy and Framework for Curriculum (National Research Council, 1990), and Moving Beyond Myths: Revitalizing Undergraduate Mathematics (National Research Council, 1991).

Much of the failure in school mathematics is due to a tradition of teaching that is inappropriate to the way most students learn (National Research Council, 1989). Most teachers teach as they were taught, and, at the post-secondary level anyway, this is predominantly a lecture/ example/examination format.

> Present educational practice in the United States offers students only one path to understanding — a long dimly lit journey through a mountain of meaningless manipulations with the reward of power and understanding available only to those who complete the journey. (National Research Council, 1989, p. 58)

> To believe that one can teach mathematics successfully by lectures, one must believe what most mathematicians know to be untrue — that mathematics can be learned by watching someone else do it correctly. Research shows clearly that this method of teaching does little to help beginning students learn mathematics, a fact underscored by the staggering rates of withdrawal or failure among students who take introductory college mathematics courses. (National Research Council, 1991, p. 24)

As well as criticizing the existing practice in mathematics teaching, the reports suggested reforms in curriculum, teacher training, assessment, and instructional materials, based on the philosophy that mathematics is a natural mode of thought and that all people can become quantitatively literate if they are given the opportunity to learn. "Revitalization" was taken to mean the dispelling of destructive myths about math and communicating the awareness that math is a language and a science of patterns and is dynamic, growing, beautiful, and fascinating (National Research Council, 1990).

A set of documents which has become the "constitution" for school mathematics teaching, written under the direction of the National Council of Teachers of Mathematics is <u>Curriculum and Evaluation Standards for School Mathematics</u> (1989), <u>Professional Standards for Teaching Mathematics</u> (1991), and <u>Assessment Standards for School Mathematics</u> (1995), collectively referred to as <u>The Standards</u>. In writing these standards for grades K-12, the National Council of Teachers of Mathematics reached a consensus that "all students need to learn more, often different mathematics and that instruction in mathematics must be significantly revised" (p. 1) and came up with these five goals for all students: that they 1) learn to value math, 2) become confident in their ability to do math, 3) become problem solvers, 4) learn to communicate mathematically, and 5) learn to reason mathematically.

To move from traditional practice to mathematics teaching for the empowerment of students, The Standards suggest five major shifts in the classroom environment.

> We need to shift —
> - toward classrooms as mathematical communities — away from classrooms as simply a collection of individuals;
> - toward logic and mathematical evidence as verification — away from the teacher as the sole authority for right answers;
> - toward mathematical reasoning — away from merely memorizing procedures;
> - toward conjecturing, inventing, and problem solving — away from an emphasis on mechanistic answer-finding;
> - toward connecting mathematics, its ideas, and its applications — away from treating mathematics as a body of isolated concepts and procedures.
>
> (National Council of Teachers of Mathematics, 1991, p. 3)

To be consistent with reformed curriculum and methods, it is necessary to consider new concepts and techniques of assessment. Assessment Standards for School Mathematics (NCTM, 1995) and Assessment in the Mathematics Classroom (NCTM, 1993) give examples of assessment by class observations, student interviews, portfolios, self-assessment and performance indicators. In Education Update, a publication of the Association for Supervision and Curriculum Development (1995), Performance Assessment is discussed. Performance Assessment involves starting from your objectives, setting tasks, specifying critera by which they will be evaluated, and observing students as they undertake the tasks.

An American Association of University Women (AAUW) report in 1992, How Schools Shortchange Girls, found that the education system was not meeting girls' needs and emphasized that gender must be considered in curriculum reform and evaluation. Inclusive teaching methods suggested are to have students read and tryout problems before they are gone over in class, provide structure in which all students (not just the quickest and loudest) answer questions, have students work collaboratively, and have more "hands-on" experiences.

The Task Force on Women, Minorities, and Handicapped in Science and Technology was appointed by Congress to develop a long-range plan for broadening participation in science and technology. It published Changing America: The New Face of Science and Engineering in 1989. This report gave a statistical analysis of participation and demand, and concentrated on recruitment and preparation on traditionally under-represented groups. Donna Hughes (1991) in an article "Transforming Science and Technology: Has the Elephant yet Flicked its Trunk?" tackled the field of science, not those it has excluded. She wrote that masculine traits are intertwined with science; objectivity, rationality, and logic are highly valued. Knowledge depends on the agreement of a significant group of people and in science; the definers of knowledge are men; science replicates its own kind. Traditionally, sciences classes consist of facts and theories, resist providing societal context, and do not encourage critical thinking or independent thought. Many excluded students "long for a context where their subjective needs can be integrated with study, where the primary focus is a broader spectrum of ideas and modes of inquiry" (bell hooks quoted by Hughes, 1991, p. 395). Sheila Tobias in They're Not Dumb, They're Different: Stalking the Second Tier (1990), approached the problem of broadening the access to science by asking non-science (but qualified) post graduate students to "seriously audit" undergraduate chemistry and physics courses to get an insight into how the teaching of these subjects might be changed to encourage more people to major in science. They found an entirely different culture from classes in social sciences and humanities. The science classes were large and impersonal, highly competitive and grade-oriented, fast-paced, there was little interaction of student with students or students with faculty, and few students seemed interested in "the overall picture" or in understanding concepts. There was

> a strong sense that scientists are born not made. Unless they are unusually self-motivated, extraordinarily self-confident, virtually teacher- and curriculum- proof, indifferent to material outcomes, single-minded and single track, in short *unless they are younger versions of the science community itself,* many otherwise intelligent, curious, and ambitious young people have every reason to conclude there is no place for them in science. (p. 11)

Dudley Herschbach, a chemistry professor at Harvard commented that there are (at least) two kinds of science students

> 'sprinters' ...who are quick to grasp new material and who do very well at the kind of manipulations demanded of them in introductory science ... and 'long distance runners,' ... who may appear to move more slowly and with greater difficulty, but whose grasp in time is profound. Science as it is currently taught and evaluated in college ... favors sprinters over long-distance runners, a significant loss to science because the latter, if they persist, often make the most important contributions. (Tobias, 1990, p. 61)

Suggestions arising from Tobias' project were that study groups and collaborative learning should be actively encouraged, exams should ask for conceptual rather than just procedural understanding, teachers should give more contextual and historical information, and that the pace should allow for more discussion and meaning-making.

The Evolution of the Philosophy of Mathematics and Science

The philosophy behind the current reform movements in mathematics and science education is the result of an evolving philosophy which, in many ways, mirrors the course of human development mapped by Perry and Baxter Magolda. Michael Guillen divided his collection of essays Bridges to Infinity (1983) into three sections intitled "Fantasizing," "Compromising," and "Optimizing." These correspond to and survey three periods in the history of mathematics before, during and after discoveries of the nineteenth and twentieth centuries which changed the concept of the nature of mathematics from divine, infallible, and unlimited, to human and fallible with limitations yet still very useful. Guillen saw the revelation of this reality to be useful in overcoming math anxiety. He challenged misconceptions and tried to transmit some of the excitement and beauty that he experienced from within the field. His general message was "math is not what you think it is."

Psychologist Christopher Lucas (1985) stood far enough away from mathematics and natural science to see the shape of their changes without being distracted by the small scale adjustments. Using Thomas Kuhn's (1970) concept of shifting paradigms — basic changes in scientific understanding — he noted the resulting or perhaps simply parallel fundamental transformations in psychology. In Lucas' analysis, devastating changes occurred in mathematical thought earlier than the period which Guillen considered critical. Sir Isaac Newton and Rene Descartes completely altered the anthropomorphic view of the world which had existed for nearly twenty centuries. Before Newton and Descartes, humans were perceived to be descended from angels and spent their lives reclaiming or reknowing the divine order. The world was but a setting in which humans sought a certain truth using infallible reason. Scientific developments in the seventeenth century led to a mechanistic and reductionistic view of nature where humans were but detached spectators. Newton saw the universe as a determinant machine, metaphorically a clock. Descartes suggested the world could be broken into parts and that these parts could be studied separately and assembled according to rigid laws of cause and effect. Descartes also saw essential differences between mind and body, object and subject, knower and known (Lucas, 1985).

Newton is often quoted as saying, "If I have seen farther than other men, it is by standing on the shoulders of giants." This is not an image of mutual support, however. "Newtonian" is the adjective attached to "science" to describe an individual working alone, grappling with knowledge on his own. In light of Kuhn's shifting paradigms, on the shoulders of giants is a pretty precarious position. And ... in the beginning of the twentieth century, Einstein, Heisenberg, Godel, and others made discoveries which contradicted the basic notions of Newton and Descartes (Davis and Hersch, 1981; Kline, 1972; Lucas, 1985; Guillen, l983). Brought into question were the existence of an objective physical reality, universal causal rules, and a natural world directly accessible to a detached observer. At the edges of scientific inquiry, in the investigations of the atom and the universe, Newton came tumbling down, but as Lucas (1985) observed, "the metaphysical view of the world is more durable" (p. 165). People's beliefs have a lot of inertia.

Advances in theoretical physics and quantum mechanics showed that the world cannot be separated into basic particles or known with infinite precision but is "a complicated web of relations between parts of a unified whole" (Stapp, 1971 ). Matter is not mechanical, mass and energy are interchangeable, space and time have no fixed reality. Both certainty and completeness of mathematical reasoning fell as Godel used logic to prove that not everything can be proved with logic (Guillen, 1983; Hofstadter, 1979), and Heisenberg blurred the subject-object and knower-known dichotomies with his uncertainty principle (Hofstadter, 1979). Nature is not an independent reality. The scientist is not impartial but is integrated with nature. This paradigm shift, still not widely felt beyond its epicenter brings scientific thought closer to the teachings of Eastern mystics. Hindu, Buddhist, and Taoist philosophies agree that consciousness is inseparable from reality. Another philosophical change resulting from scientific discoveries of this time was from the true/false duality of Aristotle (logical certainty) to the true/false/possible triad of Godel (uncertainty) (Guillen, 1983). True or false or possible is approaching the multiplicity of the four-valued logic of Taoist thought where, for example, one can have order, non-order, disorder, and anti-order (Hayles, 1991).

Philosopher Karl Popper (1979) replaced the Newtonian view that all clouds (icon for seemingly unpredictable behavior) are clocks (mechanistic, deterministic) if you look closely enough, with the inverse, all clocks are actually clouds —all physical phenomena are essentially unpredictable.

Guillen (1983), Hayles (1990) and Gleick (1987) suggested a very recent or perhaps imminent paradigm shift in mathematical thought with similar conceptions spreading to such fields as literature (in Hayles), psychology (Lucas, 1985), educational administration (Blair, 1993) and qualitative research (Patton, 1990). This new paradigm is chaos. Chaos theory in mathematics confronts previously dismissed complex behavior and looks for order and information either hidden in (Gleick, 1987) or emergent from (Prigogine & Stengers, 1984) dynamical systems. Characteristics of chaotic systems are deterministic causality at each step but unpredictability after a sequence of steps, disproportionality of cause and effect (small fluctuations leading to large scale changes), "strange attractors," self-similarity, dissipation and turbulence. Interaction, feedback, adjustment, and iteration are activities common to chaos and to human, particularly educational, experience.

The nature of mathematical thought described above follows the route from certain to uncertain, absolute to relative, deterministic to probabalistic. Another route to consider is from the external existence of mathematical objects, individually sought, to the social construction and negotiation of mathematical knowledge.

Tymoczko (1985) distinguished between the *private* theories of Platonism, logicism, formalism, and intuitionism, which perceive precise eternal relationships between atemporal mental objects, and *public* theories where a community negotiates meaning and constructs contextual ideas which are fallible, tentative, and evolving. Kuhn (1970) described any prevailing scientific thought system as a paradigm where

> A paradigm is what members of a scientific community share, and, conversely, a scientific community consists of men who share the paradigm....Within such groups communication is relatively full and professional judgment is relatively unanimous. (pp. 176, 177)

Popper (1979) argued for an evolutionary (instead of a paradigmal) interpretation of knowledge where chance responses, speculations, and guesses become hypotheses which are then subjected to experiments. Selection of the most productive responses eliminates unfit hypotheses. Knowledge (in any field) develops by the survival of the fittest ideas. Imre Lakatos, considering *informal* or living mathematics as opposed to the *formal* mathematics of pure symbolic logic, described the social negotiation of knowledge by suggesting that

> mathematics, too, like the natural sciences is fallible, not indubitable; it too grows by the criticism and correction of theories which are never entirely free of ambiguity or the possibility of error or oversight. Starting from a problem or conjecture, there is a simultaneous search for proofs and counterexamples. (Davis & Hersch, 1981 p. 347).

These proofs are not formal logical proofs but "explanations, justifications, elaborations which make the conjecture more plausible, more convincing..." (Davis & Hersch, 1981, p. 347).

Sal Restivo, as editor of a collection of essays entitled Math Worlds: Philosophical and Social Studies of Mathematics and Mathematics Education (1993) addressed the need to bring mathematics from Platonist idealism down to an earthbound view of mathematics as a "social and cultural construct, product, and resource" (p. 9) to reflect actual applications and practice.

Dorothy Buerk (1985), when investigating the ways women view mathematics, found that many see the subject as absolute, not person-made, closed to them. She wrote, "'Arcane' is a good descriptor for the view of mathematics held by some math-avoidant women — hidden, secret, mysterious, obscure. Interestingly, the Latin root of this word means 'shut up in a box'"(p. 62). In order to allow them to use mathematics effectively, she worked with a group of college women to change their beliefs so they could see the subject as a human invention with connections to their own lives, to get to know mathematics as it is used and created, not the concise, polished product that is often taught.

Philip Davis (1993) made the case that mathematics is a human institution, citing the fact that much of "used" mathematics is *convention* (the decimal system, choice of symbols, order of operations), some of it is *gratuitous* (gambling, insurance calculations), and parts are *provisional* (tax legislation, Newtonian mechanics). He used the word "mathematization" to describe the increasing use of and demand for mathematics in our everyday lives. The meaning of mathematics is "found in the shared understanding of human beings, not in an external non human reality" (Davis and Hersch, 1981, p. 410). We must accept mathematics as it is: fallible, correctable, and meaningful.

There is a theme of defensiveness in several works against the long-held and resilient Platonic view. It is often safer to hold an absolutist's view. From within, you are in control and secure, playing according to the rules. From without, there is an excuse to preserve that distance. Davis and Hersch (1981) make the claim that a typical working mathematician is a Platonist on weekdays and a formalist on Sundays. That is, when he is doing mathematics he is convinced that he is dealing with an objective reality whose properties he is attempting to determine. But then, when challenged to give a philosophical account of this reality, he finds it easiest to pretend that he does not believe in it after all. (p. 321)

## Integrating the Perspectives

Human development, teaching and learning principles of inclusiveness and social construction of knowledge, and epistemological evolution were all brought together in a short article by Duch and Norton, "Teaching for Cognitive Growth" (1993). Instead of watching people on a developmental journey, they saw young college students as ignorant, shallow and inexperienced. "Our students come to us naive epistemologists, replete with mistaken views of the nature of knowledge and its acquisition" (p. 1). Students begin college as "zebra thinkers" who subscribe to a

> baby bird philosophy of education with its own three R's — receive, remember, and regurgitate. ... Because we force them to fulfill 'breadth' requirements, the dualist's world is soon dimmed by the fogs emanating from doubt-ridden disciplines in the humanities and social sciences. As the students perceive it, certainty retreats to the 'hard' sciences, while elsewhere truth yields to disagreement and dispute. (p. 1).

Note that dualism is allowed to remain in the sciences. Duch and Norton went on to ask whether college courses are designed and taught to facilitate this maturing process and correct students' misconceptions. They encouraged experiential learning, group work, problem solving, discussion, and writing. They suggested movement from black and white tests, cultivation of "the intellectual habits of scholarly discourse" (p. 2) by serving as models, telling teachers that "this entails that we unpack our expertise to make our knowledge explicit, to invite students into the quest for knowledge by showing them not the fruits of our inquiries, but the way that we pursue them" (p. 2). Effective teaching helps the student develop a more useful philosophy.

"The Invisible Hand Operating in Mathematics Instruction: Students' Conceptions and Expectations" by Raffaella Borasi (1990) is another article which considers the implications to effective teaching and learning of the contradictions between the way students perceive mathematics to be and the way it has evolved. Borasi described as "dualistic" a set of beliefs leading to counter-productive misconceptions such as

> Learning mathematics is a straightforward matter and practice *alone* should "make perfect."
> It is no good trying to reason things out on your own.
> Staying too much on a problem is a waste of time.
> You cannot learn from your mistakes.
> A good teacher should never confuse you. (p. 178)

She asked where these beliefs come from, since they do not reflect real math, and suggested that they might be attributable to the developmental level of the student and/or to the way that mathematics is often taught emphasizing rote learning, individual work, time constraints, and lower level thinking rewarded on standardized tests. She also suggested that effective teaching requires students to "engage in activities that can generate doubt in assumptions taken for granted up to that point and to personally experience more humanistic aspects of mathematics of which they may have been unaware" (1990, p. 179). Dualistic beliefs about mathematics are not true conceptions of the nature of the subject and may be dysfunctional. They should be recognized and the teacher can encourage their development into more accurate and productive views.

Another intersection of perspectives is the book Learning and Change in the Adult Years: A Developmental Perspective by two Australian adult educators, Mark Tennant and Philip Pogson, published this year, 1995. They concentrated on the connections between experience, learning, and development in the education of adults, assuming a socially constructed definition for development. Tennant and Pogson wrote that "adult development can only have meaning in a given social or historical context" (p. 5) and that, for example, working in groups is now recognized as an intellectual ability currently valued by employers. Society dictates what characteristics define positive growth and currently the ability to collaborate is more highly valued than autonomy. This is an interesting variation of theories of connected or separate knowing and male/autonomy and female/relationships development.

Tennant and Pogson defined adult intelligence and knowledge broadly, including practical knowledge, implicit knowledge, and expertise. They considered the relationships between development of the self and social development, between effective adult teaching and experiencial learning, and between adult teachers and learners.

> 'Learning to Be' is indeed a continuous, lifelong pursuit, one in which the self struggles to preserve continuity with past experiences and simultaneously, to change and develop in order to make sense of current and future experiences. This ongoing tension between continuity and change lies at the heart of what it means to develop and learn across the lifespan. (1995, p. 5)

# CHAPTER 3

# METHOD

## Introduction

There has never been any doubt in my mind that this would be a qualitative study. I grant myself the luxury of watching and interacting with a group of people at the outset of an exciting educational experience and listening closely to their preconceptions and reactions. I share that luxury by describing and interpreting the experience for others. We stand to gain an appreciation of this group of educationally and financially disadvantaged students, an awareness of their beliefs and attitudes about learning mathematics, and an understanding of how classroom experiences attempt to convert existing beliefs and attitudes into positive factors in the students' learning, life, and work.

The students I study are in a new environment, in a setting where, earlier in their lives, they may have felt ridiculed, harassed, or ignored. It is possible that they enter the program feeling vulnerable, manipulated, defensive, or just plain scared. A loosely structured but focused interview —a conversation with an interested person— seems to be less threatening than tests or questionnaires. I use open-ended questions that ask students to recall experiences, tell stories, share their goals and dreams, their concerns and worries. I want the structure or patterns, if there are any, to emerge from the whole picture rather than be preconceived. I am eager for unanticipated information.

## Theoretical and Philosophical Orientation

In Qualitative Evaluation and Research Method (1990), Michael Patton described a number of traditions and orientations contributing to the variety within qualitative research (pp. 66-87). There is *ethnography, phenomenology, heuristic inquiry, symbolic interactionism, ecological psychology, systems theory....* , and, I was surprised to see, *chaos theory : nonlinear dynamics.* Of chaos as a "new tradition" Patton wrote,

> The chaos researcher asks: "What is the underlying order, if any, of disorderly phenomena?" And what are disorderly phenomena? The weather, waterfalls, fluids in motion, volcanoes, galaxies — and human beings, human groups, programs ...
>
> At this point chaos theory offers perhaps more than anything else, a new set of metaphors for thinking about what we observe, how we observe, and what we know as a result of our observations. Chaos theory challenges our need for order and prediction, even as it offers new ways to fulfill those needs. (1990, p. 82)

Some of the features of chaos that have implications for qualitative research are that they describe dynamical systems, there may be non linearity, small events may have disproportionally large results, small does not equal trivial, and there may be valuable information in disorder or turbulence.

My research technique is *interpretive.* Frederick Erickson described an interpretive approach in "Qualitative Methods in Research on Teaching" (1986). The "central research interest [is] in human meaning in social life and in its elucidation and exposition by the researcher" (p. 119). "Interpretive fieldwork involves being unusually thorough and reflective in noticing and describing everyday events in the field setting, and in attempting to identify the significance of actions" (Erickson, 1986, p. 121). I am reflectively aware of what I hear and see, rather than acting as a detached reporter. My questions change and my attention swerves from the original lines of inquiry in response to the meanings I attach to a situation. I take Erickson's (1986) suggestion of explicit research questions and deliberate data search as a starting point for interaction and fuel for intuition.

> When we consider fieldwork as a process of deliberate inquiry in a setting we can see the participant observer's conduct of data collection as progressive problem solving, in which issues of sampling, hypothesis generation, and hypotheses testing go hand in hand....[T]he central issue of method is to bring research questions and data collection into a consistent relationship, albeit an evolving one. This is possible, we argue here, without placing shackles on intuition and serendipity. (p. 140)

## Setting

The setting for my study is Greenfield Community College, GCC. The college's physical plant consists of a single building fringed by parking lots, playing fields, and a duck pond, built about twenty years ago on farm land at the base of a hill, not far from an interstate highway, a county town, and a river. The entrance is welcoming; the architecture is confusing (one might say chaotic), the building and grounds are well-kept, the atmosphere is generally friendly, student-centered, and thriving.

As an institution, GCC has a history of interest in and experience with programs similar to Women in Technology: Project Jump Start. The college has a strong developmental mathematics program and outreach into the elementary and technical schools in the area. It has a cooperative education program which places students in the workplace as part of their course of study. In the past four years, GCC has designed and brought to reality at least a dozen programs which focus on displaced homemakers, economically disadvantaged students, returning adults and dislocated workers. [See the Women in Technology Grant Proposal in Appendix A for more information about these programs.] The college's mission, current administrative attitude, and the sympathies and interests of a number of the faculty are oriented in a direction of the objectives of Project Jump Start.

Project Jump Start meets in the late afternoon when there are classrooms available in the college. The students gather in a laboratory/classroom furnished with tables, chairs, and workstations for experiments. There are usually two instructors and a tutor working together with the twenty students.

## Researcher

I have been a part of the mathematics education program at GCC since 1982, first as an adjunct instructor and more recently as a full-time member of the mathematics faculty. During this time, I have been interested in the success of students in the broad sense of improved confidence, self-esteem, understanding and applicability of mathematics, and increased desire to continue their mathematics education, both formally and informally. I have had considerable experience with returning adult students, women and men. Within my own classrooms, I have researched and experimented informally with collaborative learning, and writing to learn, and have investigated attitudes and beliefs about mathematics. I am familiar with the college, the Women in Technology population, and the area of interest for this research.

## Program and Sample

Women in Technology: Project Jump Start is described in Chapter 1 of this proposal and in Appendix A. It is from a group of twenty financially and educationally disadvantaged women who volunteered and were accepted by this program that I choose my sample. I work with and get to know the entire group, which functions as a learning community, but because I want to get to know the students in as much detail as possible and present them to the reader as individuals rather than statistics, my study is centered on six women selected during the first week of the semester. The sample is a random selection, voluntary acceptance.

## Permission and Confidentiality

The administrators, counselors, and instructors of Women in Technology: Project Jump Start are fully aware and supportive of my research, as are the administrators and my colleagues at GCC. They provided information and offer suggestions in my preparation and continue to do so throughout the study. The students in the program, the subjects of the study, are all adults. I introduce myself during the opening sessions in January. I stress that I am not evaluating them or their program or instructors, and I am not the proper conduit for criticisms or suggestions, or even compliments. In the course of my participant-observations, everyone's comments and responses are welcomed.

During the process of selecting my sample, I ask each student individually if she is willing to be interviewed at the beginning and at the end of the semester about her attitudes and beliefs about math. I ensure her that our discussions will be confidential, that I shall use pseudonyms for the students, and will not share my data or conclusions with anyone until after the end of the program, and then only in the form of my dissertation or an article, pseudonyms in tact. If she prefers not to answer a question, or once answered wishes to change or withdraw what she said, then I will comply with her wishes. I ask that she participate in both the initial and the final interview, and if she withdraws from the program, that we can still have the final interview at her convenience within the research period. This is an informal, personal explanation with plenty of time for questions from the student and a conscious attempt on my part to make the student feel relaxed and unthreatened. A more precise and formal statement of expectations and safeguards is written in a consent form (Appendix B), which, at the start of our interview, I ask the student to read and sign.

## Calendar

One Project Jump Start group of twenty began on September 12, 1994 and another on January 30,1995. I observed the Fall group, joining them for about one hour per week during their science and math labs and lessons. This was a preliminary familiarization of the environment and organization before I began my research with the Spring '95 cohort.

In January, I was present for the initial introductions. On their second day, I asked all of the students who were present to complete a short questionnaire indicating to what extent they agree with some statements about mathematics (Appendix D). As soon as I had a class list, I chose my sample and by the end of the third week of classes, I had interviewed five of the sample group individually for approximately forty minutes each. The sixth sample member had her interview the following week. I spent approximately one hour per week with the class, during the time period set aside for math and science. For these observations, I listened to group discussion or wandered among the groups, watching and listening, asking questions, making suggestions, giving guidance — just as I do in my own college developmental math classes. Some days, I concentrated on one topic or area. In the final week of the semester and shortly after the end, I conducted final interviews, lasting about twenty minutes each, of the six sample members.

I spoke with the math/science intructors regularly about what they were doing, why, and how they felt the students were responding. These were informal, colleagual conversations. I noted relevant information and my reactions in journal. I had a more formal discussions at the end of the semester with each of the two instructors. These were similar to the student interviews in that I had prepared questions and tape-recorded and transcribed the sessions.

During the course of the spring semester 1995, while I was interviewing and observing, I transcribed tapes and took and expanded field notes. Starting in June 1995, I began to analyze and ponder the data and my experiences with this project, as I wrote chapters 4 and 5 of this dissertation.

## Procedures

### Initial Interviews

The initial interviews took place during classtime in an empty classroom or an unoccupied public area convenient to the math/science classroom. Students were more than willing to go with me to be interviewed; they had no concerns about missing anything important in class. I openly tape-recorded our sessions, assuring each student that only I would hear the tapes. I explained again to each student of my sample what I expected from her and the safeguards to confidentiality. I told her that I want her to be herself, asked if she had any questions or concerns, and asked that she read and sign the consent form. We then started our interview/conversation, guided by the questions listed here.

A. General, personal:

1. Would you please tell me something about yourself? Describe (introduce) yourself to me.
2. What do you enjoy doing?
3. What do you feel are your strengths and weaknesses?
4. What are your goals?

5. What are your dreams? If you could do anything, what would you do?

B. Mathematics

1. When I say the word "mathematics," what is the first thing that comes to mind?
2. If math were a food, what would it be? Why? Can you think of another metaphor for math?
3. How is math different from other subjects?
4. Can anyone learn math? Are some people better at it than others? Do you think men are better at math than women?
5. Say something about your ability to learn math. Do you think you could be a mathematician?
6. Try to recall a single time or incident in your past mathematics education and describe it to me.
7. If there were no people, would math still exist?
8. What things about math do you like best? ... least?
9. What is math like? If math were a world that you lived in or visited, describe it to me.
10. What do your family/friends think of math?

C. Learning

1. What do you expect from a teacher? What are the teachers responsibilities?
2. What do you expect to do when you are learning? What are your responsibilities?
3. Suppose you are given a problem and you don't know what to do. What is your reaction? What do you do when you get stuck?
4. How do you know if you are right? What do you think or do when you get one answer and the teacher/classmate/everyone gets an different answer?
5. What do you expect to get out of this program?
6. Describe yourself as a student to me? What kind of student are you? How do you learn things best?

7. What do your family or your friends think about you participating in Project Jump Start?

D. Wrap up

1. Are there any questions you would like to ask me?
2. Are there any questions I haven't asked that you would like to answer?
3. If someone were reading about your feelings about learning math, what would be useful for them to know about you?

Written Questionnaire

The National Research Council report, Moving Beyond Myths: Revitalizing Undergraduate Mathematics (1991) lists and discusses six myths about learning mathematics. I used these in a Likert-style questionnaire, asking students to indicate the extent of their agreement with the statement. The statements are:

1. Success in mathematics depends more on innate ability than on hard work.
2. Women are less capable in mathematics than men are.
3. Most jobs require very little mathematics.
4. All useful mathematics was discovered long ago.
5. To do mathematics is to calculate answers.
6. Only scientists and engineers need to study mathematics. (pp. 10-12)

From Raffaella Borasi, "The Invisible Hand Operating in Mathematics Instruction: Students' Conceptions and Expectations," (1990), I took three more.

7. Learning mathematics is a straight forward matter and practice alone should "make perfect."
8. A good teacher should never confuse you.
9. There is no need for creativity in mathematics.(p. 178)

Themes for Observations

On five occasions in my classroom observations, I tried to concentrate on a specific theme or question. These are listed below. I took some notes, but not all of the time as I preferred to interact with the students. As soon as possible after each observation, I sat down and wrote what I saw, what meaning I attached to it, and what patterns or anomalies were suggested.

1. Collaboration. What is the extent and type of collaboration? Are there students who seem to prefer to work alone? Are there students whom others seem to prefer not to work with? What are different styles of interaction? Who is leading? dominating? looking for guidance? Is there evidence for "social construction of knowledge"?

2. Communication. What is the nature of the questions asked by the students? How do they respond to questions asked of them? Do the students talk together, or do they focus on the instructors, or are they silent? Can I discern any patterns of communication? Do some students find it difficult to focus on the teachers addressing the whole class from the front of the room? or to concentrate on their work?

3. Confidence and risk-taking. Are students willing to offer suggestions or answer questions even though they may be wrong? How do they react if they are wrong? Do they attempt to learn from their mistakes? Are they willing to try something when they are not sure what they are supposed to do?

4. Authority. Do the students expect answers from the instructors? Do they trust the answers of other students? Do they have confidence in their own answers? What happens when there is disagreement, or no answer? Are they willing to keep trying to find out answers for themselves? Do they make appropriate use of resources?

5. Developmental position. Using Perry or Women's Ways of Knowing or Baxter Magolda's stages (perspectives), can I see evidence of the various stages? What are the challenges to the positions? Do experiences seem to have different effects on different students?

Final Student Interview

1. What are your thoughts about your Jump Start experience? What was your favorite part of the math/science part of the program? What was the most difficult part? What part did you dislike the most? How might the program be better for you?
2. Are you the same person you were four months ago? How do you think you have changed since we talked in February?
3. Recall an incident from the Jump Start classroom that stands out in your mind.
4. Have you thought up any new metaphors for math?
5. Have your views or opinions of math changed? What might have contributed to the change?
6. If you could design an ideal math/science course or learning experience, what would it be like?
7. Are you satisfied with what you have done?
8. Do you have some advice for the next group?
9. What are your plans now?

Instructors' Interview

1. What do you believe are the objectives of Project Jump Start?
2. In particular, what does the math/science curriculum try to do?
3. How do you go about reaching the objectives?
4. What are your successes?
5. What are your disappointments?
6. What do you like about the program?
7. What do you dislike about the program?
8. How has the math/science component changed since the program began?
9. What changes would you like to make after this semester?
10. How would you describe the field of mathematics?
11. How does one learn mathematics?

12. What do you think are the responsibilities of a teacher?

13. What do you think are the responsibilities of a student?

14. Can you recall any anecdotes that would indicate Jump Start women's attitudes toward mathematics, science, or learning?

15. Speak briefly about your impressions of Peggy, Deanna, Kasi, Aseret, Johaly, and Carol.

## Data Analysis

Transcripts of the interviews, the results of the questionnaire, my field notes, and journal entries provided the data for my analysis. All of this information about the students and the program was observed by or reported to me, the sole researcher for this study. Throughout the research period, I was interpreting and reflecting on what I was seeing and hearing. When the semester was over, I talked with the Jump Start coordinators and obtained from them a record of the students' pre- and post- placement test scores and their preliminary application forms.

## Trustworthiness

My purpose in this research is to gain awareness, appreciation, and understanding of the beliefs about mathematics and the attitudes about themselves as learners of mathematics of a group of women preparing to enter community college and technical occupations. It is not my intent that the results of this study be construed as being general and definitive statements of the way things are or a suggestion of linear cause and effect relationships. I believe that human behavior, the learning process, and the field of mathematics are complex and dynamic, unpredictable and non-reproducible, and that observations and meanings attached to them are subjective and contextual. However, it is possible to see and describe patterns and order emerging from the changing complexity. These patterns provide a perspective for other educators and researchers as well as stimulate questions and suggest directions of inquiry. I do believe that my descriptions, findings, and conclusions have usefulness and credibility beyond my own interest and appreciation. To maximize this, throughout the proposal and research process, I attend to the issue of trustworthiness. As I guide, I use Lincoln & Guba (1985), Naturalistic Inquiry. They suggest five criteria for establishing trustworthiness: *credibility, transferability, dependability,* and *confirmability,* each with recommended techniques and a circular provision that attention to establishing trustworthiness is a way to establish trustworthiness.

Table 1

**Summary of Techniques for Establishing Trustworthiness**

| *Criterion area* | *Technique* |
|---|---|
| Credibility | (1) activities in the field that increase the probability of high credibility |
| | (a) prolonged engagement |
| | (b) persistent observation |
| | (c) triangulation (sources, methods, and investigators) |
| | (2) peer debriefing |
| | (3) negative case analysis |
| | (4) referential adequacy |
| | (5) member checks (in process and terminal) |
| Transferability | (6) thick description |
| Dependability | (7a) the dependability audit, including the audit trail |
| Confirmability | (7b) the confirmability audit, including the audit trail |
| All of the above | (8) the reflexive journal |

(Lincoln & Guba, 1985, p. 328)

Credibility

The credibility of this research is based on 1) my familiarity with developmental mathematics education, returning adult students, and affective teaching methods; 2) my persistent observation of the Jump Start Program both before and during the semester of active research; 3) triangulation of data types including individual interviews, classroom observations, and a questionnaire about the extent to which students agree with myths about mathematics; 4) regular discussion with peers in mathematics education and in research method; 5) a determination to look at evidence that seems to be counter to emerging patterns; and 6) soliciting feedback from interviewees and class members about my descriptions, ideas, and tentative conclusions.

Transferability

This research is heavily context bound. I do not anticipate transferability even for future cohorts in the Women in Technology program. What I hope will transfer is the interest, perspective, and the questions. I try to provide rich description and interpretation to help form and stimulate these. I also provide a thorough record of my method and rationale for others to use as a point of departure.

Dependability and Confirmability

The record provided here contributes to the transferability of the study and provides an "audit trail" (Lincoln & Guba, 1985, p. 319) for inquiry and analysis. In addition, I have field notes, interview transcripts, and a reflective journal kept throughout the planning and research process. I am not free from biases nor do I attempt to be. Instead, I try to be aware of what my biases are and to communicate them to the reader as I feel is beneficial. I am aware of the following biases:

- I am biased toward people who care about learning and who are motivated (although sometimes discouraged) to fulfill their potential.
- I am biased toward people who are willing to investigate and share their thoughts and feelings in an interactive and fluid way.
- I am sympathetic toward students who have been denied (or did not previously take advantage of) educational opportunities, but who are attempting to take advantage of them now.
- I see things in the light of my own philosophy that mathematics is rich, varied, and tolerant of ambiguity, and that basic mathematics understanding is a natural part of life and should be as accessible to everyone as language is.
- I value social interaction as a way to learn.

In these first three chapters, I attempt to determine and clarify for myself and others an investigation of adult students' beliefs and attitudes about mathematics, how they change, and the implications for mathematics education. I have decided what to investigate, why it is of interest and value, and how to go about my investigation. I have tried to establish my assumptions and biases, my theoretical framework, and philosophy. I have built a foundation for my inquiry from the literature of qualitative research, human development, effective teaching and learning, mathematics education reform, and the evolution of the epistemology of mathematics. In Chapters 4 and 5, I describe and analyze the subjects of my study and my observations of them in the context of the Jump Start math/sciences experiences.

# CHAPTER 4

# OBSERVATIONS

## Introduction

Not far (geographically) from the fast food restaurants and supermarkets at the edge of the town of Greenfield is a left turn into College Drive. Pedestrians, bicyclists, drivers and passengers of cars, pickup trucks, buses, and taxis are faced with a wide, gently curving lane passing through grassy (or snowy) fields. Visible about a half mile ahead is an angular concoction of walls and roofs at the base of a tree-covered mountain. To me, this sight is welcoming. I sigh at its beauty and approach with the confidence of familiarity, for I am a higher education veteran. I know Greenfield Community College, GCC, is a place of discovery, exchange of ideas, challenge, and support.

At the end of January, 1995, twenty women turn individually onto College Drive. These women are comfortable on either side of the counter at McDonald's or Food Mart; they know food stamps, welfare checks, social service offices, courtrooms and pediatricians' waiting rooms. But to them the road to science labs, computer stations, placement tests, and professors is unfamiliar, perhaps intimidating or terrifying, perhaps exciting. They are higher education novices.

On Monday, January 30, 1995, the new Women in Technology: Project Jump Start group meets to begin its introduction to college and technological occupations. At noon the women are welcomed and told about the program. They go over the daily schedule and calendar, and take the GCC reading and writing assessment tests. To get to know a very confusing building, they set off in groups of three on a scavenger hunt, asked to sign their names or pick up information sheets left at various sites. They have to find specific classrooms, offices, the library, and computer lab — rooms they will be using in the course of their program. The scavenger hunt ends at the science lab where they gather with instructors and tutors for refreshments and introductions. The Jump Start counselor, the person who will teach the Career Development class, tells the group that her name is Holly and that she likes to sing. She asks each person to say her name and one thing about herself. (There is one man involved in the program, Rick Lane, one of the math/science team. When I talk about the student participants I shall use feminine pronouns. The names I use for the students in the program are pseudonyms. With their permission, I use the real names of the instructors and coordinators.)

> My name is Carol. I am a single parent with three kids. I just quit smoking. I don't usually eat this much.
>
> I am Peggy, a single mother of two. I have a very bright daughter and a mentally handicapped son. I enjoy crafts, music, literature, and poetry.
>
> I'm engaged to my daughter's father. He's a cook.
>
> I'm married with a one year old. My husband is in school.
>
> I love order – but I have five kids.
>
> I have three children. I come from Ohio. I am very quiet but I love conversation.

Every student identifies herself by her children (all are mothers), several say they are going back to school for their children's sake, and almost everyone states her marital status. Two of the women are sisters, but the others are strangers to each other. I introduce myself as a math teacher at GCC and a University of Massachusetts student. I say that I am interested in adult students' attitudes toward mathematics, and I explain that I will be in class regularly, observing, helping, answering and asking questions. I tell them that I will be selecting a group at random to interview, that their participation in my study is voluntary, and that the questions I ask don't have "right" answers.

## The Class of Twenty

During the first week, the Jump Start participants take the GCC placement tests for math, writing, and reading to give a rough indication of their background and to serve as a baseline for progress in the areas tested. The first level courses for matriculating GCC students are Math 100, College 100, and English 100. These are developmental courses; they do not count toward a degree and are not transferable, but completion of these courses or placement out of them is prerequisite for most other courses. Seventeen of the twenty women place into Math 100, a basic arithmetic skills course. Sixteen place in English 100 (a basic writing course) and fifteen in College 100 (a basic reading and study skills course.)

Their preliminary applications give me some general information about the whole group. All live within commuting distance of the college. Nine are from Greenfield and the rest are drawn from the hilltowns to the west, Orange, Wendell, and Turners Falls to the east, and Amherst and Hadley to the south. Their ages range from 19 to 39; ten are in their thirties and nine in their twenties. Both the mean and the median age is 29. Half of them graduated from high school and the other half, having completed between eight and eleven years of school, either passed or are ready for the General Educational Development (GED) examination. All meet the Jobs Training Partner Act (JTPA) criteria of low income and job eligibility.

From this group of twenty, I choose six to get to know in greater detail. Using a random number table, I assign a number between 01 and 20 to each name on the class list, and during the math/science period the following week, I approach those women with numbers 01 to 06. This time I explain to each one individually what I want to do and that she is free and welcome to decide not to participate in my study. Everyone I ask agrees willingly, apologizing that she isn't good at math, that her English isn't very good, or that she probably won't have much of value to say.

## The Sample of Six

I introduce each of the six in the order in which I interviewed them. I have given them pseudonyms; in four of the cases the new (first) names were selected by the students themselves. I chose the others, trying to preserve some of the sense of the name — ethnicity, rhythm, or alliteration. Most of the quotations in this section come from our initial interviews. Also included here and elsewhere in this and the next chapter, are anecdotes and short quotations or paraphrases from my field notes of class observations. For these, I try to make clear the context and time of the observation. The final interviews are summarized at the end of this chapter, after a description of some of the activities and experiences.

<u>Peggy Perkins</u>

Peggy Perkins is white, 33 years old, the mother of two adolescent children. One of them, an eleven year old boy, is a Special Needs child. Peggy was born in Florida and moved to this area four years ago. She has her Learner's Permit and is trying to get her Driver's License. She lives in a rural area of Franklin County with her boyfriend and her children.

She tells of her boyfriend's influence on her. She has been with him for three years. He helped her to lose fifty pounds, encouraged her to get her GED two years ago, helped her to learn to talk to people.

> He helped me to realize that I did want to do more, and that he would help. He is from a very highly educated family. His father had more than three years of college. I wanted a college education and I was scared. How was I going to do it? I want to sit down; I want to write letters; I want to make phone calls; I just want to work myself.

Peggy appears to be motivated and confident. She is always prepared in class with her own scissors, ruler, books, and notes. She is talkative, exudes nervous energy, and seems to be driven to achieve. Peggy quickly turns the conversation to her concern about the proposed state welfare reforms, particularly the effect on the special needs programs in the public schools. Her ambitions reflect both her motivation, "I want to have a better life," and a desire to take care of her circumstances.

> I am planning to study law. I also plan on getting into a nursing program. I plan to get my LPN and then go back to school and get my RN and then go on to law. I'm interested in patients' rights, family law, divorce, child custody and so forth and even dealing with stuff like losing an apartment and losing half of what you have. I had an experience myself. Several years ago I lost half of everything I own during a move. The thing was, the company that owned the building....

Before and after answering my questions about her goals, Peggy tells me that she was in a remedial class at school, that she works at a slower rate than most people, that she does not work well under pressure, and that she is not very good at memorizing. "I have a problem with my multiplication." She had some difficult times in school as a child. "I matured a lot slower than the others did. I took quite a lot of ribbing, not just by the girls but by the boys." She acknowledges difficulties in learning but is confident that with time, effort, and allowances for her own learning style, she can accomplish anything. She attributes the transformation from a slow, shy, overweight, immature girl into a wiry, out-going, confident woman to "survival."

To Peggy Perkins, mathematics means "learning, new experiences, getting to learn the things that I never had in school, working with numbers."

> I use math on a daily basis. I have to keep track of time for medication for my kids. I have to keep track of dollars and the budget. Ummm. There is cooking. I like to cook for other people. How much do I need if I want to decrease or increase amounts?

She ran a general store in Florida where she developed and used both her accounting and social skills. She always loved math and was good at it until about the fifth grade when she fell behind, but she is confident in her abilities. "I can see myself being good at math." During one of their welcoming sessions, the students were asked "If math were a food, what would it be." I repeated this question to each of the students in my sample. When I asked Peggy, she replied, "Potato chips. Because I can't get enough."

<u>Deanna VanDyck</u>

Deanna VanDyck is white, 25 years old, a single mother of a four year old, who is in foster care. She is trying to recover from the emotional damage resulting from molestation and abuse by her father when she was a child. Deanna lives with her mother. Her immediate goal is to have her daughter returned to her "so that I can raise her the way I want her raised." Her dream is to get married and have a family. "I'd probably stay home and make the husband work."

In the classroom, Deanna is restless, chewing gum and jiggling her foot. Often she is staring into space. During one class discussion led by the instructors from the front of the room, she physically turns her back on the proceedings. In conversation with me, she is apt to avoid eye contact; she gives short answers, clears her throat before she speaks, and at times comes up with phrases that sound rehearsed.

On the first day, I recognized Deanna as a former student of mine. I went up to her and said I remembered her but not her name. She told me that she had been in my basic math class a few years ago but that she had emotional problems because of abuse and that she was pulling herself together. When I asked her the following week to be part of my sample, I was prepared for her to say that she would rather not be interviewed, but I was glad that she was not only willing but eager. Several times during our conversations, she mentions her emotional problems as the reason for lack of success at school and since then.

> I've done algebra courses, I've done accounting classes, and, just none of it, I was never able to succeed in, 'cause of all the emotional problems that I have. ... I absolutely hated school. I was dealing with [clears throat] the molestation from my father, at that time. I guess I didn't know who to turn to or, you know, where to turn, or what to do, and so, it just all bottled up inside."

> If I was emotionally stable, better than I was, I think I would have done a lot better in school and I would have got along better with the teachers.

An incident she remembers from school is an unpleasant one. (Why do teachers do these things?)

> When I was in high school I had a teacher that I did not like. I wrote a paper for him, and when I wrote, I wrote it all downhill, slanted, and he intimidated me by making me stand in front of the class to see if I stood that way too. I never went back to that class. I always skipped it.

Deanna's attitudes about mathematics seem paradoxical to me. In spite of her lack of success, she has a good feeling about math. If math were a food, it would be a cake, because of the measuring involved on baking one, yet after an early class exercise involving measurement, she came to me and said she needed a tutor because she didn't know how to use a ruler. When I try to get her to take her cake metaphor further ("Do you like cake?"), she says "I don't like cake, but I'd make it for somebody else." When I ask her if she could picture herself as a mathematician, she replies, "That's what I've always wanted to be is a math teacher ... because I can be in control."

Kasi Rousseau

Kasi Rousseau is white, 32 years old and has three children aged 14, 11, and 7. She recently left her husband and moved from the farm which was her life since she left school in eleventh grade.

> I turned 17 in November, married in December, and the baby was born in May. And then the following year, my husband and I got our GEDs here at the college. Our parents made us, basically, because they knew that it was still fresh in our minds and that it was like the best thing.

Kasi is articulate, forthright, and opinionated. During the semester, she regularly expresses her dissatisfaction with the math/science portion of the program. The words she uses to describe herself as a student are "ambitious, wanting to learn, smart, ready." She is well-groomed and stylishly but casually dressed. She wants to be an interior designer – "I love rooms, and furniture, and colors." – and have her own business.

From the initial interview until our final words, Kasi makes it clear that she hates math. A good student otherwise in school, she recalls a moment in high school algebra class.

> I can see myself right now, remembering him standing up there and me saying, "I don't get it" and him just saying, telling me again, and again, and again, and me telling him, "I don't understand it" and feeling, ummm, kinda like – stupid. I just, well, I didn't understand it, and how come everybody else was ahead of me and I just didn't get it? It was really stressful for me. And so finally I got put into a lower

phase of math and then I was fine. But in order to pursue school and to go to college [I needed algebra]. Algebra courses just scared me, and that is one of the reasons it has taken me seventeen years to come back to school.

Her food metaphor for math is "spaghetti, because it is just a mess. It is just jumbled up. It is just jumbled up numbers. Where other girls were saying, you know, potato chips, hot fudge sundaes and stuff like that, with me it is just 'Take it away!" In response to another question, she talks of mathematics as something solid, something that has to click or that she can grasp, something which is contained on the pages of a text and must be pounded into her head.

Mathematics has been a barrier to Kasi.

In school, I remember, when you went into ninth grade you had to go into interviews with counselors, and they were like, "What are you going to be when you graduate?" and my dreams then were like a dental hygienist or something. And then we saw down the (list of requirements), what I was going to have to take in college, and the first thing that came up was algebra. So it was like, chhhhhhh. And the next thing I thought of was, okay, a nurse. Well you've got to take algebra. Cross it out. I guess I won't do that, thinking that math is like the hardest thing.

Now, however, she seems prepared to try again and confident in her ability to succeed. The college course leading to her dream of interior design requires some mathematics.

But I'm not going to let that detour me this time. ... I feel confident that I can [achieve the level of math that I need] because I know that I am a very smart person, and very confident, a lot more than I ever was. ... I feel that if my daughter can do it, I can do it. If I need to be tutored, then that's what I need to do. If I have to take an extra class, or if I have to redo it, I will do it. I'm going to do it until it sinks into my head and I'm not going to let my dream dwindle because of math.

For Kasi Rousseau, there seems to be a distinction between practical, everyday calculation, and classroom mathematics. She has taken care of her family's finances for seventeen years – "checkbook, income taxes and stuff. So I can do math!" She has fixed up rooms at the farm, and for a job, dealing with measurements for construction, wallpaper, estimates, and such. But her concept of mathematics in the context of college seems to be based on test performance. In the spring of 1994, Kasi started the process of registration at GCC and came in to take the college placement tests.

> I did the math, and we were timed. I think we had 45 questions, or maybe 30 [there are 35] and I got like 15 right but I only got 20 done. I was really surprised [that I got so many right]. But then the other 15, I got wrong because I never even got to them. Fifteen wrong so it was like an F. They gave us, I think it was 45 minutes to do it, and you know, I was a nervous wreck anyway to begin with, even just walking into the school. I was just panicking.

She walked away that time, but several months later joined the Jump Start program. Throughout the semester, she has her eyes set on "passing the placement test." The classroom experiences of measuring and calculating area, volumes, densities, working with electric circuits, gathering and studying data – do not count as mathematics for Kasi, or do not work as opportunities for learning. Even at the time of our first interview, after less than a week of classes, she is not happy with the integrated, experiencial methods.

> I thought we would be doing math. I thought we were going to get more. It's just like so slow. The teacher's not up there. I thought it would be more like a math class like in high school. ... I want to have more of an understanding of what I'm going to be doing on that damn placement test, and not just be sitting there, trying to figure out something. What I'm saying is that if I'm not learning it here now, then I won't pass again.

<u>Aseret Robertson</u>

Aseret Robertson is African American, 39 years old. She has children aged 20, 15, and 11, the youngest two living with her now. She considers herself an artist. Although she has had little formal training, she has worked in various media, charcoal, water color, and oil, and she would like to get into pottery. Her goals are to have an art gallery, to direct a film, to have her own nationwide TV talk show. She has taken African dance in Boston with her sisters. One of them, a school teacher, has a woman's drumming group and a dance troupe. Aseret was born and raised in Springfield, Massachusetts, and lived briefly in California. She makes the unsolicited statement during our first talk, "I had a nice childhood."

Aseret has a striking, almost regal presence. She is tall, well-dressed, more formally than many of the others. She is pleasant and willing to work with the others, but sometimes seems detached, aloof. In spite of her initial qualifier that she is a very private person, Aseret's interview is rich with stories, philosophy, theories about gender differences and development, and examples of some of the characteristics of an adult student.

To Aseret Robertson, mathematics is a task, something she will do if necessary but neither seeks nor fears. She tells of a time she was intimidated by math and computers.

> Years ago, when I first went back to college and took a course, and took computer, I think I literally couldn't move, right in front of the computer. I could not tell you what I did. I could not tell you what I learned. You know, I went through the motions. I passed it but I was pretty much intimidated by it.

Several years ago, she took some classes at "a career development place."

> We had to take calculator, and a job came up. I had to do something; the job sounded good. It was like adding receipts for the day in a book store. I didn't know how involved the math was until I got there, but it ended up being fun, and that's like when I got over that initial thing. We would like add on the calculator, but the women in the office were fun and it didn't really seem like such a hard task. It was all right. I didn't have a problem with it.

Aseret differentiates practical and school math. Math in life is necessary, common sense, worth the effort, enjoyable, and sometimes rewarding.

> I think I've got better at math as I go along because of money. As far as money and finances is concerned, I don't like to put things down on paper, and that's where I go wrong, but as far as adding and getting money right, I'm not going to let anybody cheat me. It might take me a while to find out. I once had a boyfriend and he was working for the electric company, and his pay checks were off. I added up a year's worth of pay checks. It was like I had to do it my way, the slow way, but I will do this, and eventually I came up with the answer, and I went to the president of where they were and I said, "This is what I have, and this is how I got it," and if we're talking about dollars and cents, and if there is any way ... and I was right, you know. And that felt good.

Continuing the difference between math in context and the math of homework and tests, she gives the following example.

> Okay, my kids' father never finished high school. He has been with the electric company over 15 years. As far as reading and math, he didn't get a chance to... He could turn the city on and off, all over the country. And you talk about skills and math and add and subtract and positive. Your life is on the line, and you talk about learning styles and, when it comes to electricity and certain things, he's a genius. The best of them that have all the schooling, they'd come over and say, "hey" ...You know what I'm saying? And that's why I say that about test scores and things like that. ... I know men who have graduated from school with honors, lawyers, you know, with positions and stuff like that, and they get messed up when they go in the grocery store. I mean like how can you be so smart in one way and so dumb in others?

In context, math makes sense and has a purpose. In school, it is a set of algorithms. "It is a matter of fact. If you learn the process, you can do it. I think anybody can learn it; it's just a matter of how you are taught, you know, the process, whether you pick it up, whether you grasp it. ... I feel it is a task to go through a whole process just to come up with a certain answer. For what?"

Aseret has an interesting theory of adult education. For her, learning mathematics sends her back developmentally.

> It is like going back into elementary school to remember, because you almost go exactly to the point where you left off. I lose my adult perspective and common sense when I have to learn math things.

She does not believe that men are innately more able to learn mathematics than women but, when speaking about her son and daughter, does acknowledge a socialization difference.

> I think in the schools, or in life, I see it more geared toward men definitely have to know [math]. You are going to be a provider. You are going to run into where a woman might not necessarily need to know it as much, and I think that is a joke.

She recalls a time at school when she had to go up to the blackboard and was unable to do the problem; the teacher was frustrated; Aseret was embarrassed and humiliated. She comments on a gender difference in response.

> I think that maybe as far as the emotional, women would be more emotional about something like that, especially in their adolescent life ... they would be more self-conscious, more personal, whereas maybe a guy would laugh, like hey, that way, funny.

Aseret liked math in school "until it got serious – when we had to learn our times tables," and graduated from high school. "I probably could have done a lot better with a lot of things if I was more – not so much encouraged – but if I was told the importance." She sees the same lack of purpose in her teenage children as she saw in herself. "If I knew then what I know now...Kids have to find out for themselves." Yet, in some ways, she perpetuates her attitude.

> I have my kids. I have a 15 year old and an 11 year old, and they're asking me questions and I'm like ... To me it's a task. "Can you ask your brother?" [Laughs] "Is this a must?" "Do you have a calculator?" You know. I don't want to tax my mind. "How important is it?" You know, things like that. But maybe if it was something else, from some other subject, I'd help.

The interaction (sometimes conflict) between her role as a student and a parent is apparent for Aseret.

> I stopped working right after I moved here. I don't lack the confidence that I could get a well-paying job, or a decent job, but at times when you are a parent, and more specially a single parent, head of household, you know, you have two jobs. You have your family and work or school. You've got to prioritize and usually when I prioritize, my family comes up as first on the list.

Her children were not initially supportive of Aseret's decision to join the Jump Start program, and she missed several sessions because of her daughter.

> She's going through her changes, or whatever and I couldn't come because I had to see about her. She had that time after school and one of the things I did was — I'll invite my son later when it isn't such an emergency — I brought her back up to the college here and I said, "This is what I'm doing. This is the class that I should be in. This is something we could do together. Look they have equipment and there's dance." She's taking dance and I just kinda encourage her. ... To me it helps even with like the boyfriend, if they don't feel that it is going to exclude them. And if, it's like you're incorporating everything because first it was negative and [now the kids say] "well, you know what, I think it's kinda cool that you're going back to school, cause then you get a chance to see what we're going through."

Aseret's ambivalence about math is reflected in her metaphor. When she does not come up with a food metaphor, I offer her other possibilities – an animal, a weather system,... (all topics used by Dorothy Buerk (1992) in her math/metaphor studies).

> I'd compare it with winter. ... It has its good sides and its bad sides. I think people are more for real in the wintertime; it can be chill and freezing cold, and math can be really complicated and you can bump your head up against it, but you look out the window and the snowfall can be beautiful. Going on a sled down a hill, you know. It can be beautiful and it can be rough.

Johaly Martinez

Johaly Martinez is Hispanic, 24 years old, a single parent of two children aged three and five. She graduated from high school in Puerto Rico in 1990 and then came to the United States. At the start of her interview, she apologizes about her English. I had no difficulty understanding her, but there are times when she is not satisfied with the words she has to express herself. She begins her self-description with "I am very simple."

Johaly is quiet, attentive, cooperative, with a shy smile and a relaxed manner. She seems to be comfortable with herself and a good conversationalist. She has a strong sense of responsibility toward her children.

> I was raising kids for a few years. I just wanted them to be ready before I went to work. You know, I just wanted them to be ready for daycare. In case they want something, I want them to be able to tell the teacher, "I want this." I didn't want to leave my kids in daycare when they were babies.

Johaly wants to be a nurse – to get into the RN program at GCC and then go on to UMass for a bachelors degree. She dreams of herself as a nurse in a big hospital in Puerto Rico. She had general math and one year of algebra in high school; she didn't really like it but she got good grades, "but right now, being several years, I could hardly even do the steps." She also likes fixing things like cars and working with wood. She says she could also be a mechanic or a contractor.

She wants to learn more mathematics, realizes its importance in her career, and has confidence in herself as a math student.

> I don't like it so much, the math, but I keep always my mind open to it, because I know if I learn, I can be good at it. If I don't like it, it doesn't mean that I'm not going to do it, you know. I'm always willing to learn.

Her food metaphor for mathematics is "a kiwi – the taste, sour and sweet together." She believes math is hard for some people but that everyone can be good if he or she tries. At her high school, "girls were more smarter. The boys were kinda disorganized, very disorganized, very distracted, not interested in learning. Girls were more focused."

At the conclusion of each interview, I ask if the student has any questions or wants to ask me anything. Everyone except Johaly says no, although on two occasions, the student adds some more comments — conversation after the "official" part had ended. Johaly, however, switches roles with me and becomes the interviewer. She asks me why I chose math teaching as a career — "Do you know everything about math like calculus?" — asks with interest about my dissertation, and tells me of a friend who is working on his Ph.D. in philosophy.

Throughout the program, Johaly seems to enjoy the interaction with the other women and takes care in what she does. In one class exercise early in the semester, the students are asked to make a container that has a volume of sixty cubic inches. After working with her group to get the design, she takes the materials (old file folders and tape) home so she can take her time over it and do it well. The instructors comment that they fear she may be missing a lot of the principles and implications because of her unfamiliarity with English, and during the volume activity I hear her say, "I can do it, I just can't say it."

Carol Gibson

Carol Gibson is white, 34 years old. She has three children (the youngest is five years old) and is separated from her husband. She has just moved back to this area after spending about five years in Florida and has worked part-time in school kitchens. She likes swimming and movies, loves books and perhaps would like to be a librarian or a teacher. Her strength is reading and writing; her weakness is math – "big time."

Carol is the comedian of the group. Her comments on the first day, "I just quit smoking. I don't usually eat this much" indicate both that she is going through important changes in her life right now and that she uses humor, usually directed against herself, to deal with tension. She is pleasant, out-going and hard working, but has very low self-confidence in mathematics. In class discussions, she is always ready with an answer, but she never expects it to be right. At times she seems to revel in her ignorance.

It was several weeks into the program when I was able to interview Carol. She was present during the first week and was in my random sample, but she missed the following week because of surgery. Kasi Rousseau, another member of the sample, perhaps recognizing a math-hating compatriot, gets us together once Carol comes back.

Mathematics has been a definite problem to Carol Gibson. In her initial interview she says,

> You can't get around math. I've tried. I look and, darn, there's math. Oh God, for everything, they have to put on math. ... I'll take four histories to avoid one math. I'll take nine Englishs rather than take one math.
>
> I didn't like it in school. I can remember being in, maybe third grade and just breaking my pencils out of frustration. I just couldn't do it. The teacher would send me to the blackboard and I thought I was going to pee in my pants. And at that point it was just division. Today they're doing geometry at that age. And just looking at this problem, I just wanted to run out of that classroom, just run all the way home. I was so devastated, so overwhelmed. And I don't know why. It's just always ... So I had convinced myself, I must have heard it somewhere, that I had a mental block. So through the years, I just said, "well I have a mental block when it comes to math. I'm excused."
>
> I am not receptive to it [mathematics]. It is like my mind repels it.

She copes with practical, everyday math, however.

> In food shopping, you can give me money and a shopping list and I'll get it within $2, just from being embarrassed three or four times and not having enough, going over and having to put a roast back, back when I was 18. I can now round off. If it is $1.49, call it a buck. If it is $1.89, call it two dollars. It just works itself out.

In class, when pairs of students are working together on word problems involving fraction arithmetic, Carol shines on cooking problems like "If a recipe asks for 3/4 cup of sugar and you have 1/2 cup, how much more do you need?" She can relate to the context and picture the situation.

Carol is not convinced that everyone can learn math. "My daughter and I were discussing that this weekend, how she gets it. It seems to me, you either have it or you don't." Her two older children (a boy and a girl) are both good at math. "I find myself saying that they have their father's genes. Not their mom's. Definitely not."

Unlike Aseret Robertson, Carol's family and friends are supportive of her decision to continue her education.

> My kids think it is wonderful. If somebody calls and I'm not home they go, "My mother's at college." They don't say, "Mom's at school." They just think it's great. There are a lot of family members who want to know right away what I'm going to do, and I say, "I don't know yet. That is part of Jump Start. It's to help me decide."

Her sixteen-year old daughter helps her and encourages her – role reversal not unnoticed or unappreciated by Carol.

> My daughter said to me, "Mom, you've got to sit down with the attitude that you can do this. You're not listening to me. You're not paying attention." — you know, when I have her helping me. And I said, "I am listening to you." She goes, "No, you're not. Your mind is drifting. All of a sudden you're like, 'What do you want to have for dinner tomorrow night.' Mom, you're not into it." She's perceptive. It is pretty bad when they've got to tell me that.

There is no way Carol could conceive of herself as a mathematician.

> I'll be lucky if I can get through Basic. When I go to school in the fall, it's quite possible that I will still be in Basic Mathematics for possibly two semesters. And this is after Jump Start.

Carol's initial interview occurred during the fourth week of the semester, later than the others. When I ask Carol about math, she thinks about her work in the textbook, not the math that is included in the science experiments.

> It is going to take such a struggle, just to take a little tiny baby step. For the last four days, I've been struggling with just one piece of the chapter. Three pages in four days. ... A little tiny light bulb is starting to glow. So I'm just starting to get the (area and perimeter of) squares and now there's triangles and he's going on to the circles. I'm like, "Oh my God, when will this end?" So I'll probably just understand geometry and they'll be on to algebra.

Several weeks after the initial interview, Carol comes up to me in class to tell me that she has had a migraine headache for seven days, which she attributes to working on math problems. She thinks I might like to know because of my research. I wonder out loud about the cause – avoidance? anxiety? allergy? eye strain? To her it is a matter of fact – struggling with math gives her a migraine.

I ask Carol whether she thinks mathematics would exist if there were no people, whether it is discovered or created. She replies without hesitation, "This one is created. Definitely. It wasn't discovered; it was created. Find him. Shoot him."

Her food metaphor for mathematics is "onions — they can make you cry." I ask if it is just the negative aspect of onions that she had in mind, and she replies "definitely." I have heard this metaphor before comparing the layer structure of the onion to mathematics, and the fact that without onions many dishes are tasteless, but for Carol, they just make her cry.

At the end of our interview, she is apologetic about her feelings. "I hope I didn't offend you, being a math teacher, with my attitudes towards math. I didn't mean to insult your profession." I assure her that I want her to be open and honest and that I am used to having people tell me that they hate or fear mathematics.

<u>The Six as a Group</u>

The six women that I interview range in age from 24 to 39. They were all mothers by the time they were 20 and are currently single parents. At the beginning of the semester, all six place into Math 100, the course which builds or reviews basic arithmetic skills. Peggy, Deanna, Kasi, and Carol place into English 100, Johaly requires ESL (English as a Second Language), and

Aseret places into college-level English 101. All but Aseret and Carol place into College 100 (developmental reading).

As I look at the group of Jump Start participants, these six women —Peggy Perkins, Deanna VanDyck, Kasi Rousseau, Aseret Robertson, Johaly Martinez, and Carol Gibson — are the ones I focus upon. I examine them in greater detail than the others and bear them in mind when I consider common factors, differences, questions, and observations. I do not assume that they speak for the others or represent any aspect of the whole group other than its diversity.

<u>The Mathematics Attitude Questionnaire</u>

During the first week, I asked all of the Jump Start students present that day to complete a questionnaire on which they indicate their agreement or disagreement with nine statements about mathematics. The questionnaire and the results are in Appendix D and E. Five of my sample completed the questionnaire. Aseret Robertson was absent. There are several statements to which the five students of my sample responded in unison. All disagreed with the statement "Women are less capable in mathematics than men are." (Deanna "disagreed somewhat," the others "disagree strongly.") They indicated their belief that mathematics is necessary for a wide range of people by not agreeing with the statements "Most jobs require very little mathematics" (Deanna was "neutral or undecided") and "Only scientists and engineers need to study mathematics." They all agreed that "To do mathematics is to calculate answers" and were unanimous in their strong agreement with the statement, "A good teacher should never confuse you."

Peggy, Deanna, Kasi, Johaly, and Carol had mixed opinions about whether mathematics depends more on innate ability or on hard work. Johaly and Peggy voted for the hard work, Kasi, Deanna, and Carol for the innate ability. They separated into the same groups for two other statements: whether or not all useful mathematics was discovered long ago (the hard work women say that it was and the innate ability team say that it was not) and whether learning mathematics is a straight forward matter and practice alone should 'make perfect' (the hard work women say yes and the innate ability believe that there is more than practice involved.)

On the remaining statement, "There is no need for creativity in mathematics," the attitudes were mixed. Deanna did not believe that creativity is necessary for mathematics; Carol was undecided; The other three thought creativity plays a part.

## The Math/Science Instructors

The original design of the Jump Start program was for an integrated learning community of mathematics, science, communication, and career development. In its history of three school-year semesters and a summer session, the program has evolved to consist of distinct classes for English, computer skills, career development, and math/science. The math/science portion is still integrated and team-taught by two instructors who have been with the program since its inception, Lindy Gougeon and Rick Lane. I interviewed Lindy during the final week of the semester and Rick almost two months after the session ended. The quotations here are from those interviews.

### Lindy Gougeon

Jump Start math/science instructor, Lindy Gougeon is white, 45 years old, married with three grown children. Fifteen years ago, she might have been a candidate for a program like Jump Start. Lindy married at 18, as soon as she graduated from high school. Her husband joined the army and she followed him to Okinawa where their first child was born. They returned to the Greenfield area where she mothered, cooked, and sewed and worked part time in the local school kitchen. A need to help her husband, a self-employed builder, with some accounting sent her to GCC when her kids were in elementary school. She also had a desire to get a job "where I never have to wear a hair net again."

She started mathematics at GCC at the developmental (elementary algebra) level, fell in love with the subject and astounded herself with her success. After getting an associate's degree, she went to Smith College as an Ada Comstock scholar (for women returning to college, not straight from high school), got her bachelor's and master's degrees in mathematics from

Smith, and was appointed to the faculty of GCC in 1989. She became coordinator of the mathematics department two years later.

When I ask Lindy what she thinks mathematics is, she laughs and replies

> A few years ago, I would have said what is nice about math is that there is one right answer — a typical view of a math student, but of a novice. With the background most of us had at school, especially in our younger years, we tended to think about math in the sense that there is a right way to do it and that there is a right answer, and that there isn't a lot of give and take in math and that there isn't much subjectivity in math. That's not my feeling now. I think about math as wide open. It is a way of thinking about things as much as it is a process of finding an answer. It is a way of exploring. It doesn't just involve numbers. It involves ideas and it involves problem solving, different points of view, and awareness of the different possibilities.

Remembering the sample students' unanimous agreement on the mathematics attitude questionnaire with the statement, "To do math is to calculate answers," I asked Lindy if she thinks she is doing students who believe that mathematics is just about finding the right answer a disservice by trying to convince them that there is more to math than answers, and that even the answers may be relative and negotiable, and she answers,

> No. I think I am doing them a service because I think that it is bigger than a philosophy of math, it is a philosophy of life for me. That we can get somewhere in terms of what is good or bad or right or wrong, that is like wearing blinders. I almost think that I am doing a bigger social service by showing people that even in something that they think is as narrowly defined as math, there are options. There is more to it than they know. ... That's what education is — whatever it is you think you know, you find out there is more to it.

She comments on what she sees as her role as a Jump Start instructor.

> I don't think that my responsibility is to stand up in front of the class and present a lecture, present all the material that is in the section of the book, or anything like that. I think that my responsibility is to be there and provide some guidance and

some feedback and the opportunity to learn. I can be there as a role model for people, particularly for returning students because that is what I was myself, but I can't motivate people. They have to want to do this and they have to be willing to do it.

She explains what she sees as the goals for the Jump Start program, and the math/science segment in particular.

I never had met Rick before I started doing Jump Start, but we had similar goals in mind of wanting to make the program a real positive experience for the women, wanting to show them that they could learn, wanting to get them comfortable with asking questions and seeking answers for themselves, wanting to make them independent so that they could learn and didn't depend on us for their learning.

Generally we chose a science topic that we thought would be interesting to the women, maybe useful to them in terms of their lives, and we figured out what math they needed to be able to do it. We then decided how to bring in problem solving and how to fit the communication piece in, and went from there. So the science was running things. We started out very concrete with a certain amount of direction from us, but we tried not to give them complete directions for anything so they have to ask or work things out for themselves. We didn't put it all in the instructions. We didn't tell them everything.

<u>Rick Lane</u>

Jump Start math/science instructor Rick Lane is white, 41 years old, married with two daughters. He teaches math and science at Franklin County Technical School.

I have been teaching, well, professionally for about sixteen and a half years. After trying many majors at the university, none of them were anything that I wanted to do for the rest of my life. I realized that I had been teaching and interested in math for a long time. I was tutoring in high school. My fellow engineering students, when they got in trouble in calc 3 or multivariate, we would have study groups and I would help them. It finally dawned on me that teaching was something I wanted to do. I have been doing it ever since [I graduated from university], thoroughly enjoying it.

Rick taught math at the tech school for his first twelve years, and then began teaching science about five years ago. He is also an adjunct mathematics instructor for evening courses at GCC, most frequently teaching Math 100, basic skills.

Rick likes to build as a hobby; in fact he hobbled up to my office for our interview, having sprained his knee falling from a ladder while helping a neighbor build a shed. Learning some of the trades that his teenage students are studying has helped him understand some of their struggles. He learned carpentry from a colleague and recalls that the carpentry instructor "got thorough delight from seeing the math teacher mystified sometimes at the applications of his subject." Learning math as he did in school, by example and drill, was easy for him (except for memorizing the times tables) and so it was an eye-opening experience to start working with people who couldn't learn the way he did. His whole career, he has been adjusting his teaching to make it work for his students, changing the focus from example and drill to experience and application.

> There are certain skills that have to be practiced; I'm thinking about algebra skills and basic math facts. You have to do this but I also know that you don't remember them unless you apply them and work with them — mess around a little bit, discuss and talk about how it all fits together.

For Rick, the student is the agent, the struggler, and the teacher is there to support and to guide. He feels that "the responsibility of a teacher is to serve your students." He recalls standing back when Carol Gibson and her partner, who "have a shotgun approach to problem solving" were working.

> I just stayed out of it. I had no idea what was coming or where it was coming from — "No that's wrong!" "I don't care!" — but they understood and listened to each

other. When I sat down with them, I waited until they had something to ask. I had never seen a group anything like them.

Rick Lane believes that Jump Start has one objective: "to build confidence. To tell them they can do it because most of them come through the door thinking they can't." He sees the math/science piece as

> a convenient vehicle [to build confidence.] It has never been my impression that I should be providing them with a lot of scientific information. Our main concern was to see if they could apply principles to different situations and to verbalize what they are doing and thinking.

Lindy and Rick work comfortably as a team. They are both enthusiastic and outgoing. They correct and tease each other and spend time in class when the women are working discussing how the lesson is going, how it might be improved, or what questions arise for them. Rick is usually the one who draws attention to the larger context of the lesson; Lindy keeps things open-ended and makes sure the students assume responsibility for their learning.

## Some Pedagogical Decisions

Three pedagogical principles were fundamental in the original design of Women in Technology: Project Jump Start: a learning community, integrated subject areas, and hands-on contextual learning. Several other pedagogical decisions were discussed by the team of instructors at the outset. Three which have a bearing in this study are (a) the decision to keep students of all abilities and achievement levels together, (b) the decision not to grade work or give tests and quizzes, and (c) the decision to issue and work with calculators in the math/science activities.

Choosing a curriculum for women of varied educational backgrounds meant that a traditional college basic skills syllabus was out of the question. It was necessary to present common experiences which could lead to knowledge and understanding that was accessible and interesting to people with a broad range of skills. Open-ended investigations and problem solving situations together with collaborative learning groups were seen as a way to accommodate and utilize the diversity of background.

The decision to work with a group unstreamed by ability and the desire to provide a comfortable, non-threatening introduction to college led to the decision not to give grades. Rick Lane explains

> Grading was discussed when we first got started. They are going to run into the grading practice and experience it from here on in, but they don't need the anxiety of it at this stage when our goal is to try to get them comfortable with learning.

Lindy is of the opinion that the students do not need to be compared to each other or to some arbitrary standard. They only need to know that what they are doing has value, and in some instances, might be improved in certain specific ways.

The decision to use calculators is consistent with The Standards, (National Council of Teachers of Mathematics,1989) and practice in the GCC developmental math courses. There are two reasons for calculator use at this level: the effective use of technology is an important skill for today's world, and complicated arithmetic procedures get in the way (to an overwhelming extent for some types of learners) of seeing the larger picture or using math as a tool in an application. Some of the women resist using calculators initially, not out of fear of the technology, but out of guilt that they should be able to do it the hard way. They are assured by the instructors that scientists and technicians rely on calculators and that the emphasis for the students in this context is on estimation, what arithmetical operation to use, and how to interpret the results. They are encouraged to practice hand calculation algorithms at home and during tutoring times, but the classtime is mainly for group activities.

## Two Labs and a Test

I observed Jump Start math/science classes weekly during the semester and refer throughout this chapter and the next to these observations. It would be overwhelming, however to describe each activity in detail here, so I let two math/science classes, one at the beginning of the semester and one at the end, serve as the anchors for my descriptions. These activities indicate and represent the process and intent of the math/science curriculum.

Between the labs in time, about three weeks before the end of the session, the class was given some standardized tests, including a thirty minute multiple choice test, a re-administration of the GCC mathematics placement test that they had taken in the first week. In this chapter, I describe the two laboratory activities and the test. With these experiences and the sketches of the six women of my sample in mind, in Chapter 5, I analyze the students' beliefs about mathematics, their attitudes about themselves as learners, and the effect of the semester's math/science experiences on the attitudes and expectations of the students and instructors, and on the evolution of the Jump Start program.

### The Math/Science Classroom

The math/science classes meet on Mondays and Wednesdays from 3:00 to 5:00 in one of the college biology labs. The entrance is at the front of the room, where there is a blackboard and an instructors' laboratory bench. Parallel to this are three long lab benches with stools on the side facing the board. There are also two counters along the side walls and an assortment of safety showers, trash cans full of soil, flower pots, and emergency exits. The lab benches have sinks and electrical outlets. The counter surfaces are black; the floor is concrete; the only windows are near the roof in the back; the ceiling slopes down from back to front. Voices echo making it a difficult room in which to have a group discussion.

The design of the math/science piece is that the women are introduced to scientific method and reasoning through experiments. The need for particular mathematical concepts or procedures for the science is what determines the math that is done, either before or after the experiment. The mathematics is met in the context of scientific experiments. Students are given calculators (TI Explorers) and taught how to use them so that they can work with actual measurements without getting bogged down in arithmetical computation.

Energy Use Experiment, 2/6/95 — Beginning of Semester

I arrive at the Jump Start classroom about 3:45 while Rick is introducing the first experiment. He asks the students to form groups of three or four people to investigate the amount of electricity different household appliances use. The lab handout says, "You are now scientists and, more important, team members in search of some answers. Good luck!" Each group is given a standard household electricity (watt) meter with an outlet connected to it, and five electrical items: a lamp, a blow dryer, an electric drill, a hot plate, and a fan. They are also provided with a stop watch. Rick asks them first to discuss and list the appliances in the order they think indicates the amount of electricity they use. There is a place on the handout to write down this list. Then he (and the handout) tells them that "the faster the disk on the watt meter spins, the more electrical energy the energy-user consumes." They are asked to write down their method in detail, to show any calculations they perform, and to be careful not to touch the hot plate when it is hot. They then rank the appliances according to experimental findings, in the space provided.

The handout and Rick's verbal instructions are informal and minimal — a list of equipment, a paragraph for procedure (including suggestions for appropriate group process), blanks for the two lists, and the brief instructions and warnings. The mathematical preparation has been basic calculator use, some discussion of and practice with place value, estimation, and rounding, and an introduction to denominate numbers (numbers with units of measurement.)

The groups are self-selected, determined for the most part by where the women chose to sit when they walked into the room. Those in my sample are distributed among the groups. Initially the students are tentative, but they get down to work without much hesitation. There are brief but lively conversations to determine their guess lists, and they are eager to start plugging things in. When they start the experiment, group members fall naturally into specific tasks. One holds the stop watch, another flips the switch, another watches the wheel of the electricity meter, another writes down the results. I do not notice any person who is either a dominator or a freeloader. All seem to be involved and receptive to the ideas of the others.

The process emerges from, rather than determines, the action. This (by design) is an experiment that allows for adjustment of method. One group measures the rate of the wheel in the meter in "marks per minute." One person counts the number of marks on the wheel to pass a given spot while another times a minute on the stopwatch. Another group, after discovering that the hair dryer makes the wheel move the fastest, uses it to reset the wheel to zero before each test.

The student scientists are self-correcting. One group decides to measure electricity use by measuring "how long it takes to heat up" but runs into trouble with the fan and the drill, so cancels that plan and tries another approach. Students are confronted with problem-solving situations. (Our light doesn't work. Is it the bulb, or the set up, or...?.) They are expected to use each other as resources while Rick, Lindy, and I walk around, watching, and conversing about what they are discovering. Most questions are turned back without answers and students are encouraged to record their observations and questions. It is not difficult for me to be a co-learner, as I do not know the answers to many of their questions and have several questions myself.

As the groups finish, they are encouraged to investigate some of the questions that they have generated. Does the hot plate use more electricity when it is heating up than it does when it has reached its temperature? Do you get the same thing if you measure the use for 15 seconds and multiply by 4 as if you measured for a minute? I hear Carol Gibson say, "I'm getting confused" and others in her group try to help her understand. Deanna seems to be bored at one stage after her group is "done" and asks me whether they are going to get a break.

After everyone is finished, Rick leads the class in a discussion of results. How many guessed the "correct" order — where correct means that their before and after lists agree? (No one, although some just had two interchanged.) What are your results? (Some groups had the hair dryer first; others had the hot plate.) Why are there different results? (Students offered suggestions about different appliances, different lengths of time, whether the hot plate started from cold, the setting of the hair dryer, etc. ) One group searched the labels for ratings (watts, volts, amps) first and then wanted to know what these things are. Rick says "I'm impressed" and promises that we will be learning about those differences. Peggy Perkins tells of a time when she thought she had a faulty electric meter at her home. She called the electric company and was told to turn off the master switch and wait fifteen minutes, and then see if the wheel was moving. No one could figure out why she had to wait fifteen minutes so Lindy suggests she phone the electric company and ask them.

The class time is nearly over, so Rick tells the students that they are each to write a lab report. They briefly discuss what things should be included: what they did, why, what they found out, equipment, but no one seems fazed by the lack of structure or instructions.

Temperature Scales Activity, 5/3/95 — End of Semester

Today Colleen Doherty, former Jump Start counselor and now head of the Western Massachusetts Center for Gender Equity, is in the classroom with a video crew. They are making a video of women's opportunities in non-traditional fields and think that Jump Start will provide some good "active learning" footage. There is high energy and some self-consciousness because of the cameras. Johaly Martinez particularly is a star because, although many of the women are interviewed about what they are doing in the experiment and about the program, Johaly is interviewed in Spanish. I am pleased to see Aseret Robertson, who has not been in class for about a month.

The exercise for today is for the lab groups to make up their own temperature scales. The grouping process happens naturally; the groups have been essentially the same since the first week, with some adjustments for absences and whim. Rick leads the introductory discussion about what temperature is and asks how it is measured. Carol ventures "thermometer;" Johaly suggests touch; Aseret says you can examine the effect on other things. Rick talks about color (as of the sun), and various electronic ways. There is a smatter of creative questions which go unanswered (but not forgotten). Janice is not a member of my sample, but she is notable for asking "How does a digital scale work?" and then immediately saying "Wait, don't tell me. I can look it up."

On the front counter in the room, there are large glass cylinders, ice, hot plates, test tube stands, and unmarked thermometers about eighteen inches long made of glass. The instructions are to mark on the thermometer the temperature of an ice/water mixture and of boiling water, and to make up a temperature scale. The only restriction is that it can't be Fahrenheit or Celsius. It has to be original.

The students collect the equipment and materials that they need. They discuss how they are going to do the experiment. Should they measure the ice or the boiling water first? Most decide on the ice. They set up the stands and suspend the thermometers in the ice bath. They decide when the temperature has stabilized and then fill a cylinder with water and put it on a hot plate to boil. They discuss appropriate depth of the water, weighing the length of time it is going to take to boil against the need to have the bulb of the thermometer away from the surface of glass that is in contact with the heat source. Without exception, the groups are careful, thoughtful, and efficient. Soon each group has two marks on its thermometer.

There is a perceptible pause — "What on earth do we do now?" The instructors give a little guidance. How do you think the temperature scales we use were developed? If Herr Fahrenheit could do it, why not you? You can name it after yourself. Johaly and her partner discuss what they know about temperature. Winter weather helps them remember that the freezing point is 32° F, and that seems pretty arbitrary, so they pick another arbitrary number, 40, for the freezing point and put zero at the bottom of the thermometer. Another group lets freezing be zero, and because it can't be a centigrade scale, chooses 80 for boiling. They nearly reconsider their choice when they realize that they might want to have numbers below zero. Negative numbers do not come immediately to mind, but they have a comparable solution; their scale is named the Willyn scale (a combination of their names) and they decide to name below zero temperatures as, for example, 20° BW, standing for Below Willyn. Carol and Deanna facetiously suggest using letters rather than numbers, and they are told to "go for it." They create a letter scale with five numbered subdivisions, which they call the Bingo Scale. ("The old folks love it.")

The group that has Aseret and Peggy in it is having some group dynamics problems. Peggy seems to be, as one of the tutors expresses it, "high on something other than life." Her reactions and attitudes are not consistent with what I have observed at other times. At one point, she snaps, "somebody else can do it, then!" and folds her arms. Aseret, who comes across to me in her interview as sensible and understanding, does what I think is a remarkable job of managing the situation and encouraging the group to work together. They decide to use color as a scale, and Peggy takes pride in drawing small hands on the scale on their paper, and coloring them in varying intensity of color. This deviation from a number scale provides the route for suggestions of an audible scale of either volume or pitch (for blind people). Other suggestions are names of geographical areas ("It is very Alaska out this morning") and the rate of cricket chirps. In spite the accessibility and freedom of the activity, the creative energy generated, and the mood of useful fun, I hear Deanna say in the midst of it all, "I hate science."

For the final ten minutes of the class time, students present and explain their scales, discuss their shortcomings and advantages, and offer some of the questions that have arisen. "Will these thermometers work for all temperatures?" "If we have zero at the very bottom, will there be temperatures lower that this?" [This leads to a discussion of Absolute Zero, and to Negative Zero, a local rock band.] Deanna says that she is color blind so would not be able to use Peggy's and Aseret's color scale. They hand in their temperature scales drawn on paper and Lindy says she will make up conversion formulas or tables for the next meeting.

<u>Mathematics Placement Test, April 1995</u>

All students matriculating at GCC are required to take placement tests in reading, writing, and mathematics. Because many of the Jump Start participants wish to register for courses starting in the fall, even though they are new students and may not register until June, the Jump Start coordinators decide to administer the placement tests to the class at the end of April, approximately three weeks before the end of the program. This, and a state approved mathematics skills test administered at the same time, serve as the post tests for the session. The class, and then Lindy and Rick, are informed two weeks before the tests are given, so they can prepare.

The test comes during the time when investigations of perimeter, area, volume, and mass are leading to an understanding of density, the discovery of $\pi$, the fundamentals of trigonometry, and conservation principles. The students have become increasingly comfortable with their calculators and are beginning to use them in conjunction (to verify and explore) with the concepts and procedures of hand calculation algorithms such as the arithmetic of fractions. Class activities are done collaboratively and individual practice in areas related to the activities is encouraged, with an hour of science/math tutoring time scheduled each Tuesday. There are no quizzes or tests given as a part of the math/science curriculum. Exercises and lab reports handed in are assessed formatively, not summatively. Students are given feedback — written and spoken suggestions about how their work could be improved, not a number or letter grade — an evaluation of what they had done.

The mathematics placement tests (for three levels of mathematical achievement) were written collaboratively by the GCC mathematics department three years ago to replace standardized tests which were being discontinued by the publisher. The department attempted to create tests which better reflect the objectives of the developmental math courses offered at the college, roughly in line with the NCTM Standards (National Council of Teachers of Mathematics, 1989), yet which would accommodate large groups of students with a variety of backgrounds having limited time. The Level One test, designed for students who are not facile with algebra, was administered to all but one member of the Jump Start class. (One person, not in my sample, had enough algebra background to take the Level Two test.) The Level One test de-emphasizes complicated arithmetic calculation in favor of estimation and understanding of concepts, but it is still a timed multiple choice test of 35 short problems done by the student alone without a calculator. A score of 25 or above is necessary for the student to place out of Math 100.

The Jump Start students took this same test at the beginning of the semester for program administration reasons.

I mention the test here and discuss the responses to it in the next chapter because, although it is not part of the math/science curriculum, it had a significant effect on the students' attitudes and therefore on the atmosphere, outcomes, and future of the program. The effects of the test illuminate changes that are taking place within and around the program

## The Women and the Program after Fifteen Weeks

### The Final Interviews

My original plan was to interview my six students after the end of the program. However, because their daycare arrangements were ending and several of the women had quite a distance to travel, it was more convenient for Peggy, Deanna, Kasi, and Carol to meet with me during the final week. I met with Johaly the week after the end of the program (May 15th), and spoke with Aseret on the telephone a couple of weeks later (June 6th).

Peggy Perkins, At the end of the semester, Peggy reaffirms her love for science and for learning by doing. "I'm a visual learner. I recently got it documented for college purposes. I found it was kinda hard to do writing from a lecture. That was my biggest problem." Her favorite part was science and her least favorite was the career development class. When I ask her why she did not like that class, she replies, "Lecturing. Sitting and being told."

She found the program very helpful, enjoyed the whole time, and was satisfied with what she had done. She has registered for next semester. "I'm taking math, English, a stress [reduction] class, more computers, and modern dance — twelve credits."

Deanna VanDyck. In her final interview, Deanna tells me that the program was a struggle for her. Science and math were her least favorite part, because "I didn't like the science and I knew all of the math." To improve the program, she says, "Skip science" and

> I think the teacher should have more knowledge. And I don't think we should have tutors. If they are going to teach the class, then that's fine. but I don't think that you should have tutors within the class.

She does not think that her opinions about math have changed, but in general she feels that she has a more positive attitude toward college and herself. Her favorite part was "computers" and she takes with her the image of "me, working on the computer." I ask her what she is doing on the computer and she replies, "playing cards."

Kasi Rousseau. Throughout the program, Kasi has definite ideas of what she needs and selects from the activities accordingly. She does not attend many of the tutoring sessions, which are designed for students to work from a basic math text on skills that the student or the instructors identify as needing practice. During one of the class periods, students are working on an assignment which asks them to make up fraction or ratio problems from everyday situations. Kasi cannot see the value of it and does not get started until I bring her a home decorators catalog and point out things like the ratio of width to length of rugs, the fraction of the glassware that is blue, the placement of pictures on a wall — there are ratios everywhere. She comments that she didn't realize there was math in things like that. For the job shadowing part of the program, students are sent to two sites for two sessions of four hours each. In her final interview, Kasi recommends that this be changed.

> The first time I went I liked it, but the second time I didn't even go because they spent four hours with me the first time so the second time I was supposed to go the following Thursday, it was like, "What am I going to do? just sit there?" so I didn't go.

During math/science classes that I observed, Kasi regularly makes it clear that she hates math, that what they were doing was a waste of time, and that English class is much better because the instructor stands at the front of the class and "she just talks a lot." She reiterates this in the final interview.

> Lillian's [the English instructor] class has been very inspirational to me. She does most of the talking, but she is very funny and, I don't know, I think she makes you feel good about yourself, and you are somebody.

When I ask her which part of the program she liked the least, she just laughs. Telling me how much she hates math has become a familiar theme between us.

> You know math has always been my least favorite subject, so I would eliminate math. I really didn't learn. I thought when I came into this program that I would learn more math, like everyday we would learn a page, but it didn't pan out that way, but that's okay.

Yet she seems to be objecting to the methodology rather than the subject matter as she follows this by saying,

> I would have rather taken the science time and taken it right out and had it all math, at least for me, yeah definitely. Cause I need it. I need one on one type, the teacher right up there explaining something that I don't get, and then do it again.

And later she continues,

> I'd just as soon have science one class and math a total different class. This combination of learning the metric system in a day and then the next day doing a project and then the next day doing something else is just, you know, you are just starting to grasp it and the next thing you know you are on to something else.

Even though Kasi says she did not get anything out of math/science, she is generally satisfied with the program.

> I feel like I have grown just being here at school. I am more comfortable. I know what level I am in math, and I'm happy with it. I can only go as far as I can go. I've learned not to run away, because that is what I usually do — when the going gets tough, I go. What I want to do is keep the math book. I'll turn it in when I come back this fall. I just thought it would be just, you know, sittin' there with the kids, I

would read *Redbook*. I might as well do decimals and fractions ... and that is a way different than I felt before. I would never have thought about reading about science or light or anything like that and now I'm picking up articles all the time. Even watching science programs, I find them fascinating and before, I just went past them.

As we walk to the classroom together for our final interview, Kasi seems discouraged and depressed about state welfare changes. Just when she has taken the steps to have a life apart from her home and children, to get more education and work toward her goal of having her own interior design business, the door is shutting on her. She feels that Jump Start has been for naught because she'll need to start to find a job now, if she is going to be fully employed within twenty-four months. She has registered for classes but may be pushed in another direction.

Aseret Robertson. Aseret was absent frequently during the semester. She reappeared after almost a month's absence early in May and then was gone again. I spoke with her on the telephone in June, several weeks after the end of the program. She feels good overall about her experience. "It got me back in the groove, especially the math and science made me look at math in a different way — it's not so intimidating." She regrets that she did not get college credit for her efforts, (Jump Start is a college preparatory program so no credit is given), and thinks, looking back, that she should have applied directly for college courses.

She would have preferred more structure and challenge, yet wishes for more of the freedom (e.g. to be absent) of college, more emphasis on career selection near the beginning (when she was there), and "more flexibility with family situations." Her advice to future Jump Start students is interesting in light of her record: "Perseverance pays off."

Johaly Martinez. Johaly is quiet, content, and attentive throughout the program and is notable for her inconspicuousness. She says in her final interview, "It was nice for me." She was pleased with her job shadow with an Amherst dental group. She feels ready for college and has a better idea of what it will take for her to become a nurse. "I'm more motivated. I have no worries about it." Next semester, she will take Math 100, College 100, and two ESL classes.

Carol Gibson. At the end of the semester, Carol feels she has learned useful skills.

> I liked English the best, and the computers —I had never been on a computer before Jump Start. And language — I had forgotten a lot of punctuation. And the career development was nice too. I had never written a resume or cover letter, so everything was, well, useful.

One lesson in particular, she is relieved to have learned in the safety of Jump Start.

> I learned what plagiarism was when I went to do the essay. In high school, we just copied right from the encyclopedia and if it was long enough and neat enough, you got a good grade. And this is what I would have done if I would have entered without Jump Start, I would have done the plagiarism thing.

Carol liked math the least. "It has always been my least. It has always been my challenge, is my math. But I have been trying to face it." From what she says, it appears that she has not gained much confidence in herself (when it comes to mathematics), or in her answers.

> Everybody has been telling me that I can do it; the teachers keep saying that I can. I need to listen to them more because I have it in my head that I just can't do it.
>
> I was just working on percentages and word problems, and I was getting it and it felt good to be able to set the problem up and, wham! I look at it and it's like, "I can't do math!" I push the calculator buttons and all this zero point fifty billion — that isn't even a real number! And Rick comes by and says that it is fine. I look at him like, "You're kidding me. That was right?"

She thinks the program should concentrate on basic math skills — "We just spent too much time with electricity, you know, sockets and batteries, and I need division, long division, multiplication" — and that the students should be separated by math ability levels and learn in a traditional classroom.

Carol feels comfortable about starting classes next semester. She has registered for Math 100, English, psychology, and women's studies.

<u>The Instructors Comments</u>

Lindy sees development perhaps not perceptible to the students themselves.

> Rick and I were really patting ourselves on the back at the mid semester point. We were working with the idea of density and people were discovering that if they had the same material, it had the same density regardless of the size of the object. For whatever it was that we were measuring, I think it was probably pieces of pine, it was 0.42. They were coming out with 0.41 and 0.43 and one of the women said, "It's just like $\pi$." Earlier in the semester we had studied the relationship between the circumference and the diameter of a circle and they found out that the ratios were identical no matter how big the circle was. ... And when we were doing the density problem, she remembered that we had a constant relationship. We thought it was fantastic. We thought, "This is what we wanted to do. This is the goal." It was Janice [a Jump Start participant, not one of my sample.] She wasn't the only person ... Later Kasi Rousseau, we were doing something with similar triangles and she realized that if she figured out the ratio of sides, the next one is going to be this too. ... They started seeing patterns in dissimilar things and that's exciting. It's important not just in terms of math but it is incredibly important in terms of science. Those are the things you need to notice if you are going to be a good scientific thinker.

Rick sees an increase in confidence in all of the women and a qualitative difference in how they talk about scientific ideas, what they notice, and how they deal with uncertainty. They listen to each other. They have become familiar with pieces of laboratory apparatus and scientific method. Their lab reports have developed into concise and useful summaries.

As GCC Math 100 instructors, Rick and Lindy agree that although most of the students did not place out of Math 100, they are more likely to be successful in the course (which has a fairly high drop out rate) — and in all their courses — when they are community college students next semester.

## End of Session

On May 11th, eleven of the twenty original participants of the Spring '95 Jump Start program are awarded certificates of completion at a luncheon in their honor at the college. Of my sample of six, everyone except Aseret Robertson met the criteria of having satisfactory attendance and completing a resume, job shadow, and research paper on a math or science related topic. Aseret, although she is not at the luncheon, is one of three students on the list for a certificate of participation. These students did not withdraw officially but did not complete all of the requirements.

The "graduation" is a festive time; students are dressed up and are snapping photographs and planning reunions. Five of the women of my sample have decided which courses to take at GCC in the fall. The sixth (Aseret) plans to register in June. They have their engines started and are ready to roll.

# CHAPTER 5

# ANALYSIS

## Introduction

For fifteen weeks in the spring of 1995, Peggy Perkins, Deanna VanDyck, Kasi Rousseau, Aseret Robertson, Johaly Martinez, and Carol Gibson saw their children off to school and daycare and came together with classmates and instructors at GCC for several hours of lectures, labs, tutoring, and discussion. I talked with these six women privately and individually at the beginning and end of the session, and throughout the semester while they worked with others in class. I watched them during their math/science activities and discussed with their instructors, the objectives and effects of the experiences. The focus of my interest and attention was the students' philosophies of mathematics and learning, how their beliefs and attitudes were affected by the pedagogical approach of the math/science lessons, and the implications of the effects to adult mathematics education.

Restated from chapter 1, the purpose of my study was to

> gain awareness, appreciation, and understanding of the beliefs about mathematics and the attitudes about themselves as learners of mathematics of a group of women preparing to enter community college and technical occupations. In the event that their beliefs and attitudes are initially restrictive or seem to be counter-productive to the effective mathematics education of the students, this study considers if and how those beliefs and attitudes change in a context designed to increase the students' access to and comfort with the mathematics they need to enter a technical field.

The previous chapters present the research questions, the purpose, and the anticipated context of my study (chapter 1), the selected literature (chapter 2), and my research method (chapter 3). Chapter 4 provides the descriptions of the six women of my sample and their math/science experiences. Some of the awareness and appreciation of the students' beliefs and attitudes is accomplished by the documentary approach of chapter 4.

In this chapter, chapter 5, I consider what I saw and heard in light of the literature, in order to fulfill the purpose of my study and answer the questions that underlie my research. Some of those questions ask about the students: "How does the student view mathematics?" "How does the student view herself relative to mathematics?" "How does she perceive the learning process?" Other research questions focus on the effect of the learning environment on the students' beliefs and attitudes: "What beliefs and attitudes do the math science experiences try to foster?" "What other factors of Jump Start might affect the students' beliefs and attitudes?" The students and the program are brought together to answer the question "What is the change, if any, in the students' beliefs and attitudes during the semester?" The final question for consideration is "How can the questions and conclusions resulting from this study be useful in the planning and practice of programs similar to Project Jump Start or in other areas of mathematics education?"

## The Students' Beliefs and Attitudes

Each person has a view of learning and mathematics that has been formed and colored by experiences and opportunities. The language for a discussion of beliefs and attitudes, and the labels for the landmarks or the extremes of the axes which are available to help describe a person's views, can come either from Human Development or from the Philosophy of Mathematics. Human Development literature gives continua from *Dualism* to *Commitment in Relativism* (Perry, 1970) or from *absolute knowing* to *contextual knowing* (Baxter Magolda, 1992), and landmarks of *silence, received knowledge, subjective knowledge, procedural knowledge,* and *constructed knowledge* (Belenky, Clinchy, Goldberger, & Tarule, 1986). The Philosophy of Mathematics offers the extremes *absolute, infallible,* and *unlimited* versus *human, fallible,* and *limited* (Guillen, 1983) or *Newtonian (certain, complete, mechanistic,* and *predictable )* as opposed to *relativistic (uncertain, incomplete, chaotic, and probabilistic)* (Lucas, 1985; Popper, 1979; Gleick, 1987). But for the purpose of description of a given position, the schemes in Human Development and Philosophy of Mathematics are nearly isomorphic — close enough in my mind to blend so that I may speak of a student's belief as "dualistic" in the language of one field or "absolute" in the language of the other, or *relativistic* thanks to either Perry or Einstein. When one tries to decide <u>why</u> a person believes as she does, whether it is because of her progress on a developmental journey, or because of what she has been taught or has decided to believe when offered alternatives, it becomes necessary to separate the perspectives.

In my interviews, two questions gave me a mixture of information about what the student thought about mathematics and her emotional reaction to it. Those questions were "If math were a food, what would it be?" and "When I say the word 'mathematics,' what is the first thing that comes to your mind?" Deanna likened mathematics to a cake, thinking of the procedures of measuring and combining, coming up with product "for someone else; I don't like cake." Johaly said math is a kiwi, "the sweet and the sour together," while Aseret rejected food as a metaphor in favor of winter — math is cold, complicated and rough, yet gentle, simple, and beautiful. Johaly's and Aseret's metaphors suggest a varied field of different textures resulting in different responses. Peggy, Kasi, and Carol came up with foods that indicated their attitudes; math makes Peggy think of potato chips because she loves them and can't get enough, whereas math is spaghetti, a tangled mess, to Kasi and tear-producing onions to Carol. The word "mathematics" triggered the following immediate responses: "learning, new experiences" (Peggy), "numbers, measuring" (Deanna), "hard, not understanding" (Kasi), "a task" (Aseret), "complicated, necessary" (Johaly), and "boring, not good" (Carol).

<u>Beliefs About Mathematics</u>

In the attitude questionnaire at the beginning of the session, all six of my sample (and most of their classmates) agreed with the statement, "To do math is to calculate answers." Deanna, Kasi, and Carol had particularly narrow definitions of mathematics. To them mathematics was numbers and calculations presented to them in a textbook or written by a teacher on a blackboard. They expected a list of problems, out of context, solvable in one or two steps by the method just demonstrated to them. Math required no thinking or understanding, just remembering, or perhaps luck. "If you told me what to do, I could do it," said Deanna in frustration having been asked to investigate the relationships of various measurements of a circle. They wanted to be trained to do arithmetic. In their final interviews, Kasi said she thought "everyday we would learn a page" while Carol said "I need division, long division, multiplication." Math was something to "grasp" (Kasi) but had always been out of her reach. It has to "click" and be pounded into her head. To these women, mathematics was external, foreign, a fixed entity of limited scope, not particularly useful other than to pass tests or satisfy prerequisites.

To some extent Aseret agreed with this view. "One thing about math is that it is a matter of fact. If you learn the process, you can do it." The area of difference in Aseret's concept of mathematics from that of Deanna, Kasi, and Carol was the extent to which she acknowledged and believed in a practical, contextual, everyday version of the subject. That version made sense to her, was worth doing, and could be understood and reasoned. She could sort out her financial affairs in the face of an authority who got a different answer. She shared this practical definition with Peggy and Johaly. Peggy mentioned the everyday side right away. She used math for her children's medications, for cooking, and her budget. Math and science was a more open world to her. It was accessible, part of her life already, but she was eager to make it a bigger part.

Kasi said in her initial interview that she had done her family's taxes for seventeen years so, yes, she could do math, but this statement was an anomaly in her comments. Never again did she admit to competence or usefulness of mathematics or of science, or to a broader, problem-solving and logical reasoning definition of mathematics. When I questioned her about what she would do if she were stuck, if the problem was setting up a VCR, she would work with others, try to figure it out, read the manual, leave it for a while then go back to it; she was confident that she would be able to solve the problem. If the problem was a "math" problem she would say "I hate this" and give up (Kasi's initial interview). Carol, too, had learned and used math in the kitchen and the supermarket, and she could round numbers or subtract fractions in the "real-world" but not in school. She undervalued her practical knowledge and failed to make use of it in the class environment. In fact, both Carol and Kasi, resisted activities which asked for them to make connections between what they were working with in class and their everyday experiences.

Kasi's and Carol's view of the mathematics could be described by Perry (1970) as *dualistic* or by Baxter Magolda (1992) as *absolute knowing.* According to the Women's Ways of Knowing (Belenky, Clinchy, Goldberger, & Tarule, 1986) perspectives, they were not *silent.* On the contrary they had voices and personal opinions; but in mathematics anyway, their knowing was *received.* In Kasi's and Carol's minds, there was one right answer or procedure, and the authorities (the teachers or text) knew what it was. Deanna also believed that answers were in the possession of the teachers. She said that she could not tell whether an answer she had come up with on a math problem was right; she would have to wait until the teacher told her what the answer was. She seemed to have no sense of reasonability or verification. Getting an answer was hit or miss, luck or skill.

In response to my questioning early in the program about what she would think if she came up with an answer different from the teacher's, whether it was possible that both answers might be right, Kasi said, "I don't think so. There is only one answer. I guess that is what I've been told. There is only one answer to math. As far as English, I guess there can be controversy." When I asked Carol if she thought math was different from other subjects, she replied, "Yes, definitely. It is either black or white, with only one right answer, whereas in English or history you can reword things differently. In math it is two point five, that's it. So it is accurate. It has to be right."

When mathematics means a calculation under specific instructions, these women have a point. Ten divided by four, expressed as a decimal, is two point five. But when mathematics is broadened to include modeling of a real situation, judgment about units of measurement and accuracy, or decisions about what questions should be asked and how their answers are to be used, there are many "right" answers. Mathematics has its dualistic parts, as any subject area does. A definition of mathematics restricted to the dualistic aspects, and inability or refusal to see that there are other areas where there are relative or uncertain answers and multiple approaches is my criterion for a dualistic view of the subject.

I observed this insistence on "one right answer" when Kasi and Carol were working with a triple beam balance in the lab, before midterm. The groups were given similar collections of objects to measure: ten pennies, a battery, a glass jar. Kasi could not see the point of doing it because "they are all going to be the same. Why do we have to do this? Their ten pennies are going to weigh the same as ours." Rick and I had an interesting interaction with Kasi and Carol, trying to get them to brainstorm what might cause the masses to be different. Carol came up with one immediately: initially they weighed only nine pennies and then found the tenth on the bench, so they were introduced to the not uncommon phenomenon in science of "experimental error." Eventually they thought of wear and impurities on the surface, rounding differences of the balance reading, and differences in balances. Kasi extended the question of variability of mass measurement to the other objects. "Does a dead battery have a different mass from a fresh one?" — a great opening for scientific investigation. At that moment, Kasi was peering beyond the edges of her scientific world view.

Peggy and Aseret, on the other hand, from the beginning of the semester, did entertain the possibility of there being more than one right answer or approach. Peggy said, "If I didn't get the answer that the other person did, I would question 1) whether we did it the same way, or 2) whether or not there was an alternative way of doing the problem in order to come up with the right equation." She was not as willing, however, to question the authority of the teacher. If her answer differed from the teacher, she said, "I would question whether or not I was right. Because the teacher has been doing it a lot longer than I have." Yet she went on to tell of her daughter coming up with a counter-example for a spelling rule that her teacher had told her. In response to the same line of questioning about having different answers from classmates or teacher, Aseret said, "I'd want to understand how the teacher got their answer." She could conceive of the fact that the teacher might be wrong, that they were both right, or that they were both wrong. "There are a lot of possibilities. That would get my curiosity up." Peggy and Aseret have passed Perry's (1970) *Multiplicity* milepost or Baxter Magolda's (1992) *transitional* or *independent knowing*.

Attitudes About Self Relative to Mathematics

A person's attitudes about mathematics are closely related to her view of the field. For example, if a student (such as Kasi, Carol, or Deanna) thinks that math is a collection of problems each with a single correct answer, and now or in the past she has been unable to find that answer, she is likely to feel excluded and hopeless. On the other hand, if a student (such as Peggy or Johaly) sees math as opportunities for investigations, where she is a capable and interested investigator, her attitude is more likely to be favorable. Simplistically, attitudes toward math can be classified as negative, positive, or neutral. When they started the semester, Kasi and Carol had negative attitudes about themselves relative to mathematics, Deanna, Johaly, and Peggy expressed positive attitudes, and Aseret was neutral.

In their initial interviews and whenever the occasion arose during the semester, Kasi and Carol told of their hatred of math. It had meant failure and humiliation, and had been a barrier to possible career choices. Carol thought the ability to do math might be genetic, and she was lacking the genes. In spite of their dislike for the subject, they were determined to succeed within their own definitions of what it meant to learn math. Carol's attitude was, "I don't think I can do it, but I'll fight for it." Her migraine headache came from this battle. Kasi said, "I feel confident I can [learn the math I need], because I know that I am a very smart person." Yet she never seemed to be constructively involved with learning any mathematics. To Aseret, math was a task which she would take on if and when she saw a reason to. If she chose to, she could learn more mathematics, but, as she said to her daughter who was asking for homework help, "Is this a must?" Having struggled in school as a child, Peggy figured that if she was allowed to do it her way, at her speed, she could do anything. She was excited about learning and exploring science and math. Deanna said initially that she liked math and wanted to teach math, but this seemed to come from her desire for power and control rather than knowledge or application. Johaly, in her quiet, unassuming, pragmatic way, said that she would do what it took to become a nurse; she did not convey strong attitudes about learning mathematics.

My question in the initial interviews about whether they thought math was different from other subjects, although intended to illuminate the students' beliefs about math, gave me more insight into their attitudes. Kasi said, "Yeah, I would say math was different from other subjects, actually, because it was hard for me where other subjects came easily." Johaly said yes, because math is "complicated." Aseret said yes, because math is "so serious." Peggy, concerned more with learning than learning math, said she wasn't sure. Deanna thought all subjects are pretty much the same. "It's just you're learning a different subject." Carol's response showed that her dualistic or absolute view of math was not her general world-view. She said, "Yes, definitely. It is either black or white."

Especially the differentiation of mathematics and subjects like English and history on the basis of "one right answer," "either you know it or you don't" shows either non uniform development in the academic disciplines, or the exposure of dualistic teaching in mathematics and multiplistic or relativistic exposure to other subjects. Kolb (1981) identified this subject area differentiation as a phenomena of learning, and Dorothy Buerk (1981) studied the math-specific developmental lag in math-avoidant women. This lag has been attributed variously to a mismatch between a student's preferred learning style and the dominant teaching style of the discipline (Kolb, 1981), to gender differences and the traditionally masculine approach to schooling (AAUW, 1992), to misunderstandings of the actual nature of mathematics (Guillen, 1983), and to counter productive beliefs about learning math (Borasi, 1990). Some (but not I) would say it is because mathematics <u>is</u> dualistic, absolute, universal (Orton, 1995). Thinking there is only one right answer and not being able to, or caring to, find it resulted, for Kasi and Carol, in avoidance, frustration, bitterness, and shut-down of effective effort in mathematics.

<u>Perception of Learning</u>

Many of the Jump Start participants, including Peggy, Kasi, Aseret, and Carol, had little or no recent classroom experience. For several of them, high school had not been a pleasant experience. Kasi and Deanna did not want to be there. Aseret couldn't see the point. Peggy had difficulty socially. But these women voluntarily returned to school. Did they expect or demand (or even accept) a more effective way of learning?

<u>Responsibilities of Teachers and Students.</u> In the questionnaire about attitudes toward mathematics, the women in my sample were unanimous in their strong agreement with the statement, "A good teacher should never confuse you." During the initial interviews, I asked,

"What are the responsibilities of a teacher?" and "What are the responsibilities of a student?" Johaly Martinez thought a teacher should "explain theirselves clearly to the student, ask questions, know when to go back and when to go on" and that the student should "tell the teacher what they don't understand, ask the teacher questions, pay close attention to when the teacher explain." She told me, "I had a few teachers that had an impact on me. One was very good — very organized, very strong, very strict." Kasi Rousseau was the voice throughout for traditional algorithmic practice and single-step problems, in spite of the fact that she did not like it and it was not particularly successful for her in high school. In her first interview, after several math/science classes, she asked, "Are we going to be doing any math? Are we going to be getting books?" and complained, "The teacher's not up there. I thought it would be more like a math class like in high school." When I asked what a teacher's responsibilities are, Kasi replied, "I feel a teacher's value to me is making sure the point is in my head, whatever they are teaching, and that it stays with me." A student's responsibilities are "to take in what the teacher is saying." Carol agreed with her. The responsibilities of a student are "to pay attention, take notes, shut up, be on time."

Deanna VanDyck came back several times to the teacher as a power figure. She said she wants to teach math because she can be in control. "The teachers are the ones that are in control. We are just the students learning how to do the things they want to teach us." These students have traditional expectations of receiving knowledge from a person in authority who dispenses it. Johaly allowed for more communication and interaction between teacher and student, but still saw the teacher as central and a teacher's organization, strength, and strictness as assets. When I asked Carol about setting up a VCR, her response was to defer to the ultimate external authority, "I'd call the 1-800 number."

Peggy Perkins seemed more receptive to being an active partner in her learning. From a teacher, she expected "cooperation, guidance, making the classroom a place that students can get knowledge." Aseret Robertson thought a math teacher could "present it in a way where it doesn't look so much like you're teaching. You're learning — it is almost like you're learning and you don't know it. You know what I mean?"

Philosophy of Education as a Function of Development. What the students see as valid teaching practice, whether they can be self-directed learners, whether they can take an "it depends" or "you decide" as an answer instead of "yes" or "no," whether they can collaborate effectively and see through others' eyes may be a function of their development. Even what they see as the purpose of education develops with the students.

Weathersby (1981) suggested that along their developmental path, people begin by thinking that education is a product acquired by school attendance —a goal and an asset — and ultimately realize that it is an open-ended, intrinsically valuable process within the self —a way of life. Several of my sample had different notions of the purpose of education, suggested by my questions in the initial interviews about what they expected to get out of their Jump Start experience.

Peggy and Aseret seemed to be nearer the "intrinsically valuable process" end. Peggy was excited by learning. "I want to learn. I want my math. I want to do science. I want to learn how to read properly, spell properly. I want to learn to be the best I can. I love asking questions. I like to answer questions too. I just want to learn." Aseret took what she wanted from the program and accepted that the gain was an intrinsic one, although she would have liked to get some college credit for it. Kasi and Carol were nearer the "education is a product" end. Kasi said, "I know what I want and I know where I'm going" and what she wanted was to get her math requirements out of the way. Carol also expected from Jump Start "to get up to college level work. So I don't have to start at 100. So I can get right into credit courses."

The willingness (or ability) to see experience as a vehicle for learning may also be developmental.

> A reproductive conception of learning and a dualistic conception of knowledge lead to a "surface" approach where experience is deemed anecdotal, trivial, or irrelevant to learning. In contrast a thematized conception of learning and a

> perspective-dependent conception of knowledge lead to a "deep" or productive use of experience. (Tennant and Pogson, 1995, p.126)

From my observations of the class activities and the students' final comments, I would say that Peggy, Johaly, and Aseret were more receptive and enthusiastic about learning from experience, and that Deanna, Kasi, and Carol saw little educational value in experience and wished for un-integrated, de-contextualized pieces of information which they could then be asked about on a test. In their final interviews, the latter three suggested separating math from science (or eliminating science) and more book work. The former three did not.

Learning in Groups or Alone. In addition to the teachers' and students' responsibilities and the location of authority, there were differing preferences about whether one learns better alone or with others. Two of the people I interviewed, Peggy and Carol, said they need to be alone to learn. Peggy Perkins mentioned time as a reason for preferring to work by herself.

> I work better on my own. I don't work at a great rate of speed. I work at a slower rate than most people. I have all my life. I was kicked out of typing class in high school because I couldn't type fast enough. I could get what I had to get done, but in my own time.

Carol Gibson was comforted by the fact that others shared her difficulties. "I get excited when someone else is having a problem, too. I'm not alone. I'll ask the girls in the cafeteria, 'Are you getting it yet?' and they're like, 'no'. " Yet she preferred to work by herself, partly because of self-consciousness.

> I think I do better alone. I get too confused. She's rattling off the numbers and I'm like, huh? I need to be at home with my cup of tea, trying to work it out alone and then I bring it to class and say "I'm not getting this one", listen to what the teacher says and write down and think about it. ...It's probably the hard way of learning but I get so embarrassed that I like to do it alone.

Johaly, Aseret, and Kasi could see some value in collaboration. Johaly said, "I like (working with others) because it is sociable, but also I could be right and they could be wrong, or they could be right. They would say their point. I would say mine. We could get together." When I asked Aseret if she liked working with other people, she replied,

> Yes, to a certain extent. It's funny because I think on some things, it's good, 'cause on some things, I notice where I might be slow and I just don't get something. The other person doesn't get this and I know we're going to be taking more time, and in a sense it is frustrating, but I can imagine I'm the same way on different other things so actually I think it is good.

If Kasi were trying to solve a problem (like setting up a VCR) , she would

> probably get together with three or four people and try to work it out. Because that way, I'm getting their view point and ideas, and maybe they have like an easier way of getting the results. The combination of everybody's input will probably be easier than sitting there trying to figure it out.

The six women of my sample showed a patchwork quilt of beliefs, attitudes, and learning philosophies. Most of the observations of this section were from the initial interviews and the early classroom activities. Their views had been formed by past experiences and opportunities. As Jump Start students, they were being exposed to new experiences and opportunities. In the following section, I switch my attention to the program and the experiences it provided.

## The Jump Start Learning Environment

### The Pedagogical Intent of the Math/Science Activities

The math/science portion of Jump Start, planned and facilitated by the instructors Rick Lane and Lindy Gougeon, followed a philosophy very close to that described in the Women in Technology: Project Jump Start grant proposal (Appendix A). This was to be a unique learning opportunity: a community of self-directed learners and problem-solvers, investigating scientific principles and developing mathematical tools in integrated and contextual activities. They would construct their knowledge from carefully chosen experiences. Rick and Lindy agreed that their main objective was to build confidence They wanted to provide a positive experience from which students could build useful techniques for learning. Science and math was a vehicle for learning to learn and for developing productive beliefs and attitudes.

Learning Groups. Working together was an integral part of the math/science learning plan, with the dual objective of forming connections for mutual support and encouraging students to negotiate and practice their knowledge collaboratively (Davidson, 1990). An additional benefit was that for many occupations, the ability to work as a part of a team and to form effective networks is more highly regarded than individual brilliance (Tennant and Pogson, 1995).

Science and math experiments were good opportunities for collaborative learning. There were limited facilities and equipment, several tasks to perform simultaneously, hypotheses to discuss, and results to verify. Students grouped themselves and could change their partners at any time. There was not much shuffling, however. Some literature about collaborative learning (Johnson & Johnson, 1988) recommends various selection methods and regulations for ensuring that there is a heterogeneous mixture and universal participation. Since the Jump Start women were diverse in many ways, had strengths in different areas, and the self-selected groups seemed to be working, the instructors did not intervene. For most of the science experiments, there were five groups of three or four people; for some of the math activities, students worked in pairs.

Collaborative groups provided a student-centered active learning format to challenge the belief that mathematics is the property of experts conveyed by teacher-centered passive learning methods. Instead of being told the differences between electrical circuits in which batteries are connected in series and electrical circuits in which batteries are connected in parallel (or even that there is a difference), students were given diagrams to follow for forming the different circuits and asked to measure current. They were to make hypotheses and test them. After a class discussion of the group results, Rick reminded them, "Everything you learn in here, you learn because you have done it, not because someone told you that's the way it is." Groups allowed for a more constructivist approach to learning and a view of mathematics as human, fallible, and accessible (Forman, 1989). Small group work followed by larger group discussion and individual reports and reflection also was a way to encourage development from what Baxter Magolda (1992) terms *absolute knowing* to *independent and contextual knowing.*

Students had the chance to practice their new knowledge in their groups and have it evolve with the help of other perspectives or experiences. In their interviews, Deanna, Carol, and Aseret recounted incidents at school where they were asked to do a problem, alone, at the blackboard. From stories people have told me (and there seem to be many people who have humiliated-at-the-blackboard mathematics stories), these experiences are devastating. Even Rick Lane volunteered that his most vivid school memory was a "horrendous" confrontation between him and his elementary school teacher over memorization of his times tables. Working in groups relieved some of the stress of individual performance and helped alter the counter productive belief that mistakes and confusion are undesirable (Borasi, 1990). In small groups, students were given opportunity to venture suggestions, take intellectual risks, and give answers that were then adjusted. They felt free to admit their misconceptions and ask their friends to explain something. The group negotiated its decisions and problem-solving methods, and took mutual responsibility for its process and results. The report to the class at the end of an activity was given in the third person plural — "we found that ..." or "we couldn't decide whether ...." The message to the Jump Start women throughout the semester, reflecting both the non-threatening approach to learning math and science and the security and support of a small group, was "There is safety in numbers."

Classroom Discussion. Instructor centered "telling" was limited to the first few minutes of a class when Rick or Lindy would introduce an experiment, give some information (which they tried to keep to a minimum), or sum up the important ideas from the previous activity. Part of most classes, usually before or after a group activity, was devoted to class discussion. This was an opportunity to compare the strategies and results of the groups, and to enjoy the variety. Class discussions were more directed than the open-ended group activities were. Rick or Lindy asked questions and either responded to questions asked by students or turned them back to others for response. Misconceptions were used as cues for explanations or information.

Everyone participated in these discussions at some time. Carol almost always had an answer but rarely was her response thoughtful nor did she expect it to be correct. She would respond almost immediately to a question, with what seemed like a random collection of the most recently used scientific or mathematical terms — "the circumference of the diameter" was her answer to a question about circles. She clothed her confusion and lack of confidence in comedy. When class members were asked to think of a situation which would give rise to a multiplication problem, Carol came up with one which involved multiplying oranges by pineapples. When Lindy asked what units or label the answer would have, Carol said "square fruit." Peggy often came up with personal experiences and anecdotes; Kasi would question why they were doing this and show her dissatisfaction with body language and comments to a neighbor; Aseret was rarely present and Deanna was often inattentive, but occasionally would get involved. Johaly was quiet, rarely spoke unless addressed directly, but was attentive and seemed interested.

The class discussion was a slightly more public way for the women to try out their ideas and their new vocabulary. Little things were corrected (such as telling them that the conventional abbreviation for grams is "g" not "G.") Many misconceptions surfaced — "But I thought ..." was a common introduction. "But I thought the diameter of a circle had to go straight across (be horizontal)." "But I thought perimeter and area were the same thing." "But I thought area was always length times width." "But I thought multiplication made a bigger number." "I thought volume had to be liquid." "Is two times the radius the same as the radius squared?" Students would relate to each other's incomplete understanding rather than scoff at it.

<u>Disequilibrium.</u> At the beginning of the semester, the students all agreed with the statement, "A good teacher should never confuse you." The instructors, however, were of a different opinion, as is much of the Teaching and Learning literature. One of the desired outcomes of the math/science approach was to have students realize that confusion, uncertainty, and mistakes are a natural part of the learning process. It takes time to learn.

Effective teaching practice, especially developmentally based, recognizes the need for disequilibrium. Weathersby (1981) wrote,

> Exposure to higher level reasoning, opportunities to take others' roles and perspectives, discomforting discrepancies between one's actual experiences in a situation and one's current explanations and beliefs — these are the basic elements of the transition process... (pp. 71-72).

Some of the students seemed disturbed by disequilibrium and uncertainty. I recall Kasi saying to Rick in the second week after what I thought was a very productive class discussion about car batteries, "Why didn't you just tell us what we needed to know at the beginning?" Rick replied that if he had, no one would have anything to relate it to or any reason to remember it. The students would not have had nearly as much to contribute to the discussion.

Regular reminders along this theme and daily experiences in which the students had to readjust what they knew or what they had done last time because of different situations resulted in most of the class coming to expect temporary confusion and even to enjoy it. Toward the end of the semester, after they had measured volume of different metals by measuring the amount of water displaced, and then found density by dividing the mass by this volume, they were asked to find the density of some different types of wood. They found quickly that wood floats and the method they were comfortable with would not work, so there was a good natured outcry, immediately followed by brainstorming moving from ridiculous to workable. In their groups, everyone seemed to take this obstacle in stride.

Developmental Readiness. When learning has a human development interpretation, students are encouraged in their development by offering them experiences and challenges beyond their level. A student who has a dualistic perspective is exposed to other views and questions with multiple answers in order to help her become multiplistic or relativistic. Sometimes, however, the student is not ready to see further or the learning experience is aiming too far away from the student's level.

I asked Lindy about the students who are not ready for the Jump Start science/ math approach. Students are not always ready to have their traditional ideas upset and brought into question.

> I think that sometimes I lose students. I lose them because they aren't willing. To me I guess that says that they aren't ready. I think that (maybe this is a rationalization) you lose students no matter what. I'd rather lose the students who aren't ready than not give the students who are the opportunity to do this. Even the others, I hope that they got something out of it, that they will come back and think about it. We all need our foundations shaken a little bit at some point. I think that education is about not just keeping people comfortable with what they are doing but learning new things, exploring now ideas, learning new ways to think about things.

Remembering the sample students' unanimous agreement on the mathematics attitude questionnaire with the statement, "To do math is to calculate answers," I asked Lindy if she thought she was doing students who believe that mathematics is just about finding the right answer a disservice by trying to convince them that there is more to math than answers, and that even the answers may be relative and negotiable. She answered,

> No. I think I am doing them a service because I think that it is bigger than a philosophy of math, it is a philosophy of life for me. That we can get somewhere in terms of what is good or bad or right or wrong, that is like wearing blinders. I almost think that I am doing a bigger social service by showing people that even in something that they think is as narrowly defined as math, there are options. There is more to it than they know. ... That's what education is — whatever it is you think you know, you find out there is more to it.

<u>The Lab Activities.</u> The first experiment, on the amount of electricity various appliances use, was an introduction to scientific method and group process. It used familiar and practical objects and provided useful consumer information. The activity was simple to understand yet had scope for a variety of approaches and subsequent lines of inquiry. This flexibility of method

encouraged multiplistic thinking (Perry, 1970) or contextual knowing (Baxter Magolda, 1992) and took advantage of the students' practical and implicit knowledge (Tennant and Pogson, 1995). As soon as the groups started to work, the center of learning was the experience, and the direction, verification, and questions came from the students. The instructors were spectators and cheerleaders — "That's an interesting approach!" or "Try it and see what happens." — and made a concerted effort not to channel the activity or serve as the knowledge and answer source. The atmosphere throughout was relaxed, industrious, and supportive.

The math/science labs throughout the semester followed a similar pattern. Students either worked on an experiment in small groups, discussed the results of the last experiment, or prepared for the next one. They were given a list of associated math topics with section number references for their math textbook so they could work on rusty skills. (See Appendix C.) A series of activities with electricity was followed by a unit on density, and finally a study of temperature and pressure. The procedure and data management were left open and the possibilities are discussed and results compared, but rarely was one labeled as "the right way" — although one group's method might be deemed "most efficient," or "most eccentric," or "needs some adjustment."

By the end of the semester, the Jump Start women were expected to manage their experiments with less guidance. They were left to collect their own equipment, to plan their approach, and to make a record of results and in a useful manner and generate good questions. They were to rely on their own resources for verification of method and results. They were being trained to be independent investigators, capable of discovering or constructing knowledge.

There was less calculation involved in the temperature scale activity than in some of the density and electricity experiments, but this activity provided the opportunity to become aware of the need for and existence of negative numbers, absolute value, linear scales, formulas, and conversion of units. This experience also provided an example of a portion of mathematics, systems of measurement, which is created by people and is conventional rather than absolute. This challenges some students' beliefs that mathematics is "arcane" (Buerk, 1985), uninfluenced by human activity. The activities throughout the semester encouraged the belief that mathematics is a natural mode of thought, a social construct, product, and resource. Mathematics is dynamic; it can be talked about and played with. It is not just a set of procedures to be memorized.

The philosophy behind the math/science activities and some of the pedagogical decisions such as using calculators and working in groups on open-ended problems is in alignment with the philosophy of current mathematics education reform as described in the wide-reaching and influential National Council of Teachers of Mathematics Standards (for curriculum and evaluation, 1989; for teaching, 1991; and for assessment, 1995). The goals put forward in the Standards and the intent of the math/science portion of Jump Start is to change beliefs engendered by traditional school mathematics from a narrow, decontextualized, compartmentalized, calculation and algorithm based field which had become elitist and of decreasing general use, to a broader view of an integrated, contextual, problem-solving based field in which students would investigate real-world problems collaboratively making appropriate use of available technology.

To some extent, all six of the women of my sample, but to a greater extent, Carol, Kasi, and Deanna, shared the traditional view of mathematics that is no longer sufficient for the technology-dependent world of today. This world needs citizens of all cultures and learning styles to be able to understand mathematical concepts and apply them to new situations. Jump Start was created to prepare students for useful technological education, and this included encouraging productive beliefs and a positive disposition toward math, science, and learning. How successful was the program in reaching this goal? I attempt to answer that question in the next section on the effects of the experience on the students, but first it is necessary to consider factors in the learning environment other than the math/science activities.

Jump Start Spring '95

The Program in Flux. My naive assumption as I looked forward to this research was that I would be observing a variety of students' attitudes and behavior changing in an essentially fixed context. I was prepared for differences among the women and for development of individuals during the course of the semester, but I thought I would be observing and reflecting from solid ground. I was not prepared for the instability and uncertainty of the framework—of the Jump Start program. The objectives, structure, curriculum, and methods of the program were well-specified in the grant proposal (Appendix A). But Jump Start was evolving; the program I observed was quite different from the program that was originally designed. These changes were affected by two years of implementation, and by changes in the college (including a change of president), its financial stability, and its mission, in the progress and perception of education reform, and in the political direction of the state and the country, including more restrictive welfare policies.

Each Jump Start cohort was different, and this one had several people who had no interest in science and no intention of pursuing technological careers. A new factor affecting these women, and many more already matriculated at the college, was the proposed change in state welfare laws. If these changes were implemented, a person on welfare would have to be fully employed within two years. Students starting at the developmental level, especially students with family responsibilities, are rarely able to complete a career program or degree within that time. The Jump Start participants in the Spring '95 semester, because of the anticipated effect of new welfare laws and the publicity and concern within the college community about the changes, felt they needed to push forward and see concrete results, not just improved attitudes and more productive beliefs.

The math/science component remained fairly close in philosophy to the original learning community in which science, math, and communications were integrated, learned in the context of "hands-on" experiences with the guidance of a team of instructors working together. Rick and Lindy still operated as a team, math and science were integrated and "hands-on," but the communications component had split away into an English class and a computer class, each with its own autonomous instructor. Rick recalled,

> The original concept was for all instructors to work together, interweaving science, math, and communication. The teachers of all components were together, and writing skills were used in lab reports and papers about math and

> math experiences. Now the instructors don't communicate much. There is more isolation. It has gravitated to being a collection of college courses.
>
> The best feelings I have about the job I do was at the beginning. I really don't have a good feeling this semester. I can't put a finger on it. I just thought, when you are all working together as a team and spending time after the students are gone to work together as a team, things were all very different. You need to address the students as a whole. We did that very well at the beginning, but not any more.

Lindy attributed the dis-integration of the program to the logistics of managing schedules of instructors who were employed full time in other jobs. The original communications instructor, a special education instructor from Franklin County Technical School, decided not to continue after two sessions because Jump Start involved more time and energy than she had to spare. She was replaced by a GCC English instructor, and the coordinator and counselor, Barbara and Holly, taught computers and career development. Barbara had been associated with Jump Start for all but its initial summer session and had been coordinator for the 1994-1995 academic year. Holly was a newcomer to the program; Spring '95 was her first semester as counselor and career development instructor.

A significant change for Jump Start was that after the Spring '95 session, both of the math/science instructors decided to leave the program. Neither resigned in protest. Rick stressed to me that he cared deeply about the program and had thoroughly enjoyed being a part of it, but "there are things I want to do in my life. I just can't afford the time." He planned to work on a master's degree, and had found that on top of full time teaching and family responsibilities, there just was not time to make the commitment necessary for Jump Start. Lindy told me that she was not comfortable with the way the program was changing into a connected set of 100 level courses.

> I was doing it [Jump Start teaching] because it was fun and it was exciting and it was so wonderful to work with students like these students in such an open atmosphere. If it is going to be a Math 100 class, I do that anyway. It is not

something special and different and unique. I [pause], I don't know. I am concerned about the goals of the program. I think that it has changed because of testing. I think it has changed because of the funding sources wanting a certain result and I have been fighting it."

She, like Rick, did not feel she had the time or energy for the program on top of her college, family, and community commitments and that it was time for a new math/science team.

After each semester, the coordinators and instructors had made adjustments, allocating more separate meeting times for each of the subject areas. Standardized testing, which was introduced after the first session had concluded, was inserted before the beginning and after the end of the integrated curriculum unit. For the Spring '95 semester, some of the testing was moved into the midst of the course.

Women in Technology: Project Jump Start, based on a sense of community and common vision, was evolving unevenly. Portions were heading in different and sometimes conflicting directions. Was this to be a college-like experience or an alternative to traditional teaching methods? Were science, mathematics, and communications to be integrated in common experiences, or separated by time, space, and instructor? Was the emphasis to be on learning to think and constructing knowledge, or on memorizing and receiving knowledge? Were the women preparing for jobs or for examinations? These questions suggest another set of shifting coordinates — my own perception of Jump Start — from what I thought it was going to be to what I actually observed.

I hasten to emphasize that I did not design my study to be an evaluation of Jump Start nor do I intend this dissertation to be interpreted as that. My perspective and observations were limited to students' attitudes about mathematics within the math/science portion of the program. This made up only about twenty percent of the students' contact hours. The rest of their time was spent in English, computer, and career development classes, on their job shadow placements, or in time set aside for tutoring or Focus Group. I did not observe any of those portions and I did not interview the other instructors. My knowledge of them is strictly hearsay — information or opinion offered to me by the students of my sample or by the math/science instructors in our interviews. I did talk with the coordinator and counselor, Barbara and Holly, but my questions were about the students, not the other portions of the Jump Start program.

What I observed from my restricted viewing point was a fundamental difference in opinion about whether Jump Start should be training students in basic skills so that they would be accelerated when they matriculated as GCC students — so that they would place out of Math 100, English 100, or College 100 — or whether Jump Start should offer the students a non-traditional learning experience that made use of their practical knowledge and concentrated on hands-on, integrated, contextual activities. They would still learn and practice basic skills in context as they needed them, but those skills would not necessarily be the complete set found in the more traditional Math 100 syllabus. This difference of understanding and break-down of communication was highlighted by the decision to administer standardized and placement tests during the semester.

<u>The Placement Test in April.</u> Human behavior is complex and unpredictable. Particularly so was the attitudes of a group such as this of women interacting, sharing experiences which were designed to unsettle some of their beliefs and concepts and encourage growth. Lindy and Rick were operating far from the stable center of traditional classroom instruction; the women were in a new environment discovering new ideas, redefining concepts, and being encouraged to question and act in new ways.

Non-linear, dynamical systems can be modeled mathematically with chaos theory. One of the phenomena of chaos theory is the *Butterfly Effect*. The name comes from an example in meteorology where a butterfly flapping its wings today in Peking can transform storm systems next month in New York (Gleick, 1987) and refers to disproportionately large or significant repercussions of a small, distant action. This idea is not new. For the want of a nail, wars were lost. A straw has been blamed for breaking a camel's back. The mathematization of the phenomena, however, is recent.

The placement test during the semester and the resulting change of atmosphere and subsequent changes in the program was an example of the Butterfly Effect. This event illuminated a misalignment of purpose between the math/science instructors and the coordinators and students and its effects were magnified by a lack of communication and collaborative response.

From many angles, administering the test when they did was reasonable. An ancillary purpose (or perhaps a positive result) of the Jump Start program was to provide students for GCC. Because of state political and fiscal policies in Massachusetts at this time, Greenfield Community College's success (and survival) depended increasingly on the number of students it registered. Credit hour registrations were significantly lower than in previous years, and there was a college-wide push to remove barriers and bring in students. It made sense to get those Jump Start women who planned to enter college programs or take college courses ready to register. This was, for some of its participants, a college preparatory program, and help with and support during necessary college admission procedures was part of the package.

In addition, funding sources wanted evidence of results, and significant increases in test scores would be simply convincing to state agencies. In most classrooms, the GCC developmental mathematics classes included, tests are an important part of assessment and the ability to take tests without destructive anxiety is an essential college survival skill. A thirty minute test was no more important than the remote flap of a butterfly's wings.

However, based on my observations and interviews, it appears to me that this test at this time was disruptive, perhaps even destructive, to the math/science portion of the Jump Start program. It did not test what the students were learning (or they were not learning what it tested); it broke down the growing sense of community and of intrinsic motivation and reward; it decontextualized the mathematics thinking and separated math from science. The students, and to some extent, perhaps, the administrators and funders, saw the test as a stick against which to measure progress or achievement. It defined what was important to learn. Although it was never intended for this purpose, this placement test was looked to as an indicator of how much mathematics the students had learned and whether they were "more prepared' for college. This misinterpretation was accentuated by the fact that there was no other assessment process in place, other than self reflection, which gave the student some idea of her progress. The pedagogical decision not to give grades backfired as soon as there was a grade (the placement test result) entered into the system. That then became the only indicator of success or failure.

From the time the students were told they would be retaking the placement test in approximately two weeks, several of them, Kasi Rousseau vocal among them, questioned each topic. "Is this going to be on the test? Then why are we doing it?" On April 10th, more than a month before the end of the session, the math/science class discussion was dominated by questions about "the test." Carol said, "Can we choose what test to take? Then I want a 'retard' one." Another student asked, "Will there be algebra on the test?" "Do I have to panic yet?"

Since there was no standardized test of science knowledge, science, the cornerstone of the Jump Start program, was devalued. In Carol Gibson's final interview, I asked her how the program could have been better, and she (one of the declared math-haters) said,

> More math and less science. We focus too much on science. ...We spent a lot of time on geometry and I don't have the basics. ... I think they needed to go easier with the math. Do the basics. We just spent too much time with electricity, you know, sockets and batteries and I need division, long division, multiplication. Refreshing — that's what I thought it was going to be, you know, refreshing my skills. ... You can't do your multiplication and long division when you are supposed to do these other things.

Peggy and Johaly were not unhappy with the program, yet they used the placement test as a measure of what they had learned. When I asked her if her opinions about math had changed during the program Peggy, whose placement test score went up from 15 to 24 (out of 35 — a score of 25 places the student out of Math 100) answered, "I scored fairly well on the math. I want to retake the test, though. I was one point below (the cut-off)." Johaly Martinez, whose placement test score went down from 13 to 9, said "My math grade wasn't good."

For the six in my sample, no one placed beyond Math 100 at the beginning of the semester, and in April, no one placed beyond Math 100. Aseret Robertson did not take the test a second time during the program. Of the others, only Johaly's score went down. The mean increased from 14.3 to 17.4 in my sample and from 17.4 to 21.8 among all who took the Level One test twice and completed the program. I give these scores for completeness and reemphasize that they did not measure what was being taught in the math/science portion of the program. It was not acceleration, but increased likelihood of success in future courses that was the outcome desired by the math/science instructors and the original program design. Current implied program objectives and student expectations were leaning more toward Jump Start serving to place the student beyond the most basic course in order to shorten her time in college.

## The Change in the Students' Beliefs and Attitudes During the Program

### From the Student's Perspective

The women speaking in their final interviews sounded much as they did at the beginning of the semester. They did not report great changes in attitudes or beliefs about mathematics and learning. They did not think they had learned much math — "I went up a few points." But they all said they were different people at the end than they were at the beginning, more self-confident and ready for college.

There were a number of subtle indications of the success of the program from the students' statements: Peggy's sustained interest in science, Deanna's pride and satisfaction with making it through, Aseret's new view that math and science are less intimidating, that her practical knowledge might pay some dividends in college. There was Kasi's acceptance that she should start her college math courses with a review of basic skills, her growing independence and new focus on learning and swimming forward rather than treading water. Carol had a more positive outlook toward education and a potentially productive mentor relationship with her daughter. She realized that college could be fun — she could be herself and learn — that the range of opportunities is wide, and that there were people who would support her and believe in her.

Johaly had a more realistic idea of what it was going to take to become a nurse. She was able to have experiences away from her children and knew the demands of learning in English and of getting to school each day. She had new friendships and had seen a new world which she liked the look of.

From the Instructor's Perspective

The instructors reported changes they noticed. Rick commented on changes in expectations of the students over the course of the semester in this and previous Jump Start cohorts.

> When we start out, it is almost as if the students are looking for what we want. It takes a while for them to realize that we want them to write what they think, and can work out, and what they experience, and that there is really not one right or wrong answer. Sometimes there is, but most of the time there isn't.

The similarity between this observation and a comment by Paul Cobb in an article about constructivist mathematics classrooms is striking. Cobb wrote,

> The teacher's pedagogical agenda at the beginning of the school year typically conflicts with the beliefs the students have developed during traditional instruction at lower grade levels. For example, the teacher might want the students to explain their mathematical interpretations and solutions when they participate in whole-class discussions. However the students might assume that they are to infer an official solution method that the teacher has in mind rather than to articulate their own understandings. The teacher and students can be said to be engaging in abnormal discourse in that they have yet to establish norms for what it means to know and do mathematics." (1995, p. 237-238)

By the end of the semester, the women were accustomed to planning and explaining, formulating questions and looking for answers. All of the groups could tell whether they were getting reasonable results, and if they were not, they knew how to correct themselves. Lindy told of this movement of the source of verification from the instructors to the students. She was referring to activities involving calculation of density, mass per unit volume, done near the end of the of the semester.

> When someone had done the fraction, they inverted it and got the wrong number for density. They looked at the pattern of what was going on and they knew there was something wrong, that the pattern should continue. They backtracked and found out what they had done wrong. They knew what to look for. "Did I do the right operation?" "Did I make a mistake on the calculator?" "Did I write down the numbers wrong?" And then would go back and see if they had actually done their measurements properly.

Rick also noted the development in the students' self organization and report writing skills. Their lab reports showed increasing ability to summarize and choose pertinent information and in statistical presentation. They also had become acquainted with a variety of scientific apparatus, and were comfortable with different measuring systems. They were developing as scientists. Lindy noted, "They started seeing patterns in dissimilar things and that's exciting. It's important not just in terms of math but it is incredibly important in terms of science."

As instructors of regular college basic mathematics courses in addition to being the Jump Start instructors, both Lindy and Rick felt that all of the women were much more likely to succeed in Math 100 than women of similar backgrounds entering GCC without the benefit of Jump Start. Although Math 100 is the most basic course offered and every effort is made to make it unthreatening and useful, it has a significant attrition rate. When any of these women take a basic math class and are asked to find the circumference of a circle, they will be among the very few who know and understand what that strange symbol $\pi$ stands for, and if not its value, they will know how to find it empirically.

With any education program, the amount and type of benefit varies with the student, her developmental level, motivation, opportunities, and constraints. Rick's thoughts about the students who do not thrive were that the students lack efficacy, the determination to succeed.

This might be an unreadiness for the teachers' expectations and methods, a developmental impasse due to previous experiences.

> I think everyone can learn to a certain level. I don't expect everyone to master third semester calculus, but they can get some geometry down, which is important in our lives, and they can learn some algebra and calculator skills. For some people, it is always going to be a struggle. If someone is willing to struggle, I will spend as much time as I can with them. What frustrates me is people not willing to struggle, and there is usually a history there. Not trying is a decision that may depend on what went on in the past, maybe for a good reason. They may have had very bad experiences.

From the Researcher's Perspective

Jump Start's effects are difficult to measure, but no less valuable for it. Many of the lessons may not be realized for several years. The math/science curriculum attempted to show these women that math and science is part of their lives. They worked in class with familiar things — hairdryers, thermometers, batteries, tape measures, nails, and pennies. They investigated their world by measuring and comparing volumes and areas, density and electricity. They were asked to find examples of scientific principles and make up their own problems. They were exposed to graphs and tables by being asked to create and critique their own.

Their math and science experiences asked them to open their eyes, to be curious, to wonder and then investigate. The fact that after Jump Start, as Kasi scanned the TV programs, she stopped to watch a science or nature show, indicated some success. Jump Start tried to get the students to use resources, to hypothesize and to test, to try and to question, to reflect, record, and summarize.

They have tried learning by wrestling with problems, not by mimicking the teacher. Even if they find the latter strategy more successful in institutional settings, they have known an alternative. That alternative is more likely to benefit them in the workplace and in their life experiences. Potentially the Jump Start participants learned a variety of useful life and learning skills and were primed for success — potentially.

At the end of the semester, I sensed disappointment. Rick and Lindy were discouraged, Kasi, Carol, Johaly, Aseret, Peggy, and Deanna did not achieve the measure of success in math and science that they were looking for. One explanation for this was that the progress they were looking for was not in the direction along which they were being encouraged during their math/science activities. Some of the students were on the same team as the instructors and other students, but they were pulling in different directions.

The attitudes and beliefs of the women of my sample did not change drastically in the fifteen weeks. I know of no epiphanies or miraculous transformations; I cannot report the creation of six new women who were ready to devour, with pleasure, all the math and science they could lay their hands on. What I found was six unique people, examples to me and other educators of adult students returning to college. They were interesting for who they were and valuable for the issues and questions they brought to mind. They showed the starting points, challenges, and reasons for providing educational opportunities.

At the beginning of the program, none of the six showed enough facility with arithmetic to place her into an elementary algebra course, were she applying for matriculation at GCC. Two (Kasi and Carol) claimed to hate mathematics and science, two (Aseret and Deanna) were ambivalent, and two (Peggy and Johaly) said they liked the subject areas and were enthusiastic about learning more. They all expressed determination to learn but they appeared to differ in their investment of time and effort. Their concepts of the purposes of education, beliefs in the value of experience, and degrees of acceptance of social construction of knowledge showed different stages of development. They were scattered along the path from absolute to contextual knowing, or from dualistic to relativistic thought; some seemed stationary and others moving or ready to move. They differed in their definitions of mathematics and learning, and in their expectations of the responsibilities of teachers and learners.

Instead of noticeable shift in individuals' attitudes during the course of the semester, what I did see in the classroom was the environment for development and the preliminaries to change. The students were trying out new ideas, practicing new language and thought processes, and questioning existing concepts. Their brains were being exercised and their beliefs stretched. Even their complaints showed an interest in their own learning, the practice of perhaps a new power, and acknowledgment of the existence of definitions of mathematics and education different from their schoolroom memories.

Investigating what the Jump Start students' views were and how these interacted with their learning reinforced my own views. I came away knowing that learning comes from experience, reflection, and discussion and that most knowledge is contextual and fallible. I also reconfirmed my conviction that starting at this level at this time in their lives, with their past experiences, given the world we live in, this group would not benefit from a traditional route of years of unproductive, decontextualized, solitary drill and practice. No employer is looking for someone to do long division or "a page a day."

The greatest hope for success is for Kasi, Carol, Deanna, Johaly, Aseret, and Peggy to adopt or affirm new definitions of mathematics and learning, to make use of their experience and acknowledge their practical intelligence. They do not need to go back to where they were in grade school; they have had years of practical education since then (Tennant & Pogson, 1995). Carol does not need to struggle with long division; she should learn to make effective use of her calculator. Kasi does not need to do fifty fraction multiplication problems and then take a quiz; she should understand what a fraction is, where she is apt to come across one outside of the textbook, and when a situation calls for multiplication (NCTM, 1989). They need comfort with numbers, confidence in themselves as mathematical thinkers, estimation and data management skills. They need to see that mathematics is not mysterious and inaccessible (National Resource Council, 1989, 1991). It can make sense; it can come from a common experience and be non-threatening, fun, and beautiful. The Jump Start math/science experiences tried to show the students this — but, perhaps because they were receiving mixed messages, several were not convinced.

## The Implications to Mathematics Education

The motive behind this research was to make adult basic mathematics education more effective. By studying a group of students restarting their education in the context of an idealistic program that was adjusting to the realities of economics, personnel changes, accountability, and pragmatism, I had the opportunity to watch theory meet practice. I considered the theory, the philosophy, and the pedagogy of the math/science portion of Jump Start and its desired effects. I tried to get to know the women of my sample, and what they thought and felt about mathematics and learning. Then I watched the women in the context of their Jump Start experiences to see the mutual effect. The areas of success of the program verify and justify ideas and methods of a wide range of mathematics education reform and effective teaching and learning literature.

Thinking (hoping) something will do what it is supposed to and then watching it happen is encouraging and rewarding. But it is from the disappointments and the failures of the theory that particularly useful lessons can be learned. Problems give the theorist and practitioner cause and opportunity to reexamine, reflect, adjust, and improve both theory and practice. A belief that is counter-productive to effective education at the individual level is that mistakes are undesirable and to be ashamed of, hidden, or denied. A more productive belief is that mistakes or shortcomings are inevitable and are opportunities for improvement and growth. This is also the case at the program level. The successes are ends. The disappointments are beginnings.

### The Successes

The fact that a program with the ideals and vision of Women in Technology: Project Jump Start became a reality was itself a success. It served a neglected, often invisible and uninfluential population. The risk of failure was high. The rewards of success were not easily measured. The expense was great. Many of the ideas were untried. It required considerable energy and dedication of its staff and instructors. But Jump Start got off the ground (or came down from the clouds) and was starting on its fourth cohort of economically and educationally disadvantaged women who were interested in technological careers.

Not only were the ideas of Jump Start put into practice but they proved to be viable. The program provided valuable experience and useful skills for nearly one hundred women from the area, who may never have gathered the resources and courage to start college.

Jump Start also gave instructors the opportunities to try out some ideas and methods in a context different from their regular jobs in higher or secondary education. They could plan and carry out lessons and learning experiences which they developed from first principles, often in collaboration with someone they would never have had the occasion to work with under ordinary circumstances. Consecutive sessions allowed them to fine-tune and revise those lessons. For an instructor striving for excellence and increased opportunities for learning, this was a rare professional development opportunity.

There were also a number of particular successes among the students. For the six women in my sample, some of these are mentioned in the previous sections. They were shown an alternative to traditional teacher-centered learning. They received a foundation of learning and personal skills that gave them a solid start in their re-entry to education. They were exposed to ideas that are not often included in traditional basic skills courses.

Another benefit of the program was that it offered me as a researcher into adult basic mathematics education the chance to observe returning adult students participating in a nontraditional learning experience. By watching and listening to the students, I got a sense of the diversity of experience, knowledge, and developmental level that they represent. Observing them in loosely structured activities investigating open-ended questions, where they had to rely on their own powers of reasoning, I saw that some assumptions (for example that everyone knows how to use a ruler) cannot be made.

I was fortunate to work with this group of Jump Start participants. In particular, the six women of my sample were interesting, accommodating, and varied — nice people, all, whom I have come to care about. I feel I know them well, although when we meet again, I am likely to call them by their paper names because much of my getting to know them has been by examining my recollections of them and my transcripts of their interviews for this paper. I have tried to communicate some of their personalities and their humanity to the reader because this is inseparable from their attitudes and beliefs about themselves, mathematics, and learning.

The Problems, Disappointments, Excuses, and Lessons Learned

Disillusionment. Jump Start was an extraordinary program which became more ordinary as it met external constraints and demands. For me, that was the biggest disappointment. I observed the loss or compromise of much of what was special — integrated, contextual, experiential learning in a community of learners. Perhaps a positive outcome of looking closely at the spring '95 session will be an examination and reconsideration of the program's change and direction.

Defensiveness. The feeling of defensiveness was a disappointment for the math/science instructors. Because their objectives and methods differed from the other segments of the program, they felt the need to defend their principles and spent considerable time both in class discussion and individually with students explaining what they were trying to do and why. Because the communications portion had gone its own way and was being taught more like a standard English 100 class, there was pressure for mathematics to be taught like Math 100, not a viable option given the range of mathematical experience of the students and the commitment to integration with science.

Inappropriate Assessment. The standardized tests in the midst of student investigations of density interrupted progress Rick and Lindy felt was being made in the women's confidence and attitudes, and asked the instructors to compromise their principles and shift to a period of decontextualized, algorithmic practice, and rote learning.

In an article about adaptive schools, Andy Hargreaves (1995) wrote about one of the paradoxes of education today, which is similar to the experiential learning-standardized testing conflict of Jump Start.

> *More diversity and integration is accompanied by more emphasis on common standards and specialization.* Society demands that students acquire more flexible work skills, so educators must emphasize problem solving and

critical thinking and create interdisciplinary links among separate subject domains. Society calls for schools to respond to multicultural diversity, so educators must consider multiple intelligences, different learning styles, heterogeneous grouping, and the integration of special needs students into ordinary classes.

At the same time, the obsession with national strength and identity are spawning standardized tests, international comparisons, and even school-by-school competition based on traditional performance evaluation. This evaluation emphasizes restricted definitions of intelligence, narrow learning styles, rigid sorting and tracking, and reaffirmation of subject specialties that most tests seem to value. No wonder many teachers are perplexed. (1995, p. 15)

Rick Lane mentioned noticing an unprecedented (in his Jump Start experience) preoccupation with grades and "something concrete to show for their efforts" among the women this semester.

I have thought about [giving grades] and I think that this last group, it seems that they miss that. They want it. That wasn't true with earlier groups. This group was very different.

When I asked if he thought the tests administered during the semester had anything to do with this, his reply was "I don't know. That's when I was first aware of it. There seems to be a connection." Rick was more willing than Lindy to attribute this attitude to the particular personalities of the women and evolution of the program rather than to the event of the test.

Lindy Gougeon saw the testing as a sore spot in the Jump Start program this semester. She told me, "They made incredible progress as students until the testing issue came up. Then they deflated. Their views closed down and they became outcomes oriented."

I know that they are going to be tested at the end of the program and I have this battle with myself in terms of what is my responsibility. Is it a responsibility to give the student what I think is right, what I think is going to be the most useful in the long run? Or is it my responsibility to give the students what they need to pass a test? I don't give them what they need to pass the test because I don't think it is what they need in general, but in some respects that makes them feel like they

> have failed. That is probably the thing that I am most disappointed in this semester, that they were allowed to think that they weren't successful by the stupid standardized test.

A lesson learned from the testing issue is the need to develop a system of assessment or evaluation that is consistent with the program's objectives. The math/science portion of Jump Start draws heavily from mathematics education reform documents, the Standards (NCTM, 1989, 1991, 1995). The most recent of these is the Assessment Standards,which expands on the evaluation standards of the earlier volumes. Assessment is a relatively difficult and undeveloped area, and innovation in curriculum and teaching has had a head start of several years. To be consistent with the reform vision of high expectations and students striving to achieve them using active, contextual, and collaborative methods making wise use of available technology, the Evaluation Standards proposed that

> - student assessment be aligned with, and integral to, instruction;
> - multiple sources of assessment information be used;
> - assessment methods be appropriate for their purposes;
> - all aspects of mathematical knowledge and its connections be assessed;
> - instruction and curriculum be considered equally in judging the quality of a program. (NCTM, 1995, p. 1-2)

There are a number of assessment techniques suggested in the literature ( see Chapter 2, p. 38). Among the possibilities to investigate for the Jump Start purposes are performance assessment, class observations, student interviews, portfolios, and self-assessment. Women in Technology: Project Jump Start was an unique program using innovative methods when it was proposed. Neither the students nor the program should be evaluated by traditional methods.

Lack of Communication. One of the defining principles of a community is regular interaction and communication among its members. Part of the price paid for more separate time devoted to each of the facets of the Jump Start curriculum, to computers, English skills, career development, math and science, was the forfeiture of planned and incidental communication among the instructors and administrators.

Having done most of the planning and curriculum development in earlier semesters and during the summers of 1993 and 1994, Rick and Lindy met rarely outside of class during the spring '95 semester. They talked during and after class, but did not get together formally to plan or discuss the math/science classes. There were only three or four regular meetings with the other instructors, the coordinator, and counselor during the session, and these were held during the math/science class time when Rick and Lindy had to run in and out.

Because the math/science instructors were not comfortable with the lack of communication culminating in the imposition of tests in the midst of their curriculum, the academic dean of GCC overseeing Jump Start called a meeting of the program coordinator and counselor, the original designer, and the instructors to discuss the problems. This meeting was held on May 10,1995. I sat in on the meeting as an observer. It was a valuable opportunity for a community discussion. Some misunderstandings were resolved and some good ideas emerged (such as using portfolios instead of standardized tests to measure progress). However, I came away with the feeling that there was no shared vision and that frustration rather than enthusiasm was the dominant emotion. Those present recognized the need for better communication but also saw little time in their schedules to talk further.

The students were also members of the Jump Start community. The extent to which their wishes, views, and assessments were taken into account — the extent to which their voices were heard — is another area of concern.

I do not believe, in situations like this where human development is one of the objectives, that students can or should dictate policy or that they know what is best for them in their learning. The differences between the instructors and students in educational expertise and in developmental level gave the instructors a parental role. The instructors were caring and patient; they set standards and defined values; they were concerned with their students' confidence and well-being. They were guiding. The students were finding their voices, being encouraged in their independence, and discovering what it means to learn. They were growing.

For a learning community such as Jump Start, the students should have been willing participants who were aware of the type of program they are choosing to join. Given their acceptance or willingness to try an integrated, contextual, collaborative experience, the students should have been active partners in that experience. Self-direction and responsibility for their own learning are useful life skills, and discussions by the whole community on philosophy, methods, outcomes, problems, and achievements should have been an integral part of the learning experience. But that did not seem to be the case. There was time set aside for student input and discussion, Focus Group, but during the semester of my observations, this was poorly attended and did not include the math/science or English instructors. In practice, the Jump Start was not functioning fully as a community of learners.

Participant Selection. A concern is that awareness and thoughtful consideration of the type of experience they were becoming a part of might not have been the case for all of the participants of Jump Start in the Spring of '95; the program was under real or perceived pressure by the college and the funding sources to fill the ranks, and there was disagreement within the program about just what type of learning experience it was to be.

Jump Start was designed as a program for women planning to enter technological occupations, non-traditional for their sex. But only two, possibly three, of my sample were considering careers which involved science or technology, and those careers were nursing and teaching, traditional fields for women. The other women in my sample had little interest in learning science or mathematics and had little motivation other than to fulfill requirements. An investigative, experiential approach depends for its success on interest and perceived usefulness, not on extrinsic rewards such as credits or grades.

## Conclusion

Any woman who has taken part in the Jump Start program should know from experience that mistakes, wrong turns, temporary confusion or frustration, and disagreement among collaborators are inevitable and valuable parts of the learning process.

There were mistakes, wrong turns, frustration, and disagreement in Jump Start during the spring semester, 1995. As a complex system, many factors had unpredictable immediate effects. The program was affected from without by the educational, political, and social environment. It was affected from within by small decisions, personalities, chance happenings, and omissions. It may even have been changed by my presence, interest, and questions. For those who care about Jump Start and its objectives and who reflect upon what was happening, Spring '95 offered many lessons.

Women in Technology: Project Jump Start and the students it serves have great potential. To fulfill this potential, it is important to have a community effort with clear objectives, both for the program and for the students within the program in their learning experiences. The students should be preparing themselves (with careful guidance) for citizenship and employment in today's and tomorrow's world where technology is a fact of life, management of resources is more important than memorized facts, and flexibility and the ability to solve new problems are more important than calculation or application of standard procedures.

Jump Start sputtered and faltered in the Spring of '95, but if all portions can work together, support each other, and apply their effort along the same road, this program could be the prototype (and road-tested) vehicle for fostering beliefs, attitudes, and abilities in mathematics and learning that takes more people into the technological world of the twenty-first century. That world will be full of problems. We need to prepare problem solvers.

## Commencement

This study has reached its destination but the journey is not over. The last line is not "Q.E.D.," as it would be in the absolute, infallible, complete plane of a Euclidean geometry proof;

it is (an implied) "to be continued." The world of people learning is constructed, relativistic, fallible, and incomplete. We develop by revising what we think, believe, and feel in light of recent experiences, changing contexts, fresh ideas, and new insights.

There are several new or continuing investigations that beckoned to me in the course of this study.

- What is the relationship between the developmental level of a person and his or her success with a pedagogical method or program design? For a program designed to encourage relativistic, independent thinking, perhaps developmental readiness assessment is more important than (or as important as) skills or factual knowledge assessment.
- For people "in transition," such as the Jump Start participants who are undergoing or initiating change many parts of their lives, is support and stability more important to their success than challenge and disequilibrium? Probably this is not an either/or situation, but one of balance. What is the appropriate balance at the beginning of re-entry to education? If not as an immediate alternative to past school experiences, at what time should a student be asked to question her existing, perhaps limiting, beliefs?
- What is the relationship between extrinsic reward (grades, awards, praise) and human cognitive development?
- Many people (this researcher among them) who are currently teaching mathematics or suggesting and orchestrating reform in mathematics education, learned and loved mathematics by methods they now decry. How and why did that change in attitude occur?
- What are the stories of the conception, infancy, and maturity (or death) of innovative educational programs? What factors seem to be related to their success?
- How might this program or a similar program be viewed from the perspective of the college or the community college system? What was the articulation, the impact, the lessons learned?
- Where will Peggy, Deanna, Kasi, Aseret, Johaly, and Carol be five years from now? What will be their attitudes and beliefs about mathematics and learning? What will they have to say about their Jump Start experience?

# APPENDIX A

## EXCERPTS FROM WOMEN IN TECHNOLOGY GRANT PROPOSAL

### 1. REB POLICY SETTING AND OVERSIGHT

The Franklin/Hampshire Private Industry Council Regional Employment Board has received a proposal from Greenfield Community College (GCC), an eligible bidder for Tech Prep proposals under the FY 1995 Joint DET/DOE Education Coordination Request for Proposals. GCC's Tech Prep Service Delivery Area is comprised of two vocational-technical high schools and one community college located in Franklin and Hampshire Counties. This proposal seeks to refine and expand a JTPA-funded program (Women and Technology: Project Jumpstart) currently operated by the College. Program oversight is provided by the Franklin/Hampshire Employment Training Consortium which also helps to shape on-going program development through regular monthly consultations with GCC's program staff. Consistent input from the Franklin/Hampshire REB and business community members who provide "job shadowing" experiences for Jumpstart participants provides provides indications of the effectiveness of the program and signals modifications that need to be made in program design. Additionally, GCC's involvement as a partner in the Tech Prep West consortium enables broad collaboration with regional industry representatives, employment training program personell, and an array of secondary and post secondary institutions. These consortia partners review tech prep program content and make recommendations for changes in academic curricula and career exploration activity design.

During FY 95, the Franklin/Hampshire REB and Employment Training Consortium and GCC will remain partners in the Tech Prep West consortium. GCC will pass lead agency designation on to Holyoke Community College. Tech Prep West has provided comprehensive counseling services for youth, with a particular focus on how applied academics and raised awareness of mid-level technical careers can improve their preparation for and success in postsecondary occupational-technical programs. Through the consortium and its own initiatives GCC has shown remarkable success in keeping key players - from faculty to administrators to business and industry - working in close cooperation to help area yound people find niches in the workplace of the future.

However, partly because of the uniquely large geographic area we serve, the Franklin/Hampshire PIC/REB is submitting its own JTPA 8% proposal. In addition, past year's programs have indicated that fiscal and programatic management of JTPA 8% funds can be done more effectively within each Regional Employment Board area.

One proposal for JTPA 8% funds in the tech prep category was received and evaluated and approved by the Franklin/Hampshire REB at a meeting of the full Board in June 1994.

The Franklin/Hampshire County Regional Employment Board has indicated its support for this proposal to continue funding and expand this very successful program.

Meeting the needs of critical industries and populations within the SDA

As indicated in the FY '95 JTPA RFP package, "...the trend towards a knowledge-based economy is expected to continue to accelerate throughout the 1990's." In its report entitled "Employment 2000, Massachusetts Employment Projections by Occupation", the Massachusetts Department of Employment and Training states that "Education, flexibility, as well as familiarity and skill with computers are central to the emerging job market." Recognizing this, the Franklin/Hampshire Private Industry Council, serving as the Regional Employment Board issued its blueprint for workforce development in 1992. In developing this blueprint, the REB invited and received comment from a variety of individuals and groups that included elected officials, local chambers of commerce, community organizations, labor unions, educational organizations, and interested members of the general public. The current and emerging critical industries identified through this process are included in illustration #1. Building upon this process, the PIC/REB conducted interviews with selected firms in order to identify the education and training needs of each critical industry. Illustration #2 addresses those educational need areas identified by the PIC/REB. On-going evaluation and reassessment of training needs for current and emerging critical industries is undertaken at regular meetings of the Franklin/Hampshire PIC/REB with input from the newly formed Franklin/Hampshire School To Work Task Force.

GCC's on-going "Women in Technology" program addresses the broad set of basic educational attainment needs cited by industry informants. Direct involvement in the program by the business community has resulted in the creation of "job shadowing" placements for all participants at several area enterprises, providing the best indication that the program is satisfying the needs of the cluster of critical industries identified by the REB. Industry commitment to the program is represented by the signing of job shadow contracts (see Appendix I.a - ). In-kind contributions for these shadow experiences are represented in the budget match category. Future match involvement will be determined after collaborative evaluations with each employer now engaged in this important career development component and cannot be determined precisely at this time.

Review of programs success in foster
ing coordination between institutional players in the local education and employment training system.

Greenfield Community College has been an integral participant in the employment and training system within the Franklin/Hampshire SDA. The college has worked in conjunction with the F/H Employment and Training Consortium to develop and coordinate education and training programs through such diverse sources as: JTPA, The Massachusetts Department of Medical Security, and the Massachusetts Industrial Services Program. The college has also designed programs with funding through the Carl Perkins Act and has done so with consultation of the PIC/REB to ensure incorporation of locally identified priorities. Many of these programs have been approved by DET under section 30. Recent examples of employment and training related programs are listed in the table below:

| TITLE | TARGET POPULATION | GRANTOR |
|---|---|---|
| DeskTop Publishing 1990-1992 | Displaced Homemakers Economically Disadvantaged | Perkins |
| Business Microcomputer (BMA) 1987-1993 | Displaced Homemakers | Perkins |
| Skills for Emerging Careers 1993 to present | Displaced Homemakers | Perkins |
| Tech Prep West 1993 to present | Disadvantaged Youth | Perkins |
| Women in Technology 1993 to present | Economically Disadvantaged | JTPA 8% |
| Women's Re-entry Program 1991 to present | Returning Adult Women | College |
| Career Assistance Program 1993-1994 | Dislocated Workers | Mass Industrial Services Program |
| Nursing Enhancement 1990 to 1993 | Economically Disadvantaged | Dept. Medical Security |
| GCC-STCC Dual Enrollment | Economically Disadvantaged | Dept. Medical Security |
| Practical Nursing Fall 1992 | Dislocated Workers | ISP |
| Pathways to Health Careers fall 1992 to present | Economically Disadvantaged | Dept. Medical Security |

The first two programs, funded by the Carl Perkins Act, provided vocational training which resulted in job placement or continued education. One hundred percent of the students in these programs were economically disadvantaged and most, if not all, would qualify as displaced homemeakers, disadvantage youth, or single parents.

GCC's two currently funded Perkins programs are providing basic skills training and career exploration to displaced homemakers and disadvantaged youth. One program, Skills for Emerging Careers, addresses deficits in basic academic skills with a focus toward employers demand for computer literate employees. The other program, Tech Prep West, provides comprehensive counseling services for youth, with a particular focus on how applied academics and raised awareness of mid-level technical careers can improve their perparation for and success in postsecondary occupational-technical programs.

The Women's Re-entry Program, entirely funded by the college, provides a structured and supportive environment for students (primarily displaced homemakers and single parents) who are returning to education after a significant lapse of time and gives special attention to raising skill and confidence levels for further career development.

The Nursing Enhancement Grant, funded by the Department of Medical Security, provided additional slots and full scholarships to 13 low income students, primarily displaced homemakers or single parents.

The Dual Enrollment grant provided expanded opportunities for training in health fields to area students through coordination and articulation of degree programs between Greenfield Community College and Springfield Technical Community College. The target population was rural economically disadvantaged individuals.

In the fall of 1992, the college added a Licensed Practical Nursing Program to its curriculum. The first year of funding came from a partial state appropriation coupled with a grant from the Department of Employment and Training's Industrial Services Program. The program has been continued with college funding.

The Pathways to Health Careers Program results from Department of Medical Security funding and provides an array of prerequisite skills for entry into many areas of allied health training. This program also provides a career ladder for current health care workers to upgrade their skills and pursue professional certifications.

Greenfield Community College is currently conducting the first year of the JTPA-funded Women In Technology program - marketed locally as Jumpstart. The present proposal seeks to revise and expand what has proven to be a very successful model - providing disadvantaged women the basic skills to enter a seemless pathway of career ladder opportunities in non-traditional occupations.

<u>Determination of how to operationalize key aspects of this program into future JTPA activities</u>.

An additional requirement of the JTPA amendments is to describe the services and strategies for serving women in non-traditional occupations. Non-traditional training for women has proven to be a difficult undertaking with JTPA dollars in the Franklin/Hampshire area. The major non-traditional training occupational areas are in manufacturing and construction and these two sectors are in decline. The major emphasis in providing women entry opportunities to non-traditional occupations will be through the assessment process to encourage women to consider training in professions that may not be provided by JTPA resources (professional, technical, and managerial occupations), that empower women in the workforce. Transition to postsecondary training under the federally funded tech prep initiatives at community colleges has proved a viable avenue for meeting this important priority. Existing Franklin/Hampshire JTPA programs will continue to be closely coordinated with this extension and expansion of our JTPA 8% Tech-prep program. Tech prep will provide a pathway for women to pursue the level of training neccessary to enter emerging career areas in fields non-traditional for their gender.

As part of the on-going evaluation of Jumpstart's ability to meet future on-going JTPA activities, Greenfield Community College will meet on a monthly basis with the Franklin/Hampshire Employment and Training Consortium to monitor the progress of the grant. The Franklin/Hampshire Employment and Training Consortium and all of its programs are monitored and evaluated by the Franklin/Hampshire PIC/REB. In the past these meetings have proven highly beneficial for information sharing, problem solving, and to increase levels of cooperation and coordination among agencies. In addition, Greenfield Community College will meet all reporting requirements as outlined in the standard contract issued through the Franklin/Hampshire Employment and Training Consortium.

II MEETING PROGRAM REQUIREMENTS

Competency based

The Women in Technology curriculum employs a regionally designed and appropriately modified version of The Center for Occupational Research and Development's Applied Academics Curriculum. Developed to recognize and respond to the needs of students with non-auditory learning styles, this competency-based curriculum is consistantly hands-on yet nonetheless rigorous, requiring a high degree of student involvement in labs and special projects, exploring, experimenting, measuring, testing and building a variety of participatory teamwork and critical thinking skills. Students will acquire competencies in the following academic areas: Math, Principals of Technology (Science), Communications, and Computer Usage. At the request of past program participants, additional learning opportunities will be offered in Applied Study Skills. In addition Jump Start will increase individual academic counseling - especially at both ends of the learning spectrum - ensuring that individual learning plans meet the needs of the learning disabled participants as well as accelerated learners. Classes will be kept small - no more than twenty students entering each session - and a "learning community" atmosphere. Project staff will work closely with faculty a faculty team to develop lesson plans based on integrative learning concepts. Faculty will be given time to collaborate on the design and modification of an integrated curriculum.

**III PROGRAM DESIGN**

Proposed location, duration and intensity of the program.

Jump Start will continue to located at Greenfield Community College. Funding is being sought to expand the program to forty (40) participants over two sessions (20 students will be recruited for each session). Students will attend program instruction and career exploration activities for twenty (20) hours each week (see Jump Start Schedule, Appendix II .)

The first eight weeks of each session are classroom experiences designed to develop basic study skills, provide an understanding of career options and to develop basic academic competencies. During the final seven weeks of the program, students will continue classroom learning and participate in 4 hour per week "job shadowing" experiences in a career area of their choice that matches the Franklin/Hampshire REB profile of existing and emerging critical industries. Each session will coincide with the regular college semester to familiarize and better prepare stduents to enter regular academic programs in college environment. The sessions will occur in Fall '94 and Spring 95 - continued individual instruction, personal and career counseling will continue during the summer of 1995 to assist in transitioning JTPA-eligible women into secure academic or occupational activities.

Strategy for recruiting, assessing, and monitoring student's progress.

Jump Start participants will be recruited in the summer for enrollment in the Fall of 1994. The project's recruiter/resource developer will collaborate with the Department of Public Welfare, Franklin/Hampshire Employment Training Consortium (FHETC), and other area social service agencies and women's organizations to identify potential applicants. The recruiter will actively seek references from GCC's Admissions Office, Women's Center, Women's Re-entry, Emerging Careers, Pathways to Health Careers, and GED programs. Appropriate outreach via mailings, brochures and posters will inform the public about the program.

A JTPA "pre-application" will be completed by each applicant to determine preliminary JTPA-eligibility and to determine an applicants readiness to enter training toward a non-traditional occupation consistent with REB-identified industry demands. The FHETC will determine actual JTPA-eligibility.

Student progress will be assessed using a variety of assessment tools, including diagnostic reviews to better detect potential learning disabilities and to better understand participants career interests. Pre-tests and post-tests will be administered in Math and Reading to determine initial academic competencies and competency gain, providing accurate measures of student progress in a manner complying with JTPA and DOE requirements. The project

Counselor/Instructor will coordinate the development of individualized lesson plans in a collaborative with each student, the faculty team, and industry partner supervising the students "job shadow" experience. The career counseling component for incoming students will being in the Fall semester 1994, using the college's System of Integrative Guidance Instruction (SIGI).

Specific basic and occupational skills that will be taught to students over the course of the program.

Many members of the adult population - past graduates of high school "general track" programs - could benefit by increasing their degree of comfort with and facility in the areas of Math, Communications, Computer Usage and and Principles of Science and Technology through an applied academics curriculum, thereby deepening their knowledge of and interest in technical careers with critical current and emerging industries. Such an applied academics program is particularly effective with adult women. Research into right/left brain function of females and males supports the adoption of alternative teaching methods for mathematics and sciences based on learning style differences. Such research indicates that women generally think and communicate facts in relationship to other facts in associated patterns when compared to masculine-dominant communication patterns that tend to isolate facts as separate or discrete. A "tech prep" focus and pathway will also address the need of women, especially welfare dependent women, to focus on and prepare for higher paying , mid-level, occupational technical positions in critical industries rather than the minimal, service sector jobs toward which they might otherwise be inclined.

In fact, the women enrolled in Jump Start have responded well to the program model as implemented this past year in the Franklin/ Hampshire SDA and previously in Hamden County's JTPA Summerstart program - the originating Women In Technology program model of the Tech Prep West consortium. Sixteen of the original eighteen enrolless have remained in this years program. The model expands upon the concept of a learning community where team teaching, an integrated curriculum comprised of the academic disciplines outlined above, contextual learning, and individualized instruction based upon individual students unique learning styles and needs are all brought to bear in a mutually supportive and student-centered environment. The project Counselor/Instructor will provide appropriate academic and career counseling to develop individual learning plans during the program and follow-up counseling to program graduates. As expected, the learning levels of participants differ, resulting in some women moving rapidly on to more challenging problems and assignments, whole some participants need more individualized learning - at a slower pace. Jump Start program modifications that will be implemented with the use of these funds include:

- o providing a greater concentration via a one credit course in applied study skills and career development activities
- o revising the communication component focus to provide more

emphasis on technical (structural)writing skills

- o enhancing student assessments to better detect learning disabilities and student career interest areas
- o expanding program articulation with other career ladder programs at GCC and other institutions
- o providing follow-up (one year) academic advising for recent Jump Start graduates to aid transitioning and retention rates to regular college or related employment placements and to determine measure the programs long-term success
- o strengthening the Principles of Technology (Science) component by adding a integrated lab module

Students will pursue coursework and complete assignments utilizing both desktop and laptop personal computers and will be provided with an array of computerized and other guidance information. Greenfield Community College assures that the technology employed in the classroom is designed to reflect that technology most likely to be found in the workplace.

In light of continued federal and state emphasis on moving women off welfare and into jobs Jump Start will use an accelerated learning model to help JTPA-eligible women achieve an understanding of realistic career options, gain relevant academic competencies, and prepare for entry into a college level curriculum.

Shadowing experiences will be arranged by the projects Recruiter/Resource developer prior to each session. Assisting the projects Recruiter/Resource Developer and counselor will be the Tech Prep consortiums career counselor. This individual, funded through the Perkins Tech Prep grant, will contribute one day per week at GCC. Her role will be to oversee the the career exploration activities that include at least 1 1/2 hours per week at each site. The Jump Start Project Director also serves as the colleges liaison with the Perkins-funded Tech Prep West Consortium and will ensure coordination of information and activities from GCC and the Franklin/Hampshire REB with consortium.

The project counselor will be responsible for coordinating the curriculum and monitoring student attendance and performance. The project counselor/instructor will co-lead classroom career guidance activities as well as provide individualized counseling necessary to attract, monitor, and maintain student participation and achievement. The Project Counselor's work will continue through the summer in 1995 with students entering college career programs in the fall semester 1995. The counselor will offer individualized counseling and advocacy to ensure the smooth transition of program participants into the community college of their choice.

Please refer to the following chart for a breakdown of project objectives and activities.

During Jump Start sessions, the Recruiter/Resource Developer will develop work site placement opportunities for students for the next session of student "job shadow" experiences. Business and industry professionals will serve as mentors to the students during their shadowing experiences in work place settings. This activity will be separate from the colleges regular cooperative education program which is a structured learning experience. The intent is to provide an opportunity for exploration into various fields, perhaps leading to a more formal cooperative education experience at a later date after a career path is decided upon.

IV PERFORMANCE OUTCOMES

As described in the program design, this Project will clearly and substantially further promote the goals of Tech Prep West which include: 1) raising awareness of mid-level technical careers, 2) increasing the attainment of math/science/communications and computer usage competencies which business and industry both nation-wide and regionally have designated as essential to ensure workplace readiness and mobility, and 3) establishing a comprehensive system of technical education in the region which includes specific outreach and support mechanisms for a variety of special populations. Low income women, especially those with perhaps unrecognized potential in technical fields, comprise one of those special populations. This program of basic academic skills, communication skills, and career awareness activities will allow us to use much of what we have learned and implemented through a youth focused tech prep program to benefit a different yet no less critical segment of the future workforce.

Primary positive outcomes expected are competency gains in math/science areas, increases in self-confidence/self-esteem in these academic areas, and increased awareness/interest in Associate Degree career options and pathways toward reaching them. Outcomes in the area of competency gain will be measured through pre and post testing in the two major academic areas. Students will acquire the following competencies:

PRINCIPLES OF TECHNOLOGY (SCIENCE)

- metric system, mass & volume, density of objects circuitry, schematic diagrams, lab techniques, basic electricity (parallel & series circuits), temperature, critical thinking, problem solving, and formulas.

MATH

- operation of whole numbers, area and perimeter, calculator use, language of math, multiples, factoring, composites, ratios, fractions, decimals, percentages, open-ended problem solving, critical thinking, elementary algebra.

Positive outcomes in participant awareness/interest in mid level careers and pathways (as well as attitudinal changes and increases in self-confidence and self-esteem) will be measured by the counselor via pre and post surveys and the development of individual career plans and portfolios by students.

While a definitive career plan and acceptance into a specific college program at the end of the project will be seen as an additional positive outcome, it should be re-emphasized that the project is directed primarily at increasing general academic competencies and encouraging the exploration of alternative career options. This point is worth making because the average displaced homemaker, especially if entering with low confidence and skills in math/science areas, is unlikely to emerge a prospective laser optics technician in one semester. On the other hand, our expectation, based on past program experience, is that 80% of these students will acquire sufficient self-confidence and skills to apply to college in some other area at the end of each session, and that they will enter with a significantly clearer idea of what they have the potential to do and where they are going. At the same time, the process of skill building and career decision making will continue as college matriculants are supported not only by the continuing efforts of the Project Counselor/Instructor but also by existing staff, programs, and services geared toward returning women at Greenfield Community College. Existing services at the college include the Women's Re-entry Program, the Women's Center and the Learning Center which provides an array of individualized academic and personal counseling.

<u>Evidence of collaboration between the job training system and teducational system in the design and implementation of the proposed program: vendor capacity/management plan.</u>

Greenfield Community College will be the contracted vendor for the project. As the only institution of higher education in Franklin County, GCC is the recognized leader in providing both liberal arts and industry specific education to a wide variety of consumers. Through its Center for Business and Industry, GCC provides contract training at the workplace in both technical areas and basic educational skills.

The Franklin/Hampshire and Hampden County Employment and Training Consortia provided helpful guidance and support in the development of this proposal and will continue to assist with advice in the area of recruitment and enrollment as well as provide participant eligability certification. The Franklin County SDA will provide a Program Specialist to ensure that the program goals are met. The Executive Director of the Hampden SDA is a member of the Tech Prep West Business and Industry Council and has expressed strong support of the Tech Prep Project as a whole and particularly this additional Women in Technology Project. As we continue our planning for workplace presentations, tours and shadowing, we expect to draw further upon the resources represented by the Regional Employment Boards in both SDA's.

**Project Goal:** To prepare 40 economically and educationally disadvantaged women for entry into Associate degree, technologically-based programs that are non-traditional for their gender.

| OBJECTIVES | ACTIVITIES | RESPONSIBLE PERSONNEL | TIMELINE |
|---|---|---|---|
| 1. To recruit, interview, and enroll 40 participants in the Franklin/Hampshire County SDA.<br><br>20 participants to begin January 1995.<br><br>20 participants to begin September 1995. | 1a. Develop Jump Start informational brochures. | 1a. Recruiter/Resource Developer, Coordinator/Instruct. | Oct-Nov 1994<br>June-Aug 1995 |
| | 1b. Mail brochures/posters to community organizations in Franklin/Hampshire Counties, including DET Job Opportunity Centers, DPW offices, Women's centers and organizations, and Displaced Homemaker programs. | 1b. Recruiter/Resource Developer, Coordinator/Instruct. | Oct-Nov 1994<br>June-Aug 1995 |
| | 1c. Write public service announcements articles for radio stations and local newspapers in both counties. | 1c. Recruiter/Resource Developer. | Oct-Nov 1994<br>June-Aug 1995 |
| | 1d. Actively seek references from Greenfield Community College Admissions Office, Women's Re-Entry Program, Emerging Careers, Pathways to Health, and GED program.<br><br>Actively seek referrals from community resources identified in 1b. | 1d. Recruiter/Resource Developer. | Oct-Nov 1994<br>June-Aug 1995 |
| | 1e. Organize and present information sessions at community and educational sites in both counties. | 1e. Recruiter/Resource Developer. | Oct-Nov 1994<br>June-Aug 1995 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | 1f. | Interview prospective participants to determine program and welfare eligibility. | 1f. | Recruiter/Resource Developer, Coordinator/Instruct. | Oct-Nov 1994<br>July-Aug 1995 |
| 2. | To implement an integrated, interdisciplinary, competency-based curriculum in areas of Math, Science, Communications, Career Development, Study Skills, and Computer Usage. | 2a. | Instructors and Learning Assistants will implement curriculum to students in a program which includes a minimum of 20 hours of learning activities per week to be held at Greenfield Community College. | 2a. | Coordinator/Instruct. Counselor/Instructor, Learning Assistants, Faculty. | Sept-Dec 1994<br>Jan-May 1995 |
| | | 2b. | Individualized learning objectives for students will be designed and implemented when necessary. | 2b. | Coordinator/Instruct. Counselor/Instructor, Learning Assistants, Faculty. | Sept-Dec 1994<br>Jan-May 1995 |
| | | 2c. | Students will acquire the following competencies: | | | Sept-Dec 1994<br>Jan-May 1995 |
| | | | MATH<br>Operation of whole numbers, area and perimeter, calculator use, language of math, multiples, factoring, composites, ratios, fractions, decimals, percentages, open-ended problem solving, critical thinking, elementary algebra. | | Faculty, Learning Assistants. | |
| | | | SCIENCE-PRINCIPLES OF TECHNOLOGY<br>Metric system, mass & volume, density of objects, circuitry, schematic diagrams, lab techniques, basic electricity (parallel & series circuits), temperature, critical thinking, problem solving, formulas. | | Faculty, Learning Assistants. | |

| | | |
|---|---|---|
| **COMMUNICATION**<br>Verbal communication skills, interpersonal communication skills, technical writing skills, lab report writing, library research, and presentation skills. | Counselor/Instructor, Faculty, Learning Assistants. | |
| **CAREER DEVELOPMENT**<br>Through the use of career assessment instruments (including computerized system of guidance and information), students will:<br>• Acknowledge their skills, interests, and aptitudes as related to career interest areas.<br>• Increase their knowledge of scientific and technical careers.<br>• Participate in job-shadowing activities and gain knowledge of local industries and organizations as well as increase their employability skills.<br>• Formulate a career plan. | Counselor/Instructor, Faculty. | Sept-Dec 1994<br>Jan-June 1995 |
| **STUDY SKILLS**<br>Students will enroll in a one credit study skills course for preparation in reading comprehension, retention, test preparation, time management, learning styles, and note taking. | Counselor/Instructor, Learning Assistants, Faculty. | Sept-Dec 1994<br>Jan-June 1995 |
| **COMPUTER USAGE**<br>Knowledge and use of computer keyboard and work processing program, Word Perfect 5.1. | Coordinator/Instruct. Faculty, Learning Assistants. | Sept-Dec 1994<br>Jan-June 1995 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 3. | To ensure adequate progress in a student's level of skills and knowledge in all identified program areas: Math, Science, Communication, Career Development, Computers, Study Skills. | 3a. | Administer pre and post tests, measuring students incoming and completion scores and ascertaining skills acquisition levels. | 3a. | Coordinator/Instruct. Counselor/Instructor, Faculty. | Sept-Dec 1994 Jan-May 1995 |
| | | 3b. | Reading and Math tests will provide the actual pre and post grade equivalents. | 3b. | Counselor/Instructor. | Sept & Dec 1994 Jan & May 1995 |
| 4. | To establish individualized learning activities during the summer to further prepare students for college success. | 4a. | Assess each student's skill level and determine specific programs as necessary. | 4a. | Learning Assistants, Counselor/Instructor. | June-Aug 1995 |
| 5. | To assist in the college retention and completion of Jump Start students. | 5a. | Personal and career support services, as well as academic advising provided to Jump Start students through the first two semesters of college. | 5a. | Counselor/Instructor. | Sept-Dec 1994 Jan-May 1995 |
| | | 5b. | Follow-up studies conducted on participants during first two semesters in college. | 5b. | Coordinator/Instruc. | Sept-Dec 1994 Jan-May 1995 |

## Jump Start - Women in Technology

## Job Shadow Contract

### Program Information

Jump Start is a college preparatory program designed for women who have not previously entered and/or succeeded in higher education. The program is housed at Greenfield Community College, where the women have been attending since February of 1994 for twenty hours per week. Program goals are to assist women in developing basic skills necessary to enter college, as well as an exploration of possible career options which serve to help them decide upon a major course of study.

### Job Shadowing

Students have attended a career development class during the Spring, 1994 semester, in which they have explored possible occupations through computer and book information, as well as guest speakers and industry tours. In an effort to further explore careers and/or confirm career choices students will take part in a job shadowing experience during the Summer Institute of the Jump Start program. Job shadowing simply allows the student to observe and become acquainted with a particular work site. At some sites the student is assigned to one employee for the length of the job shadow, at other locations the student may spend time with different employees in various departments. The following statements clarify the purpose and specifics of the job shadowing experience:

1. The goal of the job shadow experience is to allow the student to learn about various positions within organizations, as well as the overall operation of the organization through observation and discussion.

2. Job shadowing is not a paid position or internship. The company has no responsibility of financial compensation to the student.

3. The student is not seeking employment.

### Student Responsibilities

1. To learn about and respect the rules and procedures of the job shadow site.

2. To acknowledge the purpose of a job shadow experience and the students role as a participant.

3. To demonstrate acceptable work habits, including adhering to the set schedule.

**Job Shadow Site Responsibilities**

1. To assign a designated employee contact for the student to follow and to acquaint the student with the organization and worker roles.

2. To remain within the confines of the job shadow experience and not offer employment to the student during the job shadow.

3. To discuss any problems regarding the job shadow with the Jump Start Case Manager.

Liability

Greenfield Community College accepts all responsibilities for any injuries students sustain while on the job shadow site.

Time Frame

The job shadow will be for four weeks, four hours a week for a total of 16 hours.

The job shadow will begin on ______________ through ________________.

The time and day(s) of the job shadow will be ______________________________.

Special Conditions

The stated conditions of this contract are agreed upon by:

_______________________________ representing ________________________
Job Shadow Contact name of organization

Date __________________

______________________________ Date _______________________
Student Participant

______________________________ Date _______________________
Jump Start Case Manager

# JUMP START

*Spring 1995*
Starting January 30, 1995

| Time | MONDAY | TUESDAY | WEDNESDAY | THURSDAY |
|---|---|---|---|---|
| | | | | |
| 12:00 | Tutoring N333 | Focus Group N435A | Tutoring N333 | Focus Group N435A |
| 12:30 | Tutoring N333 | Science/Math Lab - Tutoring S338 | Tutoring N333 | Computers N313 |
| 1:00 | Communications N333 | Science/Math Lab - Tutoring S338 | Communications N333 | Computers N313 |
| 1:30 | Communications N333 | Computers N313 | Communications N333 | Computers N313 |
| 2:00 | Communications N333 | Computers N313 | Communications N333 | Computers N313 |
| 3:00 - 5:00 | Science/Math Class S338 | Career Dev. & Study Skills N333 | Science/Math Class S338 | Career Dev. & Skills N333 |
| | | | | |

JSS95\CLASSRM.TBL

FRANKLIN/HAMPSHIRE EMPLOYMENT & TRAINING CONSORTIUM

ELIGIBILITY CRITERIA

APPLICANT MUST BE:

1. A resident of our Service Delivery Area - Franklin or Hampshire County or Athol, Petersham, Phillipston, or Royalston in Worcester County.
2. Economically disadvantaged (see below).
3. Age 16 or older (14 through 21 for the Summer Youth Employment Program).
4. Citizen, resident alien, legal refugee/parolee or other individual authorized to work in the U.S.
5. Registered for the Selective Service (males 18 and over who were born in 1960 or later).

Income Guidelines

| Family Size | Annualized Income |
|---|---|
| 1. | $7,360 |
| 2. | 10,550 |
| 3. | 14,490 |
| 4. | 17,880 |
| 5. | 21,000 |
| 6. | 24,680 |
| 7. | 28,260 |
| 8. | 31,840 |

Family income is calculated for the previous six (6) months and annualized to determine eligibility.

AUTOMATIC ELIGIBILITY

AFDC and EAEDC recipients
Food Stamp recipients
SSI recipients
Foster children (in DSS or DYS custody)
Federal Free Lunch Program

INCOME CALCULATED DETERMINING ELIGIBILITY

1. wages from all family members
2. net self-employment income
3. net rents
4. pensions
5. alimony
6. periodic income from annuities
7. active or reserve armed services pay
8. interest and dividends
9. Social Security benefits
10. wages of a full-time student
11. armed forces pay of any recently discharged veteran

EXCLUDED INCOME (NOT USED IN CALCULATING ELIGIBILITY

1. UI benefits
2. any welfare benefits
3. temporary worker's comp.
4. refugee assistance
5. veteran's aide
6. child support

All applicants are required to provide proof of citizenship, age, and residence. Males eligible for Selective Service must be registered. After eligibility is complete, each client is interviewed and assessed for an appropriate program. An Individual Service Strategy is started and the client is referred to a suitable F/HETC program or services of another agency.

518 Pleasant Street
Northampton, MA 01060
(413) 586-6987

545 Main Street
Athol, MA 01331
(508) 249-2377

One Arch Place
Greenfield, MA
(413) 774-3182

Equal Opportunity Employer/Program
Auxillary aids and services are available upon request to individuals with disabilities.

1-800-439-2370 (V/TTY)
Massachusetts Relay Service

## APPENDIX B

## LETTER OF CONSENT

February 1995

Dear Project Jump Start Participant,

I am a graduate student at the University of Massachusetts, Amherst, and a mathematics instructor at Greenfield Community College. I am particularly interested in what returning students' beliefs and attitudes about math and learning are, and how those attitudes might change to help the student learn math more effectively. For my doctoral research at UMass, I am going to work with your Jump Start group this semester, interviewing six students, and observing several of your classes and labs. I shall use the information from this research in a written dissertation as required by my degree program.

I am asking you to take part in my research. I would like to interview you near the beginning of the semester and again at the end of the semester so that I can find out something about how you view mathematics and yourself as a student of math and science. These interviews will be private, about forty-five minutes long, and I will ask questions to get you to talk about past experiences, current attitudes, and future plans. This is not a test. There are no right answers or even good answers. Everyone has her own opinions and I would like you to tell me some of yours. I will tape record the interviews and use the tape to type your responses so I will not have to take notes as we talk. I also would like permission to read some of what you are asked to write about yourself and your thoughts as part of your classroom assignments.

Everything you say in the interviews will be confidential, heard and read only by me. When I write or report on what I have seen and heard, I will protect your identity by giving you a fictitious name and disguising any other identifying information. I will not discuss what you say with anyone else, including your classmates, instructors, and counselors. I may use direct quotes from our interviews and demographic information about you in my dissertation, but only with your identity protected. In addition, I shall let you read what I have written involving you, and I will ask for any corrections or additions. If you wish to have something deleted, I will comply.

In no way will your decision to participate or not to participate in these interviews affect your standing in Project Jump Start. It is completely voluntary. I do ask that if you take part, that you agree to both beginning and final interviews. If you need to withdraw from the Jump Start program during the semester, I ask that we still have a final interview, even if it is only a few minutes on the telephone.

If you have any questions or concerns, please talk with me about them. By signing this form, you agree to participate in my research as described above.

**Signature** _________________ **Date**_________

Thank you. I appreciate your time, cooperation, and perspectives.

Susan MacLeod
773-7495

## APPENDIX C

## JUMP START LABS AND MATH TOPICS

JUMPSTART: Syllabus for Math/Science Time: Four hours a week for 13 weeks

Week1:
Introduce the use of calculators
Introduce measurement tools--work with English units--do a project like "How far can you shoot a rubber band?"
Introduce geometry with perimeter and area--measuring/calculating for real objects

Week 2:
Introduction to and discussion of the metric system
Measuring with metric units
Comparing the English and Metric systems--do a project like "English Inches vs Metric Centimeters."
Do "Discovering Pi--in English and Metric Units" lab

Week 3:
Develop a table of equivalent units for measures of length, then provide a table for conversion of other types of units (volume, mass, etc.).
Do introductory lab on "Energy usage of common household Tools and Appliances."

Week 4:
Lab week--learning about electricity
Problem solving in context of electricity problems
Series vs parallel circuits
Working with decimal numbers/Rounding

Week 5:
More on electricity-- provide less structure, more independent work
Learning how to develop a data table
Concentration on learning to format a lab report correctly

Week 6:
Wrap up of Electricity Unit
Introduction to three dimensional geometric figures
Types of figures/Formulas for figures

Week 7:
Volume project like "Create a container that will contain 64 1"-cubes."
Work with cubes of other dimensions
Ask, then discuss, "How many cubic inches are there in a cubic foot?"
Measuring volumes by different methods/Approximating volumes

Week 8:
Introduce the density with the "Which object is denser?" lab
Do "Density of wooden blocks" lab. (requires understanding of volume)
Work with the idea of "averages"

Week 9:
Do "What is the density of water?" lab.
Do "Which liquid is denser?" lab
Catch-up time--or work on a math/science enrichment topic of your choice

Week 10:
Do "Design your own temperature scale" lab.
Discuss, and work with, formulas for temperature conversions
Design a temperature conversion table

Week 11:
Working with thermocouples
Learning about graphs/graph sketching
Do "Thermocouple reading/graphing/interpolating and extrapolating" lab

Week 12:
Presentation of a new topic
Exploration of the subject
Design your own lab on a topic presented

Week 13:
Presentation of the labs you have designed

Class Format:

We generally begin each class with a brief discussion of the upcoming lab. We never tell students why they are doing the labs; we tell them what they are going to do and sometimes, particularly early in the semester, what data to collect. We then "let them loose" to discover! As the semester progresses, we let them decide for themselves what data they need to collect to answer the questions we have asked. Our belief is the less we tell them, the more they learn.

We try not to separate the math from the science. We work with math concepts in the form of labs whenever we can. The math ideas students work with in this class are the ones they need in order to understand the science labs.

Early in the semester, we concentrate on using a calculator and making sure answers make sense. Later in the semester, particularly in the tutoring sessions, they can practice doing operations "by hand."

Notes:

- The topics are flexible and coverage depends upon the group of students
- The topics for weeks 12 and 13 are new--we have not tried them yet
- Time should be provided for discussion of ideas and student questions--whenever possible allow students to explore their ideas, ask and answer their own questions

JUMPSTART: Syllabus for Self-paced Math Time: Two hours a week for 13 weeks

Week1:
Review of whole numbers, place value system, and operations on whole numbers
Using a calculator for these operations
Problem solving, Estimating, and Rounding
Introduction to the division-of-two-whole-numbers definition of fractions

Week 2:
Decimal numbers, place value, and operations on these numbers
Using a calculator for operations with decimals
Problem solving and Estimating with decimals

Week 3:
More working with decimals
Decimal Word Problems/Applications with Decimals

Week 4:
Percents, particularly in relation to decimals
Converting Percent <--> Decimals
Percents on the calculator

Week 5:
More on decimals and percents
Percent word problems

Week 6:
Fractions, with an emphasis on ratios
Working with ratios
Ratio problems

Week 7:
More on fractions--part of whole/part of group--work exclusively with pictures
M&M's/Hershey Bars exercise

Week 8:
Fraction word problems--use calculators and concentrate on correct operations

Week 9:
Operations with fractions--without the use of a calculator

Week 10:
More operations with fractions

Week 11:
More work with fractions

Week 12:
Extra week for catching up

Week 13:
Extra week for catching up

Notes:

'These are just ideas for topics that could be covered if the goal of the tutoring sessions is to give students the opportunity to cover much of a MAT100 course in these periods.

'Independent self-pacing assumes student motivation and ability to learn independently. It does not provide the support the majority of students at this level will find necessary to be successful. This program really needs an instructor available at every tutoring session if students are do other than reinforce the ideas they work with in the math/science labs.

'This time should not be a lecture-format class since students are at such a variety of levels mathematically (many are at the 100 level, but even these vary a great deal)

'Students working at their own pace, with the regular support of an instructor, could take chapter tests when they complete each chapter of the text that would verify their readiness to go on.

## APPENDIX D

## MATHEMATICS LEARNING QUESTIONNAIRE

Math Learning Questionnaire                                        Name:

For each of the statements below, check (✓) whether you agree strongly , agree somewhat, are neutral or undecided, disagree somewhat or disagree strongly .

1. Success in mathematics depends more on innate ability than on hard work.

| agree strongly | agree somewhat | neutral or undecided | disagree somewhat | disagree strongly |
|---|---|---|---|---|
| | | | | |

2. Women are less capable in mathematics than men are.

| agree strongly | agree somewhat | neutral or undecided | disagree somewhat | disagree strongly |
|---|---|---|---|---|
| | | | | |

3. Most jobs require very little mathematics.

| agree strongly | agree somewhat | neutral or undecided | disagree somewhat | disagree strongly |
|---|---|---|---|---|
| | | | | |

4. All useful mathematics was discovered long ago.

| agree strongly | agree somewhat | neutral or undecided | disagree somewhat | disagree strongly |
|---|---|---|---|---|
| | | | | |

5. To do mathematics is to calculate answers.

| agree strongly | agree somewhat | neutral or undecided | disagree somewhat | disagree strongly |
|---|---|---|---|---|
| | | | | |

6. Only scientists and engineers need to study mathematics.

| agree strongly | agree somewhat | neutral or undecided | disagree somewhat | disagree strongly |
|---|---|---|---|---|
| | | | | |

7. Learning mathematics is a straight-forward matter and practice alone should "make perfect."

| agree strongly | agree somewhat | neutral or undecided | disagree somewhat | disagree strongly |
|---|---|---|---|---|
| | | | | |

8. A good teacher should never confuse you.

| agree strongly | agree somewhat | neutral or undecided | disagree somewhat | disagree strongly |
|---|---|---|---|---|
| | | | | |

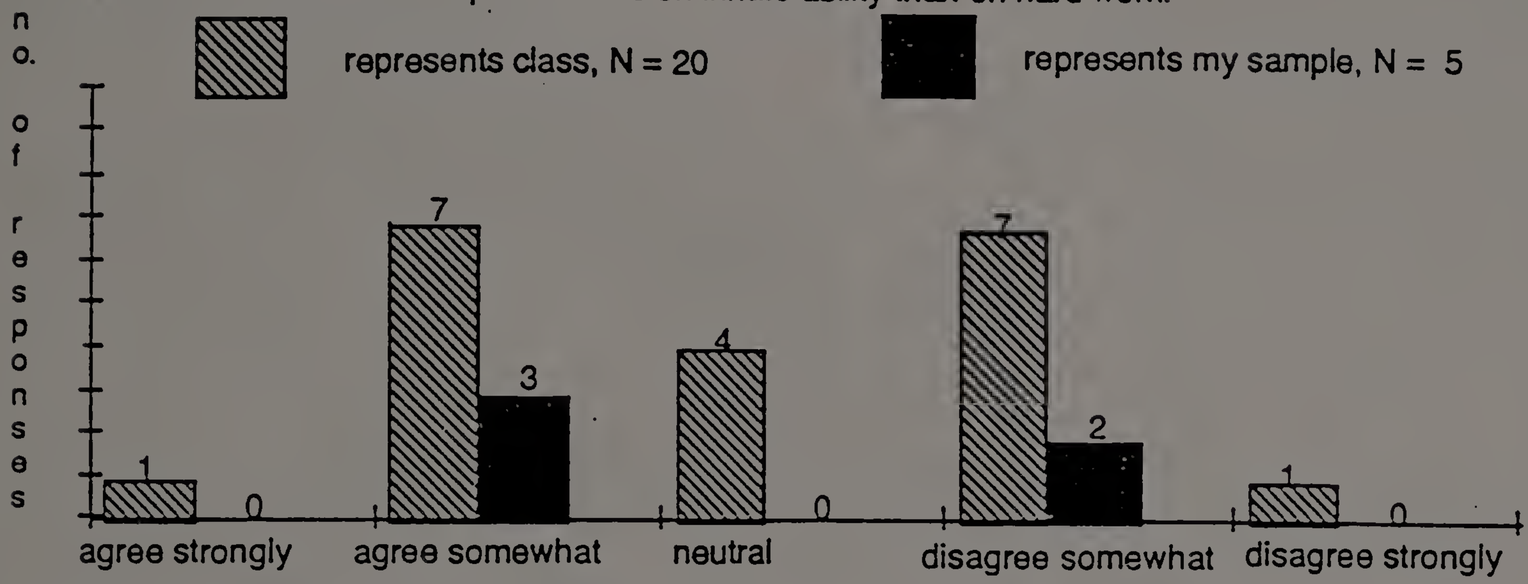
9. There is no need for creativity in mathematics.

| agree strongly | agree somewhat | neutral or undecided | disagree somewhat | disagree strongly |
|---|---|---|---|---|
| | | | | |

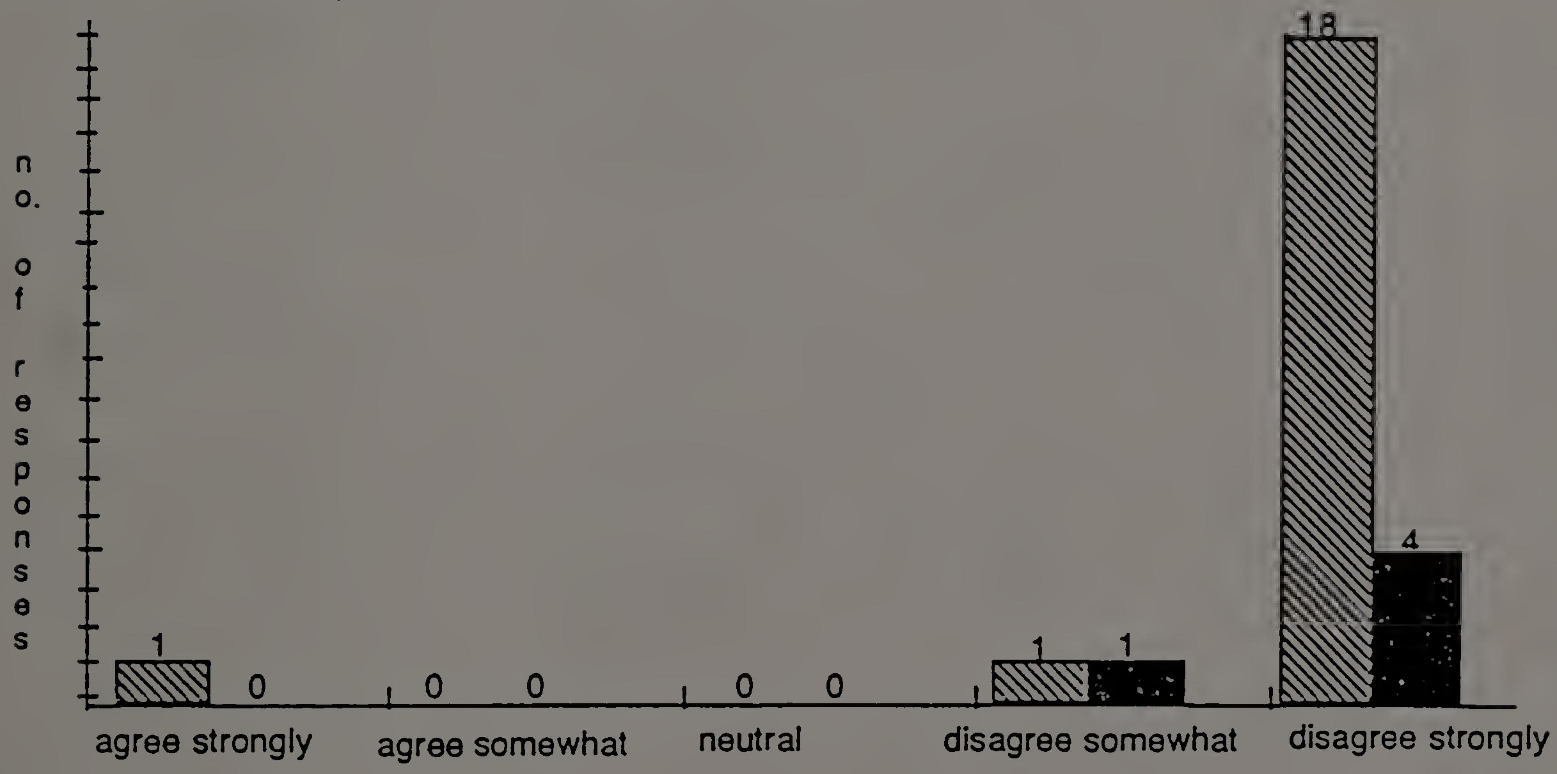
## APPENDIX E

## QUESTIONNAIRE RESULTS

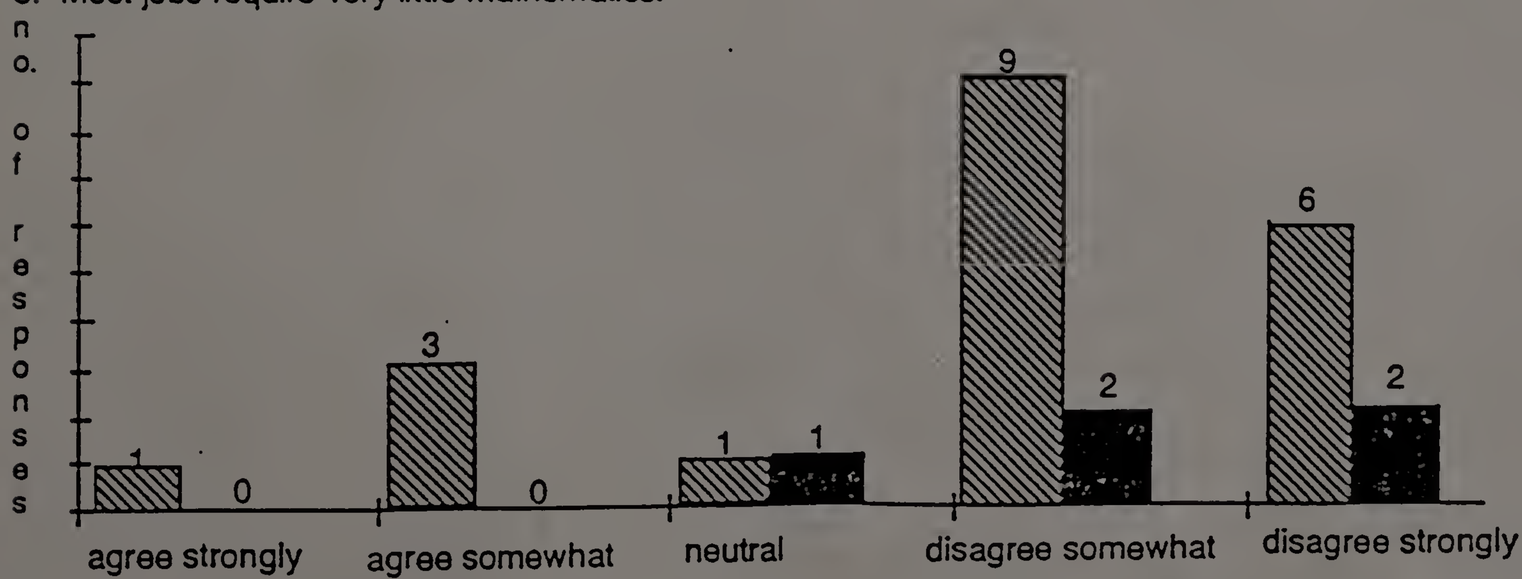
1. Success in mathematics depends more on innate ability than on hard work.



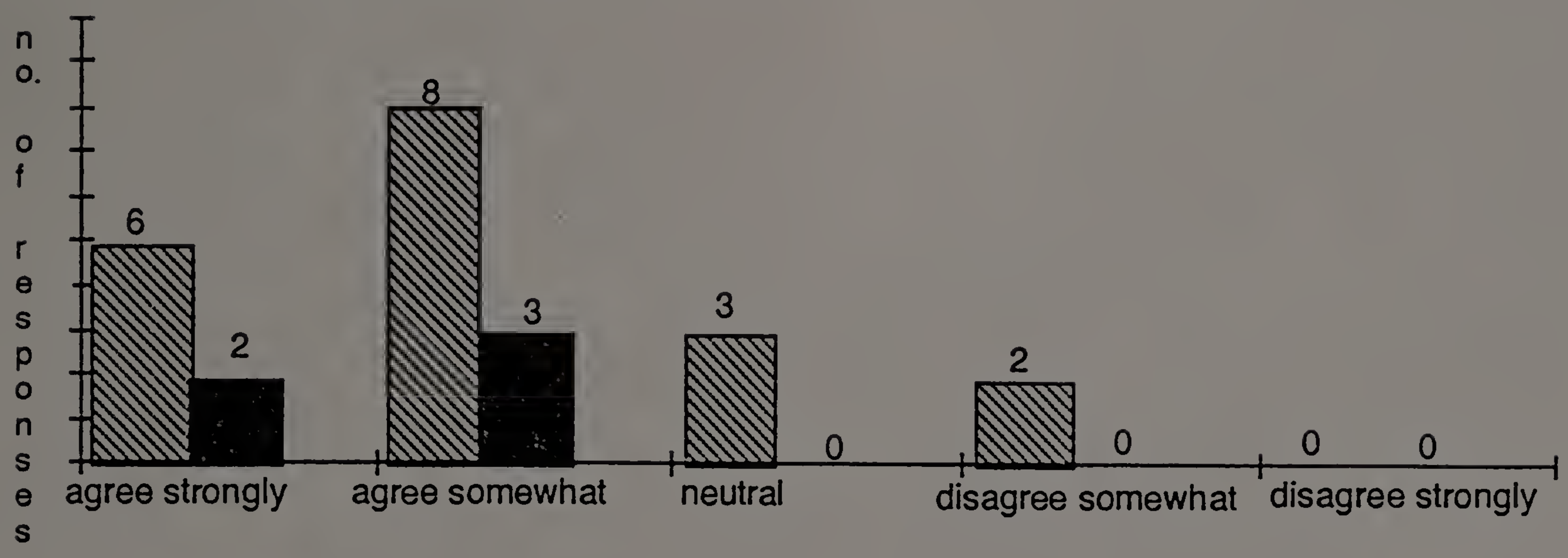

2 Women are less capable in mathematics than men are.



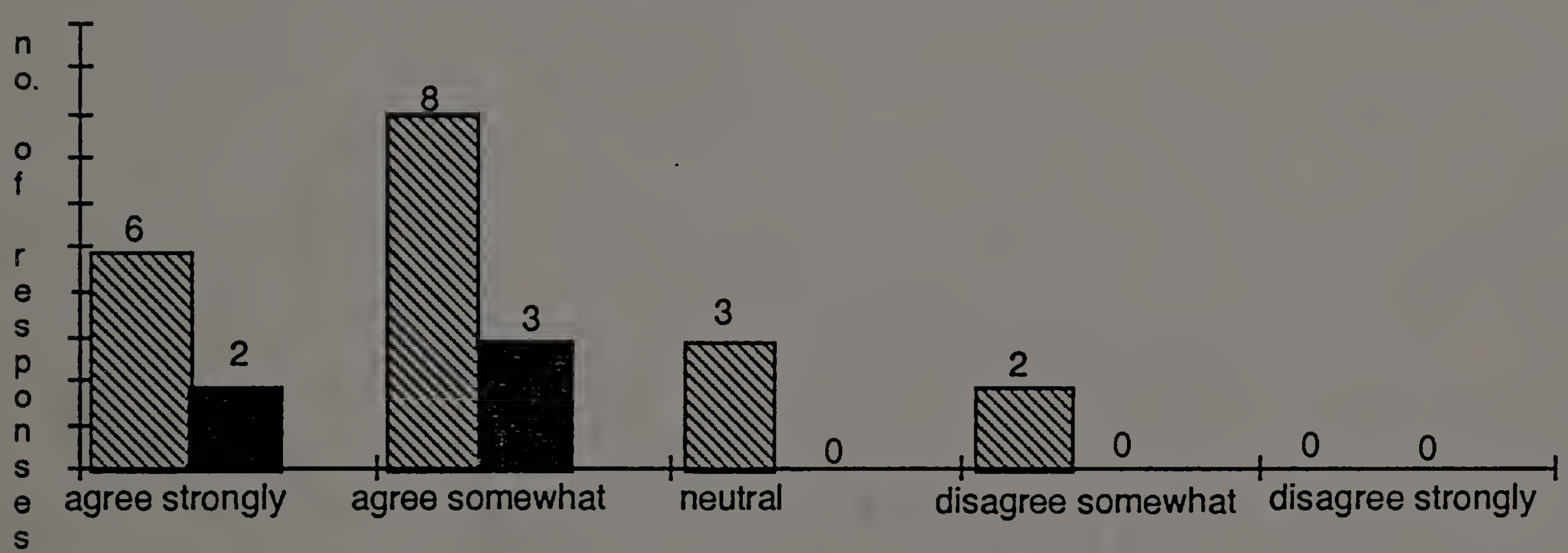

3. Most jobs require very little mathematics.



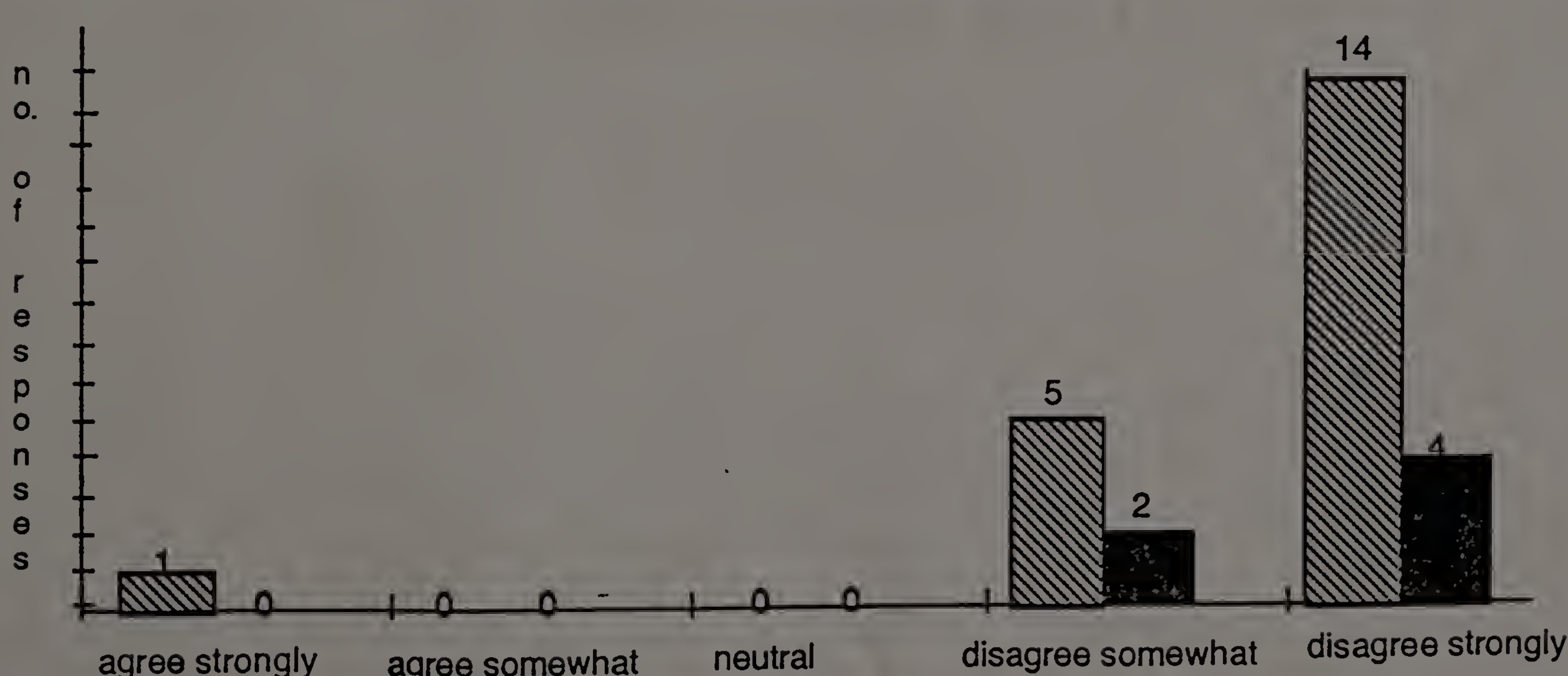
4. All useful mathematics was discovered long ago.



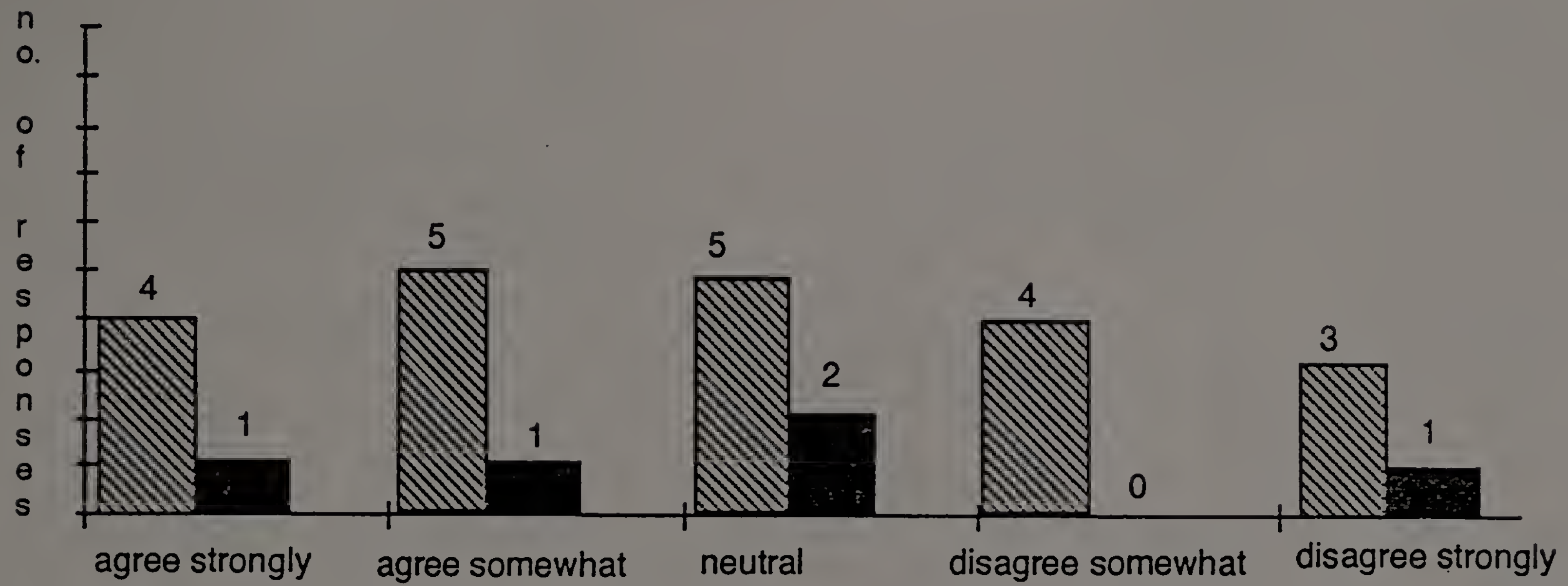

5. To do mathematics is to calculate answers.



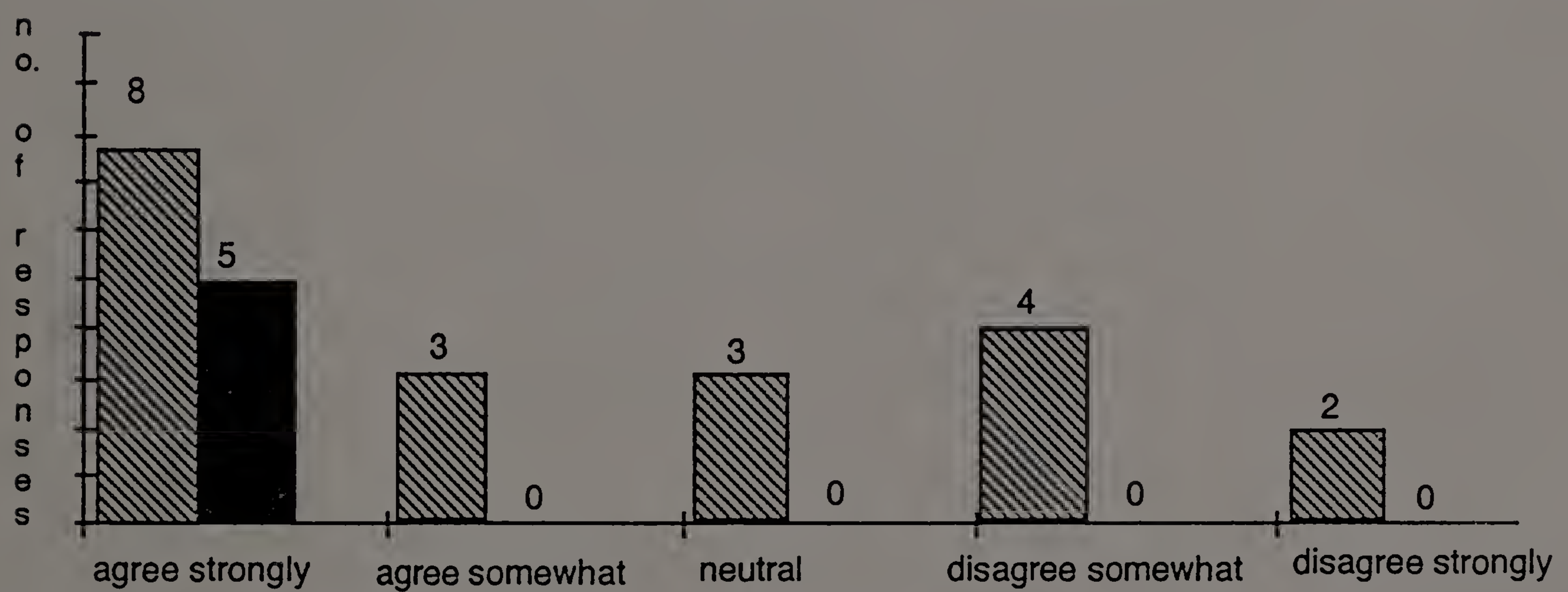

6. Only scientists and engineers need to study mathematics.



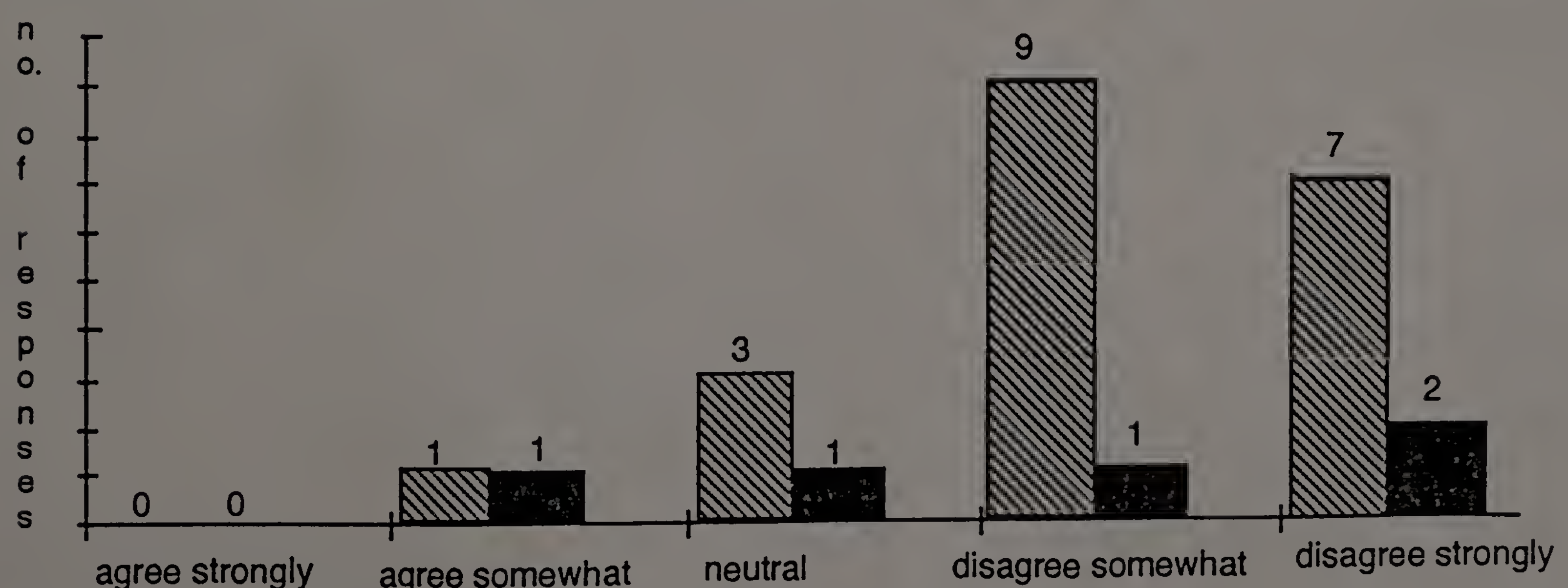
7. Learning mathematics is a straightforward matter and practice alone should "make perfect."




8. A good teacher should never confuse you.




9. There is no need for creativity in mathematics.



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