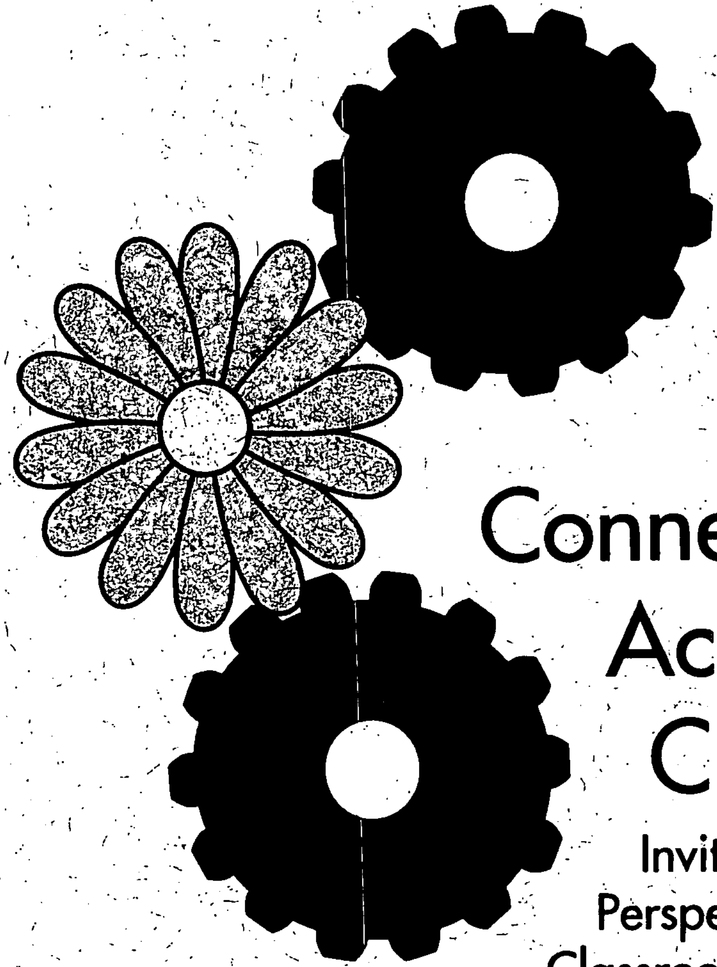
DOCUMENT RESUME

ED 408 171 SE 060 255

AUTHOR	Behm, Charlotte; And Others
TITLE	Connections across Cultures: Inviting Multiple Perspectives into Classrooms of Science, Technology, Math, and Engineering.
INSTITUTION	Mission Coll., Santa Clara, CA.
SPONS AGENCY	National Science Foundation, Arlington, VA.
PUB DATE	96
NOTE	321p.; For summary introduction of this report, see SE 059 894. A product of the Pac-TEC Project.
CONTRACT	ATE-94-273
AVAILABLE FROM	Pac-TEC Project, Mission College, MS21, 3000 Mission College Blvd., Santa Clara, CA 95054.
PUB TYPE	Reports - Descriptive (141)
EDRS PRICE	MF01/PC13 Plus Postage.
DESCRIPTORS	American Indians; Black Students; *Career Awareness; *Classroom Environment; Educational Change; Elementary Secondary Education; *Engineering Education; *Equal Education; Higher Education; Hispanic Americans; Learning Strategies; *Minority Groups; Problem Solving; Sex Differences; Student Motivation; Technology Education
IDENTIFIERS	African Americans; Native Americans

ABSTRACT

This book comprehensively describes the Pac-TEC project which organizes educational reform around the problem statement that mathematics, science, technology, and engineering education is not inclusive of all thinking and learning styles, and therefore is not addressing the present and future needs of the expanding, evolving culture base of the United States. The Pac-TEC project has a research component consisting of interviews, classroom trials, literature, research, discussions, textbook analysis, and visits to the learning environments of classroom teachers (N=26). The teachers were chosen from elementary to university level with 15 of those teachers being members of groups that are underrepresented in science, mathematics, engineering, and technology. The questions that guided the research phase pertained to the reasons why some students are uncomfortable with science, mathematics, engineering, and technology; possible contributions and new perspectives that women and people of minority cultures can bring to the fields of science, mathematics, engineering, and technology; a picture of what a Native-American, African-American, Hispanic-American, or woman-centered technology style would look like; and what motivates students to study and remain in science, mathematics, engineering, and technology. This document explains the reasons behind the Pac-TEC research project, how some underrepresented individuals cope with the majority educational system, and includes some sample solutions. (DDR)



Connections Across Cultures

Inviting Multiple Perspectives into Classrooms of Science, Technology Math, and Engineering

2

BEST COPY AVAILABLE

3

Pac-TEC Suggestions for Classroom Changes

PRESENTS THE WORLD AS A DYNAMIC SYSTEM OF INTERCONNECTIONS AND DISCOVERY

- Allows a Discovery Process and Acknowledges Uncertainty in Acquiring Knowledge.
- Includes Open Ended Problems.
- Insures Subjects are Alive and Holistic.
- Explores Technology's Role in Society.
- Promotes Social Interaction and Human Interconnections.

CREATES A SAFE, STIMULATING ENVIRONMENT

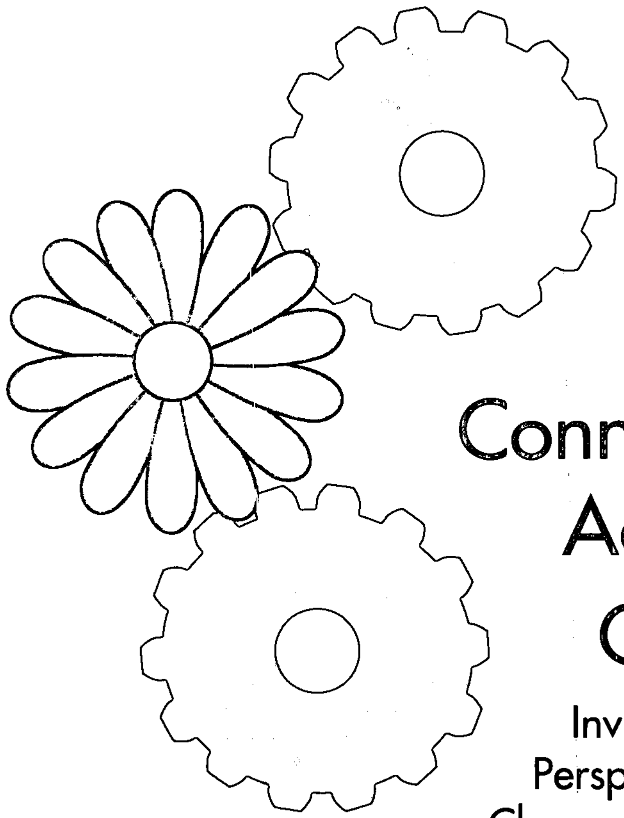
- Develops a Comfortable Classroom Environment.
- Supports a Cooperative Learning Environment.
- Vitalizes Physical Space.
- Embraces Collaborative Conversation Styles.
- Uses Technology Tools Holistically.

EXPANDS THE PARTICIPANTS PERSPECTIVES

- Promotes Multi-perspectives.
- Integrates Family and Community.
- Resources.
- Adapts to Diverse Learning Styles.
- Uses a Variety of Assessment Tools.

MOTIVATES STUDENTS TO PERSONALLY EXPERIENCE AND INTERPRET MATERIAL

- Engages Students.
- Encourages Reflection.
- Relevant to Students.
- Involves Working in Groups and Develops Interpersonal Skills.
- Values Feelings and Intuition.



Connections Across Cultures

Inviting Multiple Perspectives into Classrooms of Science, Technology Math, and Engineering

This project was supported, in part, by the
National Science Foundation
Opinions expressed are those of the authors and not necessarily those of the Foundation
grant #ATE 94-273

Pac-Tec Project
Mission College
MS21
3000 Mission College Blvd.
Santa Clara, CA 95054
(408)748-2764
email: PacTec@wvmccd.cc.ca.us

Preface

The teachers who created this book established a goal of finding ways to enliven and enrich the classrooms of math, technology, science, and engineering. The teachers decided to look past the existing system, past the traditional methods and ideas, to new resources and new paradigms.

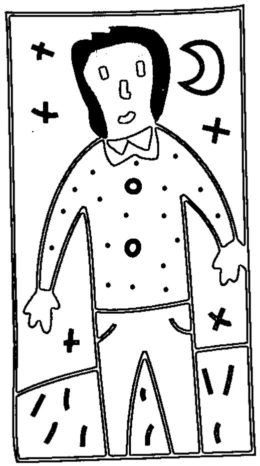
The teachers searched for new clues by focusing on Native Americans, African Americans, Hispanics, and women, who together comprise 65 percent of the student population. Despite their large population, these four groups continue to be severely underrepresented in the fields of science, engineering, technology, and math.

Since these student populations are missing from the targeted disciplines, the teachers concluded that their invaluable, unique approaches to problem solving, learning, and culture must also be absent. As the teachers learned about the cultures that are underrepresented in technology, they not

only found ways to attract and retain students from these under represented groups, but they also found rich clues to what can be added to enlighten and enrich the educational environment for all students.

This book presents teaching methods that bring richness, inclusion, and diversity to the classroom by building on characteristics which are important to and valued by under-represented groups. The same teaching methods can also allow teachers to uncover and nurture the interests and resources *all* students bring to the classroom – assets which may have remained dormant in the traditional educational system.

The book offers simple, easy-to-use strategies for changing the classroom environment. These strategies are clarified and supported by quotes from literature, using hundreds of recent references. Additionally, these ideas are illustrated by examples that teachers have used in actual classrooms. These illustrations are designed to be used as guides and idea generators, in support of teachers who want to use these strategies in their own curriculum and course content.



PROJECT FOCUS AND IMPETUS

PROBLEM STATEMENT

Math, science, technology, and engineering education is not inclusive of all thinking and learning styles and therefore is not addressing the present and future needs and the expanding, evolving culture base of the United States.

PROBLEM ANALYSIS

Some statements that define and support the PROBLEM STATEMENT above:

(a) The majority of students (specifically women, African Americans, Hispanics, and Native Americans) are severely underrepresented in these fields as they do not enter and remain in the fields. Conversely, if what is interesting to any underrepresented groups or types of people is not part of the curriculum , we cannot hope to appeal to students who are skilled and interested in these areas.

(b) The current passive, highly structured classroom environment does not prepare students for the work environment of the problem-solving oriented technological worker. Specifically, the technologists of the future will be required to solve problems in a climate of increasing complexity and diversity in today's global economy.

(c) The education offers little relevance to the real world in which students live and work. As a result, many students do not perceive or identify with these fields and see little importance or rewards in studying in these fields.

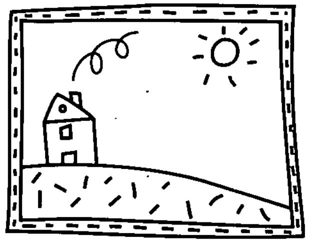
Contents

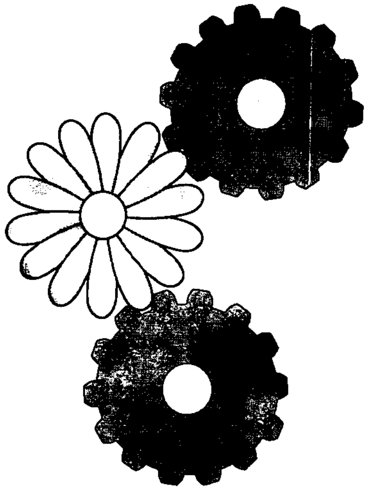
PART I

The Purpose and Goals of the Grant

PART II: Classroom & Curriculum

Pac-TEC
Problem Definitions and Problem Solutions

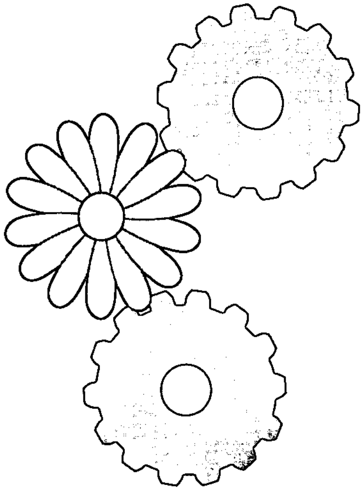




Let Us Hear From You

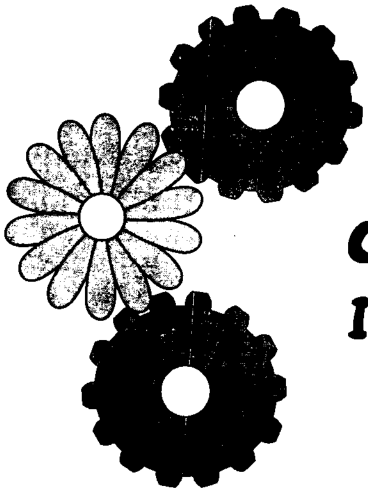
- The Pac-TEC project is interested in hearing comments, questions, and suggestions concerning this book.
- What has worked well in your classroom? We'd love to hear about it!
- We are also interested in establishing partnerships with other people or groups interested in our work.
- If you would like additional copies of this book, contact us at the addresses below.

Pac-TEC Project
c/o Charlotte Behm
MS 21
Mission College
3000 Mission College Blvd.
Santa Clara, CA 95054-1897
(408) 748-2764
e-mail: pactec@wvmccd.cc.ca.us



PART I

The Purpose and Goals of the Grant



CHAPTER I:
Introduction

10

CHAPTER ONE INTRODUCTION

1. Who is the Pac-TEC Project?

The Pac-TEC Project is a group twenty-five classroom teachers who researched education in the fields of math, science, technology, and engineering. The Pac-TEC Project is funded by a grant from the National Science Foundation in the Advanced Technological Education Program.

Fourteen of the faculty are members of groups which are underrepresented in technology, math, sciences, and engineering. The Pac-TEC group consists of faculty within the fields of technology, math,

REFERENCES THAT CLARIFY/SUPPORT:

Math is less interesting to students than other subjects in high school, so borrow from them: English teachers make them feel that they have done something wonderful when they put together a coherent analysis of a play or write a humorous story. English teachers encourage students to talk about their ideas; math teachers, on the other hand, are more likely to reward a right answer. It is even common for teachers (and students) to be annoyed at the student who finds alternative ways of proving a theorem or solving a problem. Rather than being appreciated for originality, the student is often cut short when presenting an explanation.
(Brush 1980 pg. 102)

The comparison between high school English and mathematics

sciences, and engineering, as well as faculty outside those fields. The philosophy of the project is that much can be learned from other fields because (a) many of these fields are able to attract and retain students from groups which are underrepresented in technology, math, sciences, and engineering, and (b) it is beneficial to have the perspectives of faculty who were not comfortable enough with traditional teaching methods in technology, math, sciences, and engineering to study them.
(Institute 1994)

The faculty who have participated in the project are listed on page 13 with the subjects they teach and school affiliation (all in California).

classes provides us with suggestions for directions to take in making classes more enjoyable: (Brush 1980 pg. 104-5)

- Encourage students to express their own ideas.
- Ask questions which do not have only one right answer.
- Reward interesting approaches to solving problems even if they do not lead to the right answer.

- Talk about the reason students are learning about a topic in terms of how this topic fits into mathematics and how it helps one to understand real-world phenomena.
- Translate theorems into common parlance whenever possible.
- Summarize topics frequently so that students know how today's lesson is related to yesterday's and tomorrow's.
- Repeatedly demonstrate that mathematical algorithms are not random and arbitrary, but are understandable and logical.

A source of trauma for many young people is the *style* of the mathematics classroom. Students complain that there is little opportunity for debate or discussion. Many say they like English and social studies better than math because they can participate more in class and there is not so much pressure to find the one right answer. Mathematics does depend on right answers, but it can also be experienced as a series of discoveries that we all make for ourselves. More often than not, however, math is presented as a fixed set of rules to be digested whole and without dispute, which may discourage students from learning.
(Tobias 1987 pg. 34)

Charlotte Behm, Engineering, Mission College, Santa Clara
Denny Bruzynski, Math, West Valley College, Saratoga
Rich Cameron, Journalism, West Valley College, Saratoga
Doug Campbell, Math, West Valley College, Saratoga
Donette Dake, Computer Technology, West Valley College, Saratoga
Wade Ellis, Math, West Valley College, Saratoga

Jim Freeman, Engineering, San Jose State University, San Jose
Leo Johnson, Electronics Technology, San Jose High School, San Jose
Kevin Jordan, Math, Los Gatos High School, Los Gatos
Greg Lippman, English, Gunderson High School, San Jose
Lin Marelick, Graphic Arts Mission College, Santa Clara
Tiffany Maraldo, Art, Gunderson High School, San Jose

Sonia Martin, English, Santa Clara High School, Santa Clara
Greg Mostyn, Accounting, Mission College, Santa Clara
Diane Procell, Science & English as a Second Language, Sylvandale Middle School, San Jose
Gwen Quail, Chemistry, Santa Clara High School, Santa Clara
Carl Silva, English Archbishop Mitty High School, San Jose
Eric Smith, Physics Aptos High School, Aptos

Kathleen Tilton, English, Mission College, Santa Clara
Karl Ting, Math, Mission College, Santa Clara
Tom Trask, Biology, Mission College, Santa Clara
Leman Uyuklu, Library, West Valley College, Saratoga
Bryce Williamson, English Del Mar High School, San Jose
Wendi Wooldridge, Science, Sylvandale Middle School, San Jose
Judy Zaches, Biology, Wilcox High School, Santa Clara

13

2. What is the Goal of the Pac-TEC Project?

The goal of the Pac-TEC project is to develop new teaching strategies for technology, math, engineering, and science that will improve the education for all students. The focus is to make the educational experience inclusive of the preferences and styles of students who traditionally are not attracted to these fields. Specifically,

- The redefinition of teaching techniques allows for increased flexibility and diversity of learning styles, perpectives and cultures within classrooms.

- Increased flexibility and diversity attracts students who cannot or do not choose to fit or mold themselves into the limited roles in which traditional teaching methods require students to fit.

REFERENCES THAT CLARIFY/SUPPORT:

Without changing the substance of their courses, teachers can change elements of their style and of the atmosphere they set in the classroom, and trust that such changes will have a significant impact on students.
(Brush 1980 pg. 105)

We believe that all courses can be adapted to fit a multicultural climate with very little research by the instructor. Establishing a classroom environment that facilitates learning, reflects respect for all students and demands that respect be displayed by other students is a first step. Providing an educational experience that is challenging and inclusive in a tolerant environment is a goal that all instructors may achieve.
(Academic Senate for California Community Colleges 1991 pg. 10)

Multicultural education focuses on the value of being different. In science education, multiculturalism means that teachers teach culturally relevant material in ways that invite participation in culturally appropriate ways.
(Melear 1995 pg. 21)

Multicultural education is an approach to teaching and learning that seeks to empower individuals so they may function in a global society.
(Academic Senate for California Community Colleges 1991 pg. 3)

3. Which Students Are We Writing About?

Many students find it difficult to be successful when studying math, science, technology, and engineering. These students can be from various backgrounds, from various ethnic groups, and be male or female. Students from all groups can be turned off to these fields and can benefit from new teaching methods. However, the research of the Pac-TEC project is focusing on particular segments of the student population in its efforts to find clues to new solutions.

REFERENCES THAT CLARIFY/SUPPORT:

The research associated with females and minorities adds an interesting dimension for the needed reforms in science education. Certainly the findings provide information about necessary changes. There is considerable evidence that current programs are serving no one well, including students who are most successful and those who pursue further study of science in college.
(Yager 1993 pg. 249)

Curriculum transformation resulting in the integration of multiculturalism must address not only what but how we teach. Transforming the curriculum in both content and climate is intended to address the needs of those not traditionally represented in the academy including women, person of color, and person with disabilities.
(Academic Senate for California Community Colleges 1995)

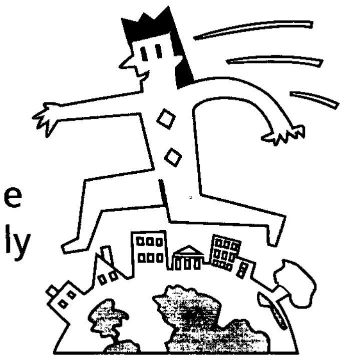
The Pac-TEC project focuses on four particular groups – women, African Americans, Hispanics, and Native Americans. The majority, 65 percent, of students in the United States are members of these groups. However, these four groups are underrepresented in technology, math, engineering, and the sciences. The National Science Foundation defines underrepresented groups as those whose representation in particular fields is less than their representation in the populations. (Kelly 1995; National Science Foundation, November, 1994) While women and African Americans, Hispanic Americans, and Native Americans have increased their representation in science and engineering disciplines, their participation rates remain unacceptably low. (Chahin 1993; Finley et al 1992; Mendoza 1995; National Science Foundation, February 1994)

A department whose introductory course conveys the beauty and excitement of physics and its relevance to students' social concerns and intellectual interests can expect to recruit more students. (Ferhs and Czujko 1992 pg. 37)

Women uniquely bring a human side to engineering. At least I do. I feel that what I bring is good for men and women. (Geppert 1995)

4. What Was Our Process?

Initially the project has focused on thoroughly understanding the problem we want to solve. Our problem analysis has consisted of interviews, classroom trials, literature research, discussions, textbook analysis, visiting classrooms of innovative and award-winning teachers, and using the diversity of our own group to explore and understand varying preferences, perspectives, and styles.



We have found some of our most interesting and valuable insights (intuitive leaps) from using ourselves as subjects. For example, visiting two museums produced interesting and useful responses. The women's observations and feelings about the museums were radically different than those of the men. 17

Other resources in the community were used. For example, we visited industry sites to compare the working environments of engineers and artists, and we also visited a local summer math institute which teaches Hispanic students.

Problem Definitions as design specifications:
The analysis of the problem led to an extensive list of Problem Definitions. These Problem Definitions describe characteristics of the solutions that will successfully address the problem.

The Pac-TEC project has generated over a hundred solutions in order to test and refine the Problem Definition. Beginning in Chapter Four, we have included some of those solutions along with some solutions we found in the literature.

Solutions:
The solutions require varying amounts of class time and preparation. Solutions generally do not require major changes in course content, but instead incorporate new teaching methods with existing content following the Problem Definition. A teacher can choose to change a small percentage of content, develop a style that works for his or her situation, and expand as appropriate.

References that Clarify and Support:
Many original references used in the PacTEC Project are presented in their original form, and are carried throughout the book in the lower part of each page. This use of primary source readings gives the reader the opportunity for personal interpretation and reflection.

5. What Questions Did We Ask?

The Pac-TEC team asked questions such as:

- What about the science, math, engineering, and technology fields is uncomfortable to students?
- What tells students they are unwelcome?
- Why do students feel like they do not fit in?
- Do women and people of minority cultures have something different to offer, perhaps a new perspective, that can benefit these disciplines?

REFERENCES THAT CLARIFY/SUPPORT:

Despite these dangers, I am joining the growing dialogue on gender and language because the risk of ignoring differences is greater than the danger of naming them. Sweeping something big under the rug doesn't make it go away; it trips you up and sends you sprawling when you venture across the room. Denying real differences can only compound the confusion that is already widespread in this era of shifting and re-forming relationships between women and men. (Tannen 1990 pg. 16)

Whereas we might wish to be able to treat all students, regardless of ethnic origins, the same, the reality is that we fail to provide them with the best education when we do that. For that reason, there is a real concern when teachers indicate that they make no distinction between their

- How can the fields value the unique talents and skills that students from underrepresented groups have to offer?
- What would an African-American-centered, Native-American centered, women-centered, or Hispanic-centered technology style look like?
- What can we learn from schools and academic fields that are able to attract and retain members of these groups that are underrepresented in math, science, engineering, and technology?
- What motivated students to study and remain in math, science, engineering, and technology. What led others to chose something else or leave these fields?

Hispanic American and Euro-American students. Perhaps, as has been suggested earlier, that is part of the problem .
(Rakow and Bermudez 1993)

If you are looking for a nearly pure model of an applied science constructed entirely by women, take a look at nursing science. The nursing faculty I work with are better scientists than most male engineers or physicists of my acquaintance. They exhibit less interdisciplin-ary bias, are less competitive, more collaborative, less motivated by careers-manship, and more driven by genuine interest in scientific discovery and concern about the value of their work for society.
(Barinaga 1993 pg. 387)

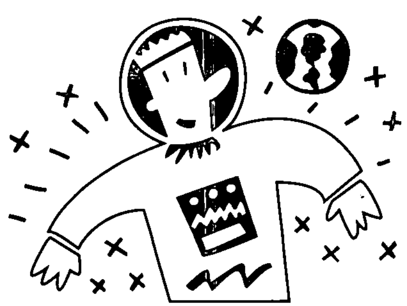
Although people connected by culture do exhibit a characteristic pattern of style preference, it is a serious error to conclude that all members of the group have the same traits as the group taken as a whole. (Guild 1994 pg. 16)

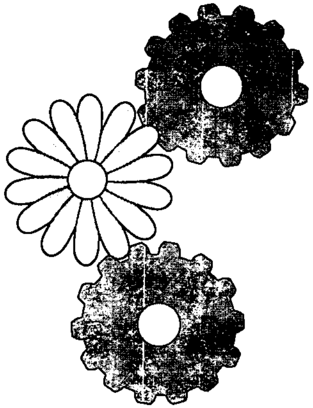
6. What Did We Find and What Did We Do With the Information?

The Pac-TEC project found common themes in the styles and preferences of the four underrepresented groups. Since many of these styles and preferences are absent in technology, math, science, and engineering education, it follows that the styles and preferences of these particular groups are absent.

The Pac-TEC project used this information to create a variety of criteria that teachers can use to develop techniques that adds balance and supports diversity in the classroom. Each teacher can easily adapt her or his existing teaching to meet the criteria. Solutions do not necessarily replace current curriculum, but augment and enrich the curriculum through the establishment of new and creative teaching methods.

The project participants have discovered that even though we started with a focus on underrepresented groups, our work benefits the entire student population by improvements in the classroom environment, in technical classrooms as well as in the humanities and literature.



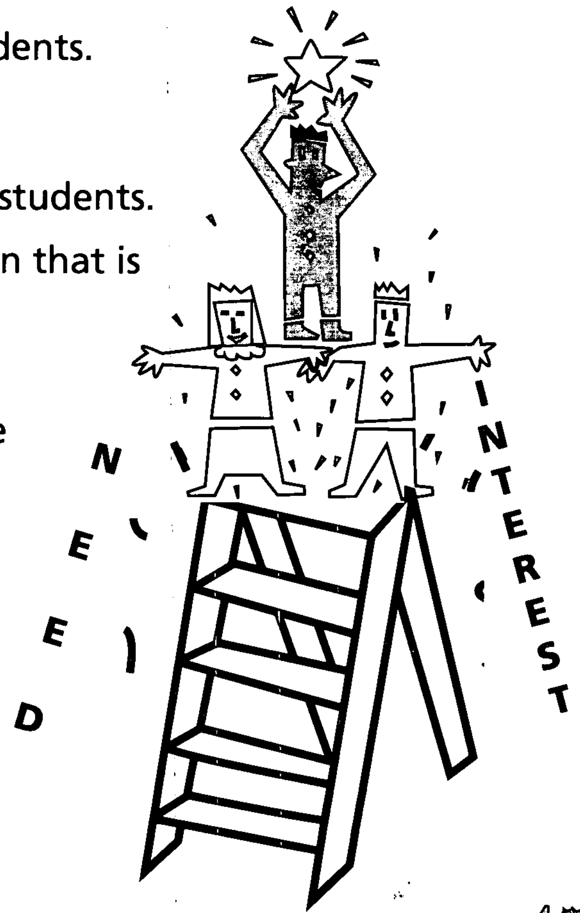


Chapter Two: Why Is The Pac-TEC Project Researching These Issues?

CHAPTER TWO: Why Is The Pac-TEC Project Researching These Issues?

The Pac-TEC project's goal of finding new ways of teaching math, science, technology, and engineering offers several opportunities for positive change. The conditions which motivated us to pursue this work are listed below and are explored in this chapter.

1. Trends show declining interest in these fields among all students.
2. Many teaching methods have not changed for decades.
3. Traditional methods of teaching are not effective for many students.
4. The education system was designed for a student population that is different than today's populations.
5. New groups of students require new teaching methods.
6. New options for incorporating diversity in the classroom are needed.
7. The skills needed in the workplace are changing.



1. Trends Show Declining Interest

Trends in student interest in math and science based careers cause concern and demand innovative change:

general population: Even though workforce projections show a 36% increase in the need for people with technical and scientific backgrounds in the next ten years, student interest in many of these fields is decreasing. (Hubbard 1995)

REFERENCES THAT CLARIFY/SUPPORT:

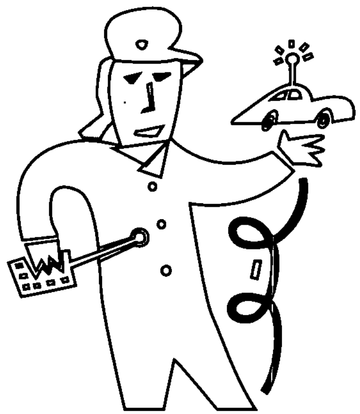
Enrollments in engineering technology programs dropped 7% in the fall of 1994. (LeBuffe 1995)

Interest in majoring in engineering is down 25% since 1982. (President's Council 1992 Ercolano 1995)

Between 1966 and 1988, the percentage of first year college students planning to major in science and mathematics fell from 12% to 6%. Of those who begin science or engineering majors, one third to one half leave before graduation. (Tobias 1992)

Nearly 30 percent of all seventh-graders express a preference for a career in fields related to science and engineering. However, this percentage declines steadily through middle and high school, so that by twelfth grade, fewer than one in four boys and one in ten girls still choose such a career. (Fisher 1992, National Assessment 1988, Price and Hafer 1995)

Only 40 percent of high school graduates have taken chemistry, only 19 percent have taken physics. (Fisher 1992)



underrepresented groups – population trends: The appeal for greater participation of women and minorities in science-based fields is not merely altruistic; it is essential for maintaining and expanding an adequate talent pool of technical professionals. Our pool of talent for new science and technical professionals is predominantly female or minority, the very segments of our population we have not attracted to these careers in the past. (AAUW 1992, President's Council 1992, Shalala 1995)

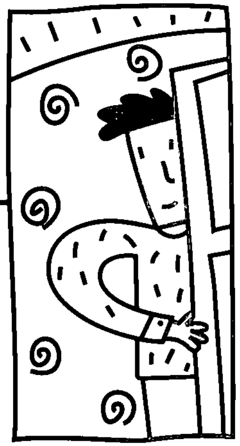
REFERENCES THAT CLARIFY/SUPPORT:

Changing demographics affect the talent pool of the future. There is a continual decline in the proportion of students of traditional college age in the total population.
(President's Council 1992)

The population of traditionally under-represented groups is growing disproportionately; by 2010, one in every three 18-year-olds will be African Americans or Hispanic, compared to one in five in 1985.
(President's Council 1992)

By 2030, the total elementary school-aged cohort of the United States will be about equally divided between non-Hispanic whites and all other racial/ethnic groups combined. As the workforce expands, it will be increasingly minority and female; the very groups who are currently underrepresented in technical fields. (Fisher 1992 Day 1993)

underrepresented groups in math, science, engineering, and technology: Minority groups and women show less interest in math, science, engineering, and technology than general population and also have lower retention rates in these fields.



REFERENCES THAT CLARIFY/SUPPORT:

Like African-Americans, Hispanics, and American Indians, girls begin to drop out of science and math courses and activities during elementary and secondary schools... The most striking difference between boys and girls is not in achievement or opportunities to learn but in their attitudes toward science and math. (National Science Foundation, November 1994 pg. 22)

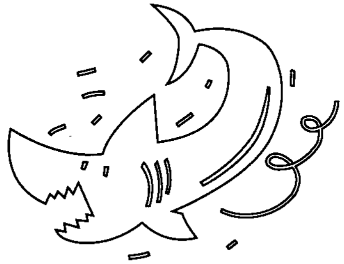
Since 1973, there has not been a gap in the mathematics proficiency scores of boys and girls at ages 9 and 13, according to the National Assessment of Educational Progress tests. Since 1986, a slight gap between the scores of 17-year-old boys and girls has virtually disappeared.

In science proficiency, the 1990 average score of 9-year-old girls was virtually the same as boys. A gap between girls' and boys' scores appears at age 13 and becomes larger by age 17; these gaps have persisted since the 1970's and are found primarily at the highest levels of science proficiency.
(National Science Foundation, November 1994 pg. xxxii-xxiii)

High school seniors asked why they decided not to take certain courses in their senior year responded that they did not like mathematics (40 percent of females and 27 percent of males) or did not like science (35 percent of females and 22 percent of males). (National Science Foundation, November 1994)

Advanced science and mathematics courses are essential to preparation for collegiate science and mathematics. Among 12th grade students in 1992, there were substantial differences in the proportions of students who had taken 8 or more semesters of math classes in high school: 44 percent of white; 32 percent of blacks; 30 percent of Hispanics, 28 percent of American Indians; and 64 percent of Asian.
(National Science Foundation, November 1994 pg. xxiii)

The three minority groups studied in the National Action Council for minorities in Engineering (NACME)'s report have a long way to go before they catch up with the largely white male population of engineers in the marketplace. African Americans, Hispanic Americans, and Native Americans, who together make up about 28 percent of the college-age population, hold just 8.5 percent of all bachelor-level engineering degrees. And attrition among minority populations is significantly higher than it is among nonminorities. Two out of three minority freshmen enrolled in engineering do not complete



the coursework required to earn a degree–that's twice the rate for nonminorities.
(Briefings 1995, Kelly 1995 pg.9)

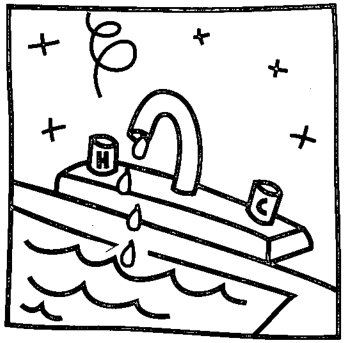
Women constitute only 8% of all U.S. engineers, making engineering the most male dominated of all professions.
(McIlwee and Robinson 1992)

Data shows that the persistence of females through the Science & Engineering pipeline to the receipt of the doctoral degree is consistently below that of men.
(Hubbard 1995, Kaplan and Aronson 1994, Williams 1995)
With the population of freshman engineering students declining (it dropped 26 percent alone between 1982 and 1994 according to the Engineering Workforce Commission) attrition has become a loss few schools can afford.
(Ercolano 1995 pg. 26)

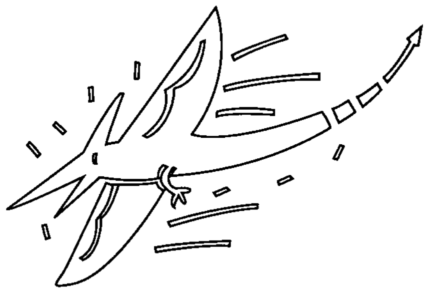
A quote from an African-American: "To spend most of my life fighting these attitudes levies a tax that is a form of intellectual emasculation. It is a tax I would not wish upon my enemies. My Ph.D. brought the national total from six to seven black astrophysicists (out of 4,000). Given what I experienced, I am surprised there are that many." A quote from a woman: "Repeated episodes wear you down to the point that changing occupations begins to sound like a good idea."
(Price 1995 pg. 12)

"It goes back to what I call water torture, because by itself, each little piece is not a big deal. But the accumulation of all the tiny little pieces keeps women in the position of always saying, 'I'm not quite there, I'm not quite good enough.' Either I make myself a buddy and try to be acceptable to the guys or I just want to be invisible and blend in. If I want to stay in that environment, everything I do makes me feel bad. Why wouldn't I opt to do something easier?". . .

(second woman in panel) "I consult with high-tech companies in the Austin area concerning recruiting and retaining women engineers. These companies get them in for three years and then they're gone. They're leaving the profession. They disappear because it's easier, and I think it's the water torture. The environment, as you said, instills insecurities. It's just a little bit every day, every day and they find that they're not happy. If they have a choice to go do something else, they're leaving and doing it."
(Geppert 1995 pg. 45)



2. Many teaching methods have not changed for decades.



The reform of curriculum and teaching methods is beginning. However, in many schools, science, math, engineering, and technology teaching follows the same models that were developed decades ago.

REFERENCES THAT CLARIFY/SUPPORT

The curriculum doesn't prepare kids for the world in which they are going to live. We've moved from an industrial-based economy. In 1950, 60 percent of the jobs in the nation were unskilled compared to 33 percent today and only 15 percent by the year 2000.

The unskilled jobs are disappearing, and the workplace is being transformed. Increasingly, employees from entry-level workers to senior management need the ability to use a wide array of knowledge, to access information, and to manipulate data. So the workplace demands very different skills than the workplace of 1950 did.

But if you look at our typical math or science or language arts curriculum, they haven't changed that much since 1950.
(O'Neil 1995)

During the 1960's and 1970's, "hands-on" approaches were added that provided laboratory focus. This allowed the students to manipulate equipment, apparatus, objects, and measuring devices so as to verify the objective principle or process that was being studied (an "engineer" approach). Yet little was or is done to include "entrepreneurs" or "poetic" students.
(Samples 1994 pg.17)

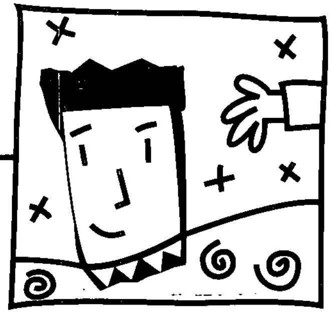
Many science teachers believe that "experimental work" means assigning students a canned experiment and then asking them to repeat the steps in the same fashion as countless students have done in the past.
(Sternberg 1990)

Science is taught as a fixed body of facts, principles, and definitions to be memorized. Science is divided into the separate disciplines, thus fragmenting students' knowledge and understanding. (WEEA 1995)

We've beaten out all the questions and looked for the right answer, and in so many cases there are so many more than one right answer. I think that it's very important to help kids understand that I [the teacher] am not an expert and what's a right answer form may be very different for them, and that's OK. As long as we learn to respect each other's right answer.
(Schneider 1993)

3. Traditional methods of teaching are not effective for many students

Improvement in the classroom environment brings benefit to all types of students, not only those who are in underrepresented groups. Improving education promises to attract and retain a larger population of students from *many* groups. (Asimov 1992, Yager 1993)



REFERENCES THAT CLARIFY/SUPPORT:

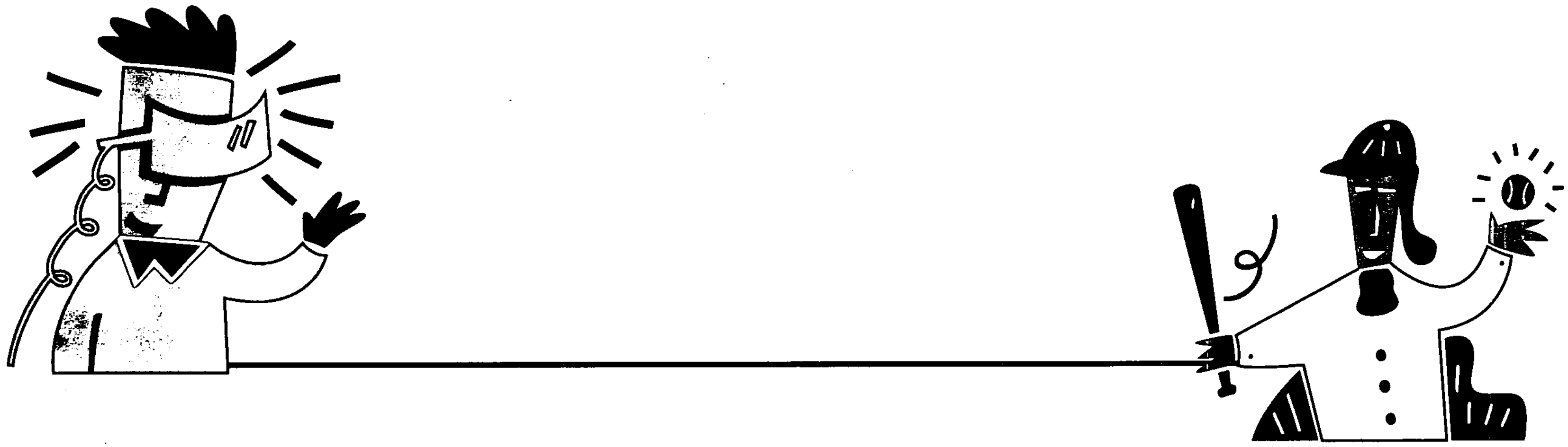
You could say this is pipeline problems to be handled in lower grades, but there could be another conclusion: there is something wrong with the quality of instruction in college science, especially at the introductory levels. Three recent studies support this conclusion. Students concluded that while college science is "difficult," it is much more difficult and dull than it needs to be.

Students wished there had been some attention to "how things came to be understood the way they are." They wanted some way to creatively address the courses' material. Exams emphasized regurgitation of facts or standard techniques and, because so many science faculty graded on a curve, exams tended to foster competition instead of cooperation.

In another study of switchers – students who entered with strong aptitude but got out – many were repeatedly discouraged by the small picture that they felt was the focus of their science classes. They complained that their instructors treated each formula, fact, or idea in isolation, and they grew impatient with the overly rapid pace and the constant focus on memorization and number crunching. They longed to understand facts in context, to find connections, and to comprehend underlying structures.

A third study found little difference between switchers and non-switchers. Most switchers did not have more conceptual difficulties with science and math, or less inclinations to work hard than the nonswitchers. Instead students made switching decisions because of a loss of interest in the subject, work overload, a punishing pace, poor teaching, and unapproachable faculty. Non-switchers stayed because they found ways to deal with it (study groups or outside assistance). (Tobias 1992)

More than one-third of seventh- and eleventh-graders find their science classes "boring" and by high school few students find science classes "fun," according to research that was carried out by the NAEP [Nationally Assessment of Educational Progress, a congressionally mandated program.] in a 20-year long study. (Fisher 1992)



Teachers spend an inordinate amount of time on rote drill and practice and on the memorization of facts and insufficient time on problem-solving and reasoning exercises. When science and mathematics are taught with an emphasis on memorization and rote drill, students become bored and "turned off."
(President's Council 1992)

The reform literature in mathematics education argues strongly for the need of a quality mathematics education for all students.
(Davenport 1993 NCTM, 1989).

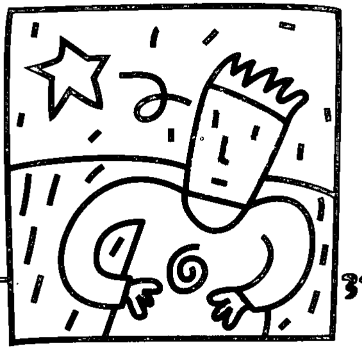
Students consistently tell me that their teachers rarely encouraged them to speak up creatively. They say teachers overwhelmingly wanted them to "learn" what was in the syllabus and the standardized tests, and not to question the curriculum or go off in directions that the teachers didn't know much about.
(Schneider 1993)

U. S. Students are unprepared to deal with real-world demands in science and math, even after 12 years of school. Far from being "first in the world in science and mathematics achievement by the year 2000," as projected By George Bush in September 1989, U.S. students rank near the very bottom of the industrialized nations in science and math achievement.
(Fisher 1992)

If students continue to think that truth comes only from the front of the room, and that learning is a product that can be standardized, we are going to end up with sheeplike, uninformed citizens who are not capable of conducting public debate on difficult issues. And that will leave the "solutions" to the spin doctors, advertisers, elites, and lobbyists. (Schneider 1993)

4. The education system was designed for a student population that is different from today's populations.

Historically, most efforts have focused on recruiting Hispanic, African-Americans, Native American or female students into the existing educational system, a system which was not designed by or for people in these underrepresented groups. Many students from underrepresented groups have said that they feel like outsiders in this system: a system which often is unable to utilize the richness and wisdom of their own cultures, experiences, and preferences. These students leave even after significant resources have been spent to recruit, train, and retain them.


39

REFERENCES THAT CLARIFY/SUPPORT:

Though it is trite to say that a white, male, hierarchical system has dominated higher education, teaching too often has reflected an authoritarian, detached, and competitive style that leaves little room for the views of women and other cultures. The traditional classroom, in which professors talk and students listen, tightens the restraints of this dominant cultural straitjacket. Such an environment robs teachers of the opportunity to learn what women and students of color have to offer and disregards the fact that their intellectual development can take different forms as a function of their gender and culture.
(Mendoza 1995; Meyers and Jones 1993 pg. 9)

A Native Alaskan teacher speaking on what she learned in teacher education courses: "I only learned how to teach white kids. I didn't learn one thing about teaching Native kids. It *is* different, you know. But I don't think they even thought about that."
(Delpit 1995 pg. 107)

For bilingual/bicultural students to be successful in the science classroom, they need to assimilate both linguistically and culturally to a white male dominated way of thinking and learning. Historically, many Hispanic/Latino children have encountered school-taught science concepts in a culturally unfamiliar manner as well as in an unfamiliar language.
(Barba 1993 pg. 1055)

Students from minority cultures, far from being culturally deprived, have rich and elaborate cultures. Their rich cultural characteristics are evident in their languages and communication styles, behavioral styles, and values. These theorists also contended that the cognitive, learning, and motivational styles of ethnic minorities such as Afro-American and Mexican Americans are different from those fostered in the schools. These students, therefore, achieve less well in school because the school culture favors the culture of White mainstream students and places students from other backgrounds and cultures at a serious disadvantage. The school environment consequently needs to be reformed substantially so that it will be sensitive to diverse learning, cognitive, and motivational styles.
(Banks 1988 pg. 453)

Science is seen by many students, of all ethnicities, as irrelevant to everyday life. Scientists are thought of as nerds, those that do science "act white."
(Laren 1995 pg. 15)

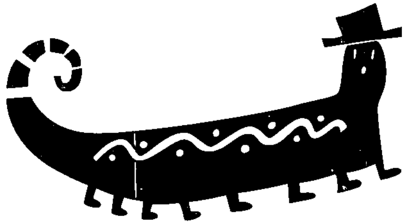
Course content tends to emphasize the White wealthy male experience.
(Grant 1989 pg. 2)

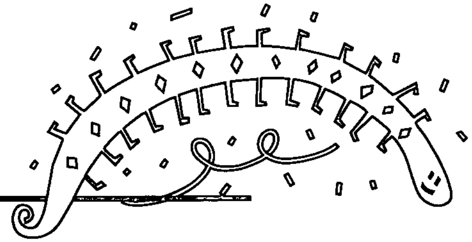
Among gender-equity advocates, there is willingness to acknowledge gender differences. Research shows differences for males and females on three of the major approaches to learning styles. Schools are geared more to the learning styles of white males, which tend to be individualistic and competitive. In contrast, many girls prefer cooperation over competition, acknowledging and building on others' ideas to define common meanings over individual contributions, and understanding over assessment.
(AAUW 1992, Clark 1994, Kalonji 1994, Kramaerae and Treichler 1990, Pearson and West 1991, Sandler 1982, Schwartz and Hanson 1992)

Pretending that women and men are the same hurts women, because the ways they are treated are based on the norms for men.
(Tannen 1990 pg. 16)

The classroom structure, designed to foster independent non-collaborative thinking, is most supportive of white male, middle-class socialization models, and it continues through university. It encourages sex-role stereotyped forms of communication — independence, dominance, assumption of leadership — in which males have been trained to excel. Women, conversely, feel uncomfortable and excluded in situations requiring such behavior; yet, their participation – as questioners as well as newly-minted authorities – may be critical to knowledge acquisition and school success. The importance that women place on mutual support, building collaborative knowledge, and applying it practically is devalued in comparison with the importance of individual expertise to males and their inclination to debate abstract concepts. (Ong 1981, Pearson and West 1991, Schwartz 1992)

A survey of 847 students at a state college showed that women and minority students preferred interaction style of learning along with peer conversations and writing course papers over classroom lectures. Male professors, who made up the majority of college teachers, preferred the lecture method of teaching. Thus women and





minority students had to adapt their learning styles to less preferable models, continuing the trend of a chilly classroom climate for them. (Ferguson 1992)

Even when the content of coursework includes issues of concern to women, strategies of teaching and methods of evaluation are rarely examined by faculty to see if they are compatible with women's preferred styles of learning. Usually faculty assume that pedagogical techniques appropriate for men are suitable for women.

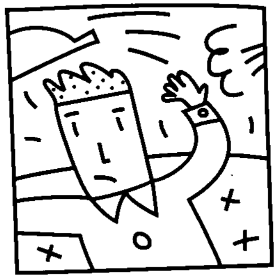
We believe that conceptions of knowledge and truth that are accepted and articulated today have been shaped throughout history by the male-dominated majority culture. Drawing on their own perspectives and visions, men have constructed the prevailing theories, written history, and set values that have become the guiding principles for men and women alike. Our major educational institutions – particularly our secondary and post-secondary schools – were originally founded by men for the education of men.
(Belenky et al 1986 pg. 5)

Usually, we are supposed to learn it the way men see it. Men move quickly to impose their own conceptual schemes on the experiences of women. (Belenky et al, 1986 pg. 202, Duras 1975 pg. 111)

The potential for bias on the part of male investigators is heightened by the recurring tendency to select exclusively or predominately male samples for research. This omission of women from scientific studies is almost universally ignored when scientists draw conclusions from their findings and generalize what they have learned from the study of men to lives of women.
(Belenky et al 1986 pg.6)

As slow as the improvement in numbers has been, my perception is that the improvement in the climate for women engineering students is moving at an even slower pace...the profession of engineering is still strongly male-dominated – in its instruction, its practice, its reward systems, and its social interactions. Engineering is definitely not as user-friendly for women as it is for men.
(Panitz Feb. 1995)

5. New Groups of Students Require New Teaching Methods.



The practice of trying to force students from underrepresented groups into an educational model designed by and for white males can be as difficult and unrewarding as trying to fit a round peg into a square hole. This strategy takes large amounts of resources, produces high stress, and ultimately can offer only a limited success rate especially when students have other career options. In addition, forcing students from any group to conform to a rigid model of any sort allows only a fraction of the students' potential, interest, and contributions to emerge.

REFERENCES TO CLARIFY/SUPPORT:

Women and culturally diverse students are growing in numbers on many campuses, bringing with them differing ideas and needs for their education that challenge old ways of teaching. (Meyers and Jones 1993 pg. 7). Many of us need to expand our teaching skills. In doing so, we can meet students on their own turf and stretch their ability to approach learning in different ways, all of which seems vital as our students bodies grow in diversity. (Meyers and Jones 1993 pg. 155).

A paradigm which assumes uniformity in standards for teaching, learning, and research is ill-suited to promoting diversity, whether it is based on gender, race, culture, or any other set of constructs. (Fried 1995)

Certain people of color differ in their world views and cognitive styles form those held by the dominant culture. (Gollnick and Chinn 1990)

Research has demonstrated that students have different learning styles. Whereas we might wish to treat all students the same, regardless of ethnic origins, the reality is that we fail to provide them with the best education when we do. (Rakow and Bermudez 1993).

During my training in science, I learned that there was one right answer, one correct interpretation of the data. My teachers lectured with the voice of authority imparting knowledge. They presented the current theories as established facts, as "the way things are" — information to be mastered rather than interpreted.

A scientist was interviewed who felt that the social experience of most women and minorities had taught them to doubt authority, and that this kept them from doing well. (Shepherd 1993 pg. 137)

Native American students often perceive mathematics as calculating, obsessive, sloppy, isolated, and interpersonally out of touch with the real world. This image conflicts with attributes Native Americans value. (Megginson 1990)

Unless conditions change, Hispanic and African-American representation in higher education and in science professions is not likely to improve. (Trankina 1992 pg. 235)

6. New Strategies for Incorporating Diversity in the Classroom Are Needed.

New methods offer additional options to teachers who want to support diversity. New choices can augment techniques that have presented problems in the past. (*See references below.*)

REFERENCES THAT CLARIFY/SUPPORT:

Given the time demands of the discipline, the sequential nature of courses, or the articulated expectations that are necessary to complete successive courses, such as math and science, it may not be possible to fully integrate a multicultural view in every course in every discipline.

Without changing the substance of their courses, teachers can change elements of their style and of the atmosphere they set in the classroom, and trust that such changes will have a significant impact on students. All courses can be adapted to fit a multicultural climate.
(Academic Senate 1995, Herrmann 1993, Brush 1980)

Making direct efforts to enlighten non-minority students about the cultural biases of their perspectives can negatively affect a teaching career. Student learning which occurs in this area is both cognitive and affective and is therefore very difficult to grade in any traditional fashion. This upset can provoke negative comments about the instructor's teaching skills and the quality of the course. (Fried 1995)

The majority of people that are in a position to encourage, foster, and modify the achievements of Hispanic Americans are Euro-Americans, who have little knowledge of the Hispanic American culture or problems that face Hispanic American young people. (Rakow 1993, Delpit 1995, Grossman 1984 pg. 7&16)

At a time when America's classrooms are beginning to reflect the significant increases in minority populations already apparent in the general populations, the teacher candidate pool is becoming increasingly white. The National Retired Teachers Association reports that by the year 2000, minorities will account for only 5% of public school teachers compared to 12% today.
(Zapata 1988)

Learning about culture can support views of non-dominant cultures as Others. (Fried 1995)

Talking about diversity issues directly can be risky for faculty. During a study of women at a major university, several faculty members and graduate students declined to comment on sexism in their departments for fear of making the situation worse. "There is definitely a backlash going on," one professor said. "People are tired of hearing about this issue even though it's not gone away." (James, 1996)

7. The Skills Needed in the Workplace Are Changing.

The actual jobs of engineers and technologists of today have expanded past the limited view of technology as only bridges, powerful machines, faster computers, and more powerful weapons. Scientific and technical professions now are doing work that involves a broad range of physical, environmental, and social sciences. (McIlwee and Robinson 1992) People need skills that reach beyond the technology itself, such as working in groups, making technology appropriate for the needs of society, communicating effectively, and successfully addressing environmental and global issues.

REFERENCES THAT CLARIFY/SUPPORT:

Soon after moving from industry to academe, I decided to survey my friends in industry to be sure I was covering the "right" material. The survey told me: courses lack balance; overuse of computations destroy students' literacy in a discipline; students need to know previous work; I need to help students conceive design as a compromise, emphasize problem-solving skills, teach the power of teamwork and communication. (Mason 1994)

We must incorporate uncertainty in our education, as that is part of real technology and its design. (Hazelrigg 1994)

In the process of technical design, the diverse parts of the "given-world" of the scientist and the "made world" of the engineer are reformed and assembled into something that divorces itself from science and marries it to art. (Petroski 1992)

The organization of science is becoming more flexible as the boundaries between fields become more permeable. As a result, employers place high value on engineers who can communicate, collaborate, and work across disciplines. (Griffiths 1995 pg. 29)

Chapter Two: Why...

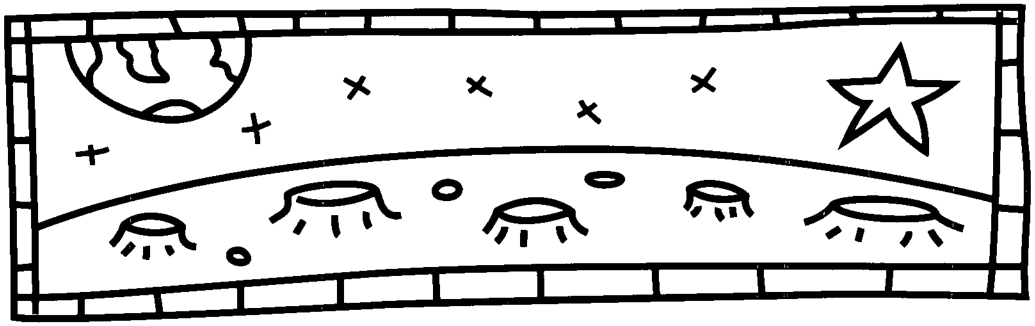
Many of the priorities and learning styles prevalent in underrepresented groups are in alignment with the expanding skills required of the workforce of the 21st century. For example, cooperative work groups and holistic, "big picture" thinking trains students for the workforce of the future. (Culotta 1994, Fitzgerald 1995, Sarantos 1994)

When technical leaders are interviewed, they consistently ask for additional skills and knowledge to meet the challenges of the ever-changing complex global environment. A panel of four corporate executives and a National Science Foundation Director made the following observations in November, 1994 about the technical workplace: (Educating 1995)

- We're looking for:
  - A systems perspective
  - Technical skills and their application
  - Writing and presentation skills
  - People who can think beyond the box, beyond traditional curriculum

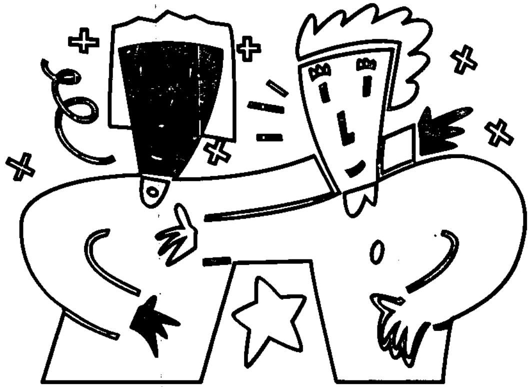
- People have to be able to work together and function in teams. Of particular importance are conflict resolution skills – being able to get a group consensus
- We need good communicators; we need people with good interpersonal skills (said by several panelists); you don't get that in traditional curriculum

The opinions of the panel members are echoed by others in other articles, referenced in this chapter and in our appendix.



CHAPTER THREE: UNDERREPRESENTED GROUPS

39



CHAPTER THREE: UNDERREPRESENTED GROUPS

Even though students from underrepresented groups are an ever-increasing percentage of our student populations, their cultures and learning styles many times are not included in our educational system. In fact, these cultures and styles are often actively excluded and ridiculed.

Instead, the standard programs teach students from underrepresented groups how to fit in, how to navigate their way through the current system. These educational institutions were created decades ago for a different population. This traditional population is only a small subset of the students we now want to attract and retain in our educational system.

Students who are African American, Hispanic, Native American and female have unique contributions to make to the science-based professions. They have characteristics and perspectives which can enhance the teaching and practice of science. However, the environment must allow and support these differences or their unique contributions cannot emerge.

Chapter Three examines the educational environment for these students:

1. Students must learn to survive in the current system

2. Survival skills

3. Different styles: what is missing?

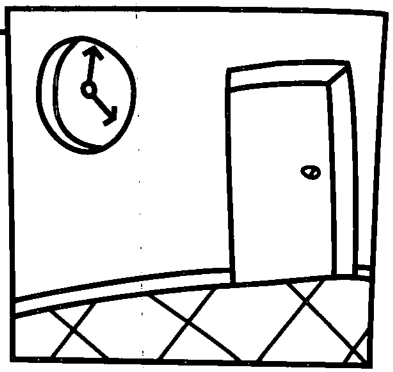
1. Students Must Learn to Survive In the Current System

During the past decade, significant efforts have been made to increase the participation and achievement of women and underrepresented minority students in scientific and technological careers. (Rakow and Bermudez 1993) Historically, most efforts have focused on recruiting more non-traditional students into the existing educational system. This system, however, was not designed by people in underrepresented groups.
(Grant and Sleeter 1989)

The prevailing solution that is used to increase the participation of underrepresented groups is to teach students how to deal with and move through the existing system. Because many educational institutions and classrooms remain inflexible, the students must reject their own learning styles, methods of communication, and perspectives and then mold themselves into different models in order to complete school.
(Barba 1993, Ferguson 1992, Grossman 1984, Schiele 1991, Shepherd 1993)

REFERENCES THAT CLARIFY/SUPPORT:

Strategies include "big sister" programs that pair first-year women with upperclass women, special study groups, lectures, junior and senior high school outreach programs, and separate "math and science" residence halls for women. Yet despite these efforts, the total number of women in engineering hasn't increased since 1983. Therefore, some say, more radical steps are in order. (Emmett 1992)



41

Programs which teach students to find their way through the current system can benefit students. (Anderson 1993, Ferhs and Czujko 1993, MacKay 1995, Panitz 1995, Rodrígues 1993) However, teaching only survival skills can yield only a limited return. (McCurdy 1992)

Our progress will likely plateau at levels lower than desired if students who are recruited are uncomfortable, leave the professions (in school or later), and also tell other potential students about it. (Baker 1994, Trankina 1992) The schools need satisfied "customers" who communicate their positive experience to their friends and family. It is much easier to build a program by positive word-of-mouth and "repeat" business than to have to market to all new customers/students.

42

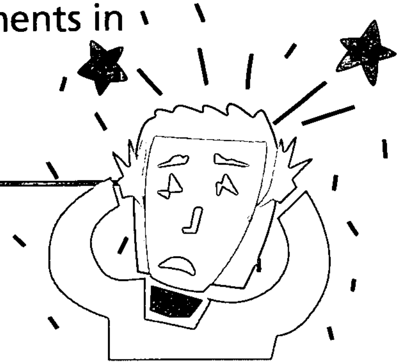
Although a woman's grades in college suggest that she mastered the masculine mode, she felt that it really never quite "took." Someday she hopes to master it. (Belenky et al 1986 pg. 199)

To many senior members of the profession, being a scientist meant jumping into a world where toughness is a virtue, colleagues are for competing with, students had to sink or learn to swim, and signs of "femininity" were better kept hidden. But more and more of the younger women scientists of today are questioning whether science has to be that way. They are beginning to envision a time when a critical mass of women will be reached, and the rules themselves could begin to change. They are eager "to change science" rather than changing women" until they fit this funny mold that has been created in their absence." (Barinaga 1993)

Women are leaving careers in science and engineering at almost double the rate of men according to a National Research Council. (Levander 1994)

2. Survival Skills

The existing system has taught that many aspects that are important and valued by underrepresented groups, such as feelings and holistic thinking, are inappropriate for science and scientists. Students who discuss or use such methods can be ridiculed. (Barinaga 1993, Schwartz 1992) Many students from underrepresented groups make personal adjustments in order to survive in the educational system.



REFERENCES THAT CLARIFY/SUPPORT:

Many Hispanics students at our college, which has a high Hispanic population, learn to be rigid and give up themselves to study engineering. (Martinez 1995)

Women are afraid that if they discuss the possibility that they are doing science differently, it will be assumed that the science they are doing is not as good. (Barinaga 1993)

Many studies show that male-female conversations are more like men's conversations than they are like women's. So when women and men talk to each other, both make adjustments, but the women make more. Women are at a disadvantage in mixed-sex groups, because they have had less practice in conducting conversation the way it is being conducted in these groups. This may help to explain why girls do better at single-sex schools, whereas boys do about the same whether they go to boys' schools or coeducational ones.

A professor commented on how pleasant she found it to work on all-women committees, as compared to the mixed-gender committees she was more used to. But when she made this observation at a mixed-gender dinner party, a man strenuously objected. He said he had noticed no differences between all-male committees and those that included women. This man was surely telling the truth as he experienced it, because when women and men get together they interact according to men's, not women's, norms. So being in a mixed rather than a same-gender meeting makes less difference to men than to women. (Tannen 1990 pg. 235-7)

At times, particularly in certain academic and work situations in which adversarial interactions are common, women may feel compelled to demonstrate that they can hold their own in a battle of ideas to prove to others that they, too, have the analytical powers and hard data to justify their claims. However, they usually resent the implicit pressure in male-dominated circles to toughen up and fight to get their ideas across.
(Belenky et al 1986 pg. 146)

Women in engineering have successfully made themselves genderless. They feel like they must be seen as professional engineers. Women in other disciplines say, "I am a woman and I am a scientist and I bring something special to my science."

Women engineers are divorced from that. They don't even recognize that they can say they have a gender, both to themselves and to others. It takes two hours in any conversation with a group of engineering women before they can recognize that something is different about them from a male engineer; and that that's okay. Maybe even positive.
(Geppert 1995 pg. 44)

The stories many women told began when authorities attempted to inflict their opinions in areas in which the women believed they had a right to their own opinions. The conflict was between the absolutist dictates of the authorities and the women's own subjectivism. At the time the women experienced the conflict not as an invitation to growth but as an attempt to stifle their inner voices and draw them back into a world of silent obedience.
(Belenky et al 1986 pg. 88)

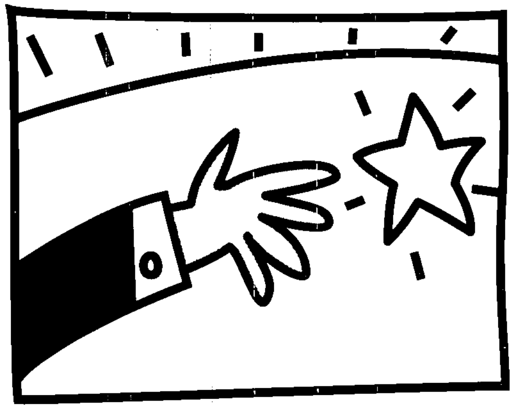
Those history books just said, "The Russians set up camp at Ruby" [an Alaskan village]. Nowhere did they talk about how they killed Natives for sport or stole women from their families and forced them to get married. My own aunt was one of those women. They (the professors and students) just couldn't see the other side. Finally, in all my classes I just gave up and decided to learn what they said to learn, so I could get out. If they said 2+2=5, I learned that. If they said Christopher Columbus discovered America, I regurgitated it back to them.
(Delpit 1995 pg. 108)

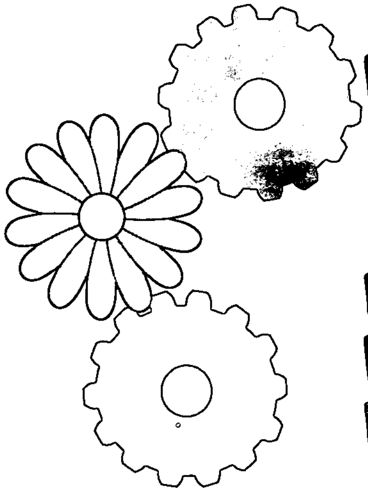
An African-American elementary teacher comments on her teacher education experience in a predominately white institution: White people want black people to be humble, to be grateful they gave them a bit of time. Usually I just can't do it, but I should have gotten the Academy Award for my performance. So the joke started then and went on for four years.
(Delpit 1995 pg. 106)

3. Different Styles: What Is Missing?

Many members of underrepresented groups have particular styles and preferences that are absent in the common classrooms of math, science, technology, and engineering. In fact, several of these *missing* styles and preferences are common characteristics of students from *all four* underrepresented groups: Native Americans, African Americans, Hispanics, and women. Of course, one must be careful not to stereotype all members of this group as being the same.

Many teaching techniques which have been well-researched and evaluated can be used to add diversity and balance into the classroom environment. (O'Neil 1995, Meyers and Jones 1993) Activities such as active learning, cooperative groups, design and open-ended problems, as well as inclusion of a variety of learning styles can be used.





PART II

Pac-TEC Problem Definitions and Problem Solutions

The Pac-TEC project focused on the development of new teaching techniques for science, math, engineering, and technology through the mechanism of studying students from underrepresented groups. This extensive analysis of the problem has led to the Problem Definition (specifications) which begin in the following chapter. These specifications describe characteristics of solutions that will successfully address the problem.

We focused on the criteria or specifications that describe a solution but we did not include solutions that are suitable for all teachers. We know that each classroom is unique. Therefore, the Pac-TEC project has developed criteria that can be implemented in a large variety of classroom situations.

Even though the Pac-TEC project developed its own solutions, we emphasized the definition of the problem. Using the specifications contained in the Problem Definitions, teachers can then create their own solutions that are applicable to their own classrooms.

This manual includes some solutions that we developed and ones that we found in the literature. These examples can be used as illustrations or guides, and hopefully will encourage teachers to use these specifications to develop their own solutions for their own classrooms.

Pac-TEC
Problem Definition

PRESENTS THE WORLD AS A DYNAMIC SYSTEM OF INTERCONNECTIONS AND DISCOVERY

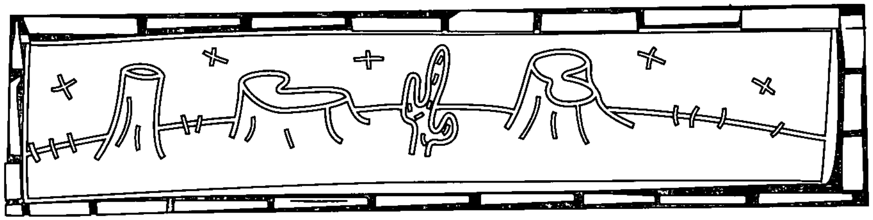
Allows a Discovery Process and Acknowledges Uncertainty in Acquiring Knowledge.
The solution allows for false starts and detours whereby knowledge is acquired. Teaching materials illuminate and support the journeys to discovery along with the endpoints. Acknowledges that science is continually discovering new ideas and that scientific models are not the same as "truth."

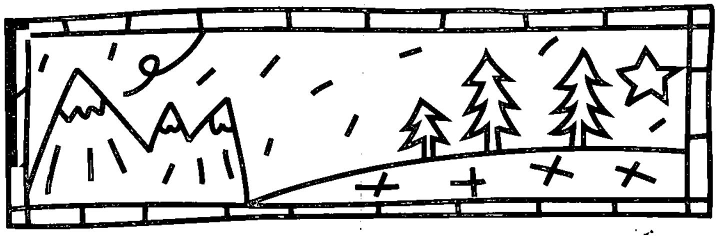
Includes Open Ended Problems.
The solution uses problems with multiple possible outcomes and routes to get to those outcomes. The entire solution must not be known (to the teacher) at the beginning. The solution provides a variety of tasks with conclusions that are not pre-determined.

Insures Subjects are Alive and Holistic.
The solution emphasizes the wholeness and wonder of the human experience where there is a connection between living and non-living systems. The solution develops understanding and mastery of whole systems thinking and synergetic behavior among the components of the system. The solution teaches whole concepts, rather than discrete separate skills and isolated information The solution avoids presenting information out of context.

Explores Technology's Role in Society.
Solutions emphasize that technology is one of many choices, and there are good and bad consequences associated with it. Low-tech or intermediate-tech examples are included as well as technology use in a variety of cultures. Military, aggressive, or destructive models or examples are omitted.

Promotes Social Interaction and Human Interconnections.
The solution includes social interactions, interpersonal relationships, fellowship, and community as part of teaching methodology. Solutions value interconnections between humans and with other parts of nature.





Pac-TEC Problem Definition

CREATES A SAFE, STIMULATING ENVIRONMENT

Develops a Comfortable Classroom Environment.
The environment is physically comfortable, nurturing, safe, inviting, and friendly to non-traditional students. It's O.K. to reach and fail; it's safe to ask questions and be tentative or wrong; a student is not criticized, put down or dismissed. The students' intelligence is respected. Information builds on prior knowledge, wisdom, and experience, constructed from student awareness.

Supports a Cooperative Learning Environment.
The solution uses and develops cross-curricular partnerships that model cooperation for students; emphasizes and nurtures collaborative learning environments with interdependency of group members; motivates by affiliation rather than competition.

Vitalizes Physical Space.
The classroom (a) is constructed and decorated with various inviting colors/textures, (b) includes items, colors, and decoration styles that reflect the students' cultures, (c) contains sufficient flexible space for free movement of students and furniture (d) promotes collaborative groups and reflects community, (e) has varied shapes, especially rounded and curved, (f) has hanging items, (g) contains natural lighting and indirect lighting, (h) is visually peaceful, inviting, but stimulating, and (i) allows student and instructors to interact (j) nature is included. Suites of room are interconnected. Technology tools are peripheral to the focus of the learning space.

Embraces Collaborative Conversation Styles.
The solution uses and encourages the use of a exploratory, non-linear, collaborative, and non-hierarchical conversation mode; enlightens students on defensive word-warrior dynamics of typical classrooms. The solution puts concepts in a story format.

Uses Technology Tools Holistically.
Technology tools are only a part of the solution process, not a topic unto itself; they support learning and doing. Students direct the use of technology in solving problems, keep ownership of their learning process, and personally validate their results. The use of technology tools requires human interactions or dialogues; technology tools bring people and/or various topics and subjects together, rather than isolate them. Technology that incorporates violence is not used.

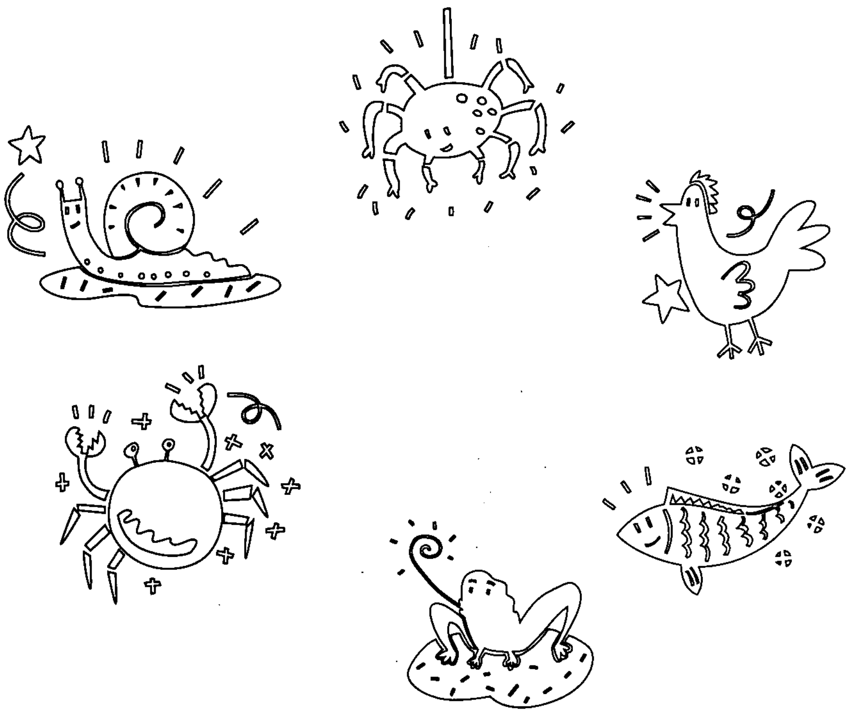
Pac-TEC
Problem Definition

EXPANDS THE PARTICIPANTS PERSPECTIVES

- **Promotes Multi-perspectives.** The solution presents a new way of looking at something in the students' current life. Students look outside traditional paths and environments to solutions. Multiple perspectives close in on truths.

- **Integrates Family and Community.** The solution integrates the family and the outside community into the classroom, is sensitive to balancing family roles with learning; promotes desired behavior by community affiliation rather than authority.

- **Encourages the Use of Original Resources.** The solution includes primary source readings (not the textbook), such as scientific reports, non-fiction, fiction, interviews, etc. The readings and writings are used to elicit student responses (oral, written, and artistic) that are personal or analytical. The mind is initially expanded, not contracted. Personal experiences and opinions of students are valued.



Adapts to Diverse Learning Styles. The solution is inclusive of a variety of learning styles. Teachers and students assume the roles of facilitator, coach, student, and lecturer at least once during the semester.

Uses a Variety of Assessment Tools. The solution includes frequent evaluation by more than one different assessment tool. The assessment includes the learning styles of "right-brain" groups. Stakeholders agree on clear criteria for assessment.

Pac-TEC
Problem Definition

MOTIVATES STUDENTS TO PERSONALLY EXPERIENCE AND INTERPRET MATERIAL

Engages Students.
Students are actively engaged in the process; no lecture only curriculum. Students feel good about accomplishing an activity. Student-teacher contacts and roles are expanded. Student engages more than the mind in the education process.

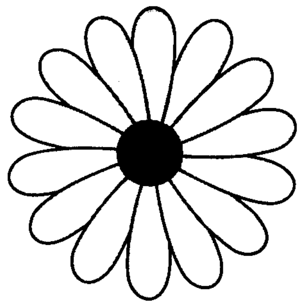
Encourages Reflection.
The solution encourages students to discuss and evaluate their work. The solution gives students the opportunity to reflect upon, revisit and revise their work during quiet time.

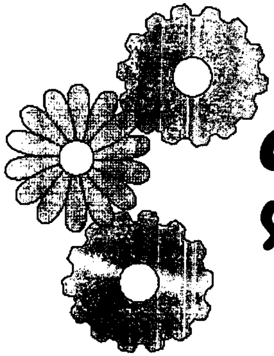
Relevant to Students.
The solutions provide connections with real-life contexts that reflect home environment, as well as social, political, and economic conditions of the real world. Students' life experiences and previous knowledge provide a foundation for learning and exploring the subject matter.

Involves Working in Groups and Develops Interpersonal Skills.
Students (a) help to achieve the goals of a cooperative group, (b) communicate well with other members, (c) make sure the group works well together, or (d) take on a variety of jobs within a group.

Values Feelings and Intuition.
Feelings, sense of belonging, and intuition are valued. Solutions factor in the emotional component of intelligence.

56





Chapter Four: Presents the World As A Dynamic System of Interconnections and Discovery

- Allows a Discovery Process and Acknowledges Uncertainty in Acquiring Knowledge
- Includes Open Ended Problems
- Insures Subjects are Alive and Holistic
- Explores Technology's Role in Society
- Promotes Social Interaction and Human Interconnections

CHAPTER FOUR: PRESENTS THE WORLD AS A DYNAMIC SYSTEM OF INTERCONNECTIONS AND DISCOVERY

A Solution Allows a Discovery Process and Acknowledges Uncertainty in Acquiring Knowledge.

The solution allows for false starts and detours whereby knowledge is acquired. Teaching materials illuminate and support the journeys to discovery along with the endpoints. The solution acknowledges that science is continually discovering new ideas and that scientific models are not the same as "truth."

REFERENCES THAT CLARIFY/SUPPORT:

Textbook authors and teachers don't talk to students about their many trials and errors the first time they look at certain problems, or about how much mathematics they learn in the course of the struggle itself. We get the impression that they can do math instantly and with ease. It would help to know more specifically how math experts cope with problems and what they do when they forget what to do. Those insights might reveal the skills really needed in mathematics.
(Tobias 1987 pg. 11)

Sometimes the math teacher contributes to math anxiety. If the teacher claims to have had an entirely happy history of learning math, she may contribute to the idea that some people – specifically she – are gifted in mathematics, and others – the students – are not. A good teacher, to allay this myth, brings in the scratch paper she used in working out the problem, to share with the class the many false starts he had to make before solving it.
(Tobias 1993 pg. 53)

Most of us are so busy 'covering the material' that we miss the chance to 'uncover it' with our students." Eleanor Duckworth in "The Having of Wonderful Ideas" (1972) quotes Dawkins.
(Meyers and Jones 1993 pg. 14)

SOLUTIONS

New Styles. It is important to note that any subject ca taught in a way that is congruent with any style. A lite lesson in which students put themselves in the place of author and imagine a different ending, a history test i which they put themselves in the place of a President imagine another way of winning a war, a science assig for which they design an experiment. (Sternberg 1990

Creativity Tithe. I'd like to propose a "creativity titl that 10% of classroom time be devoted to encouragi individual initiative and creativity. Creative dialoguir way to get kids involved again in the education proc like to propose that the education process be reinvig by rewarding teachers who aren't afraid to risk lettir say what they think, and who aren't afraid to say th don't have all the answers. I can't think of anything more promise for the future than a teacher who, in a dialogue with kids, is willing to say to a student, "I don't know the answer to your question, but how do you think we might find it together?" (Schneider 1993)

So long as teachers hide the imperfect processes of their thinking, allowing their students to glimpse only the polished products, students will remain convinced that only Einstein–or a professor–could think up a theory.

The problem is especially acute with respect to science. Science is usually taught by males and is regarded as the quintessentially masculine intellectual activity. And science is taught – or, at least, it is heard by students in most introductory courses – as a series of syballine statements. The professor is not indulging in conjecture; he is telling the truth. And, in one of the most shocking statements in all our hundreds of pages of transcripts, a student concluded that "science is not a creation of the human mind."

One of our most sophisticated science students we interviewed said in an interview during her first year at college that you had to "accept at face value" anything a chemistry professor said. By her senior year Simone had come to realize that the professors had been talking not about facts but about models, although they presented the information as if it were fact. (Belenky et al 1986 pg. 215)

The voice of the scientific authority is like the male voice-over in commercials, a disembodied knowledge that cannot be questioned, whose author is inaccessible. (Fee 1983 pg. 19)

SOLUTIONS

Ideas:
Students create a musical instrument from everyday recycled materials.

Students write a commercial to promote a consumer product, including the reasons the public will buy it.

Students design and build a composting toilet, after specifying the criteria for success of the product.

Students use yeast to make bread rise, brew beer and make vinegar.

Students paint an abstract picture that shows the exertion of the human body while running.

Students create art using only objects found in nature.

Students attempt to design and build a perpetual motion machine.

A man complained about what he and his friends call women's "shifting sands" approach to discussion. These men feel that whereas they try to pursue an argument logically, step by step, until it is settled, women continually change course in midstream.
(Tannen 1990 pg. 92)

Scientific theories can never provide a complete and definitive description of reality. They will always be approximations to the true nature of things. To put it bluntly, scientists do not deal with truth; they deal with limited and approximate descriptions of reality. (Capra 1982 pg. 48)

Twentieth-century physics has shown us very forcefully that there is no absolute truth in science, that all our concepts and theories are limited and approximate.
(Capra 1982 pg. 57)

A Solution Includes Open Ended Problems.

The solution uses problems with multiple possible outcomes and routes to get to those outcomes. The entire solution is not known (to the teacher) at the beginning. The solution provides a variety of tasks with conclusions that are not pre-determined.

REFERENCES THAT CLARIFY/SUPPORT:

Engineers put things together to make things that haven't been around before. To accomplish this, they must work with people, resources, and policies, and they must consider social needs. Yet as we all know, since World War II, engineering education has been fairly reductionist and analytical. Students really haven't been trained to look at open-ended dilemmas. We ask them to solve problems we already know the answers to. (Educating 1995)

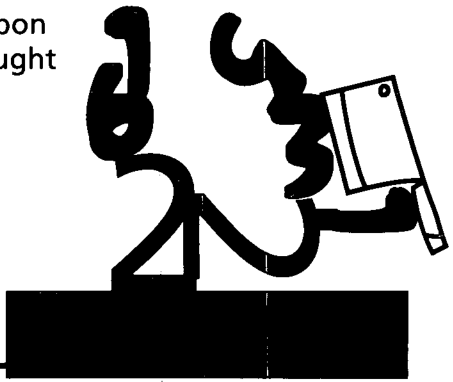
Women embrace technical problems more generously than men. We consider, for example, the appeal of a product as well as its usefulness, the ease of the handling of a product as well as its functionality, and the alternative applications along with the design applications. Women, because we are women, often bring additional priorities to the table. Engineering would be quite different if there were more women engineers. (Panitz 1995)

SOLUTIONS

Open-ended Problems in Math.
Teachers change questions, so that instead of there being one correct answer there are many possible correct answers. A traditional math problem, such as "what percentage of the chairs in the room are blue?" has one correct answer. In contrast, a problem which states "find examples of objects in your life that make up 20% of a whole" has many answers. These open-ended math problems become personalized to students' lives by encouraging students to create their own solutions from their own experience.

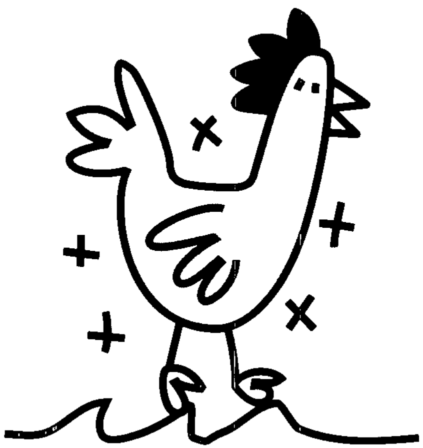
Mathematical Sculpture. One of the problems for many students who study mathematics is that the concepts are often too abstract and lack visual or tangible models to help them construct meaning. To encourage students understanding of complex, yet essential mathematical concepts, teachers have their students sculpt, in three dimensions, an abstract mathematical property (examples: associative property of multiplication, addition property of equality, commutative property of addition or multiplication, etc.).

Materials for the project can vary and may lead to some interdisciplinary collaboration with art and industrial arts departments. Assessment of the project can be based upon how successfully the sculpture reflects the students thought process, as assessed by a variety of "judges."



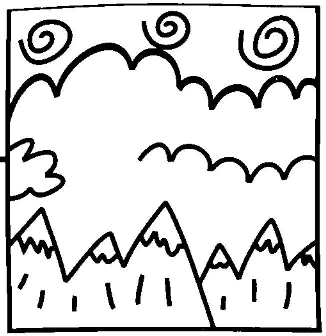
SOLUTIONS

Walk on water. Student interest and motivation in science is often increased through participation in the solution of a challenging problem that involves a good deal of fun. One such activity is having students design, in groups, solutions to the problem of being able to walk on water. To help facilitate the problem-solving process, teachers give their students materials which are usually associated with non-floating behavior and ask them to manipulate the materials shape so that it can float. Lumps of clay are excellent for this activity. While performing this task teachers ask their students to apply what they learned toward designing a special set of "shoes" that will allow them to walk on water. Teachers encourage the development of form and function and creativity. The class hosts the water-walking event in either early fall or during the spring months when the weather is warm.



A Solution Insures Subjects are Alive and Holistic.

The solution emphasizes the wholeness and wonder of the human experience where there is a connection between living and non-living systems. It develops understanding and mastery of whole systems thinking and synergetic behavior among the components of the system. The solution teaches whole concepts, rather than discrete separate skills and isolated information. It avoids presenting information out of context.



64

REFERENCES THAT CLARIFY/SUPPORT:

The systems view looks at the world in terms of relationships and integration. Systems are integrated wholes whose properties cannot be reduced to those of smaller units. Instead of concentrating on basic building blocks or basic substances, the systems approach emphasizes basic principles of organization. Examples of systems abound in nature. Every organism – from the smallest bacterium through the wide range of plants and animals to humans – is an integrated whole and thus a living system. What is preserved in a wilderness area is not individual stress or organisms but the complex web of relationships between them. (Capra 1982 pg. 226-7)

All these natural systems are wholes whose specific structures arise from the interactions and interdependence of their parts. The activity of systems involves a process known as transaction–the simultaneous and mutually interdependent interaction between multiple components. Systemic properties are destroyed when a system is dissected, either physically or theoretically, into isolated elements. Although we can discern individual parts in any system, the nature of the whole is always different from the mere sum of its parts. (Capra 1982 pg. 226-7)

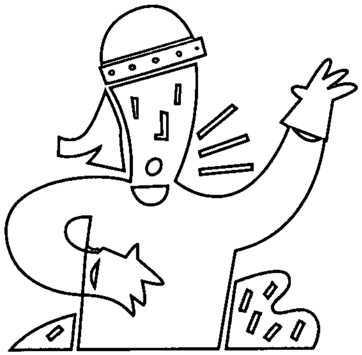
A careful analysis of the process of observation in atomic physics shows that the subatomic particles have no meaning as isolated entities but can be understood only as interconnections, or correlations, between various processes of observation and measurement.

Subatomic particles, then, are not "things" but are

SOLUTIONS

Storytelling Rituals. Storytelling is used by the world's cultures to disseminate history and tradition. For example, in many cultures the elders transmit their knowledge to the young in the form of stories and ritual trials. These experiences, gained by the young during their ritual apprenticeships, are added to the original stories and thus history and tradition are united giving the culture identity and continuity. To show the continuity and evolution of ideas in science, teachers can use storytelling and rituals in the classroom to teach the origins and development of global science and technology.

Isaac Newton once said "I may have been able to see further than most men, but it is because I stood on the shoulders of giants." It is important to show how ideas in science have been developed over time by incorporating the contributions of all those who came before us. Establishing origins, continuity, and change are essential for understanding the scientific and technological traditions of the world. Teachers can encourage and help facilitate this understanding by having their students develop rituals that help them construct meaning in the science and technology curriculum.



interconnections between "things," and these "things," in turn, are interconnections between other "things," and so on. In quantum theory you never end up with "things," you always deal with interconnections. (Capra 1982 pg. 80-1)

The emergence of organic patterns is fundamentally different from the consecutive stacking of building blocks, or the manufacture of a machine to produce a product in precisely programmed steps. Nevertheless, it is important to realize that these operations, too, take place in living systems. Although they are of a more specialized and secondary nature, machine-like operations occur throughout the living world. The reductionist description of organisms can therefore be useful and may in some cases be necessary. It is dangerous only when it is taken to be the complete explanation. Reductionism and holism, analysis and synthesis, are complementary approaches that, used in proper balance, help us obtain a deeper knowledge of life. (Capra 1982 pg. 267)

Some children develop a habit of focusing on the global characteristics of a problem rather than on its particulars; others do the reverse. Ideally, a student would be flexible enough to do either. Since schools traditionally give more weight to analytical approaches than to holistic approaches, however, the student who does not manifest analytical habits is at a decided disadvantage. (Hilliard 1989)

SOLUTIONS

66

Environmental Beauty. Students need environments that stimulate creativity and reflection. They also need to relate learning and education to areas that are outside the confines of the conventional classroom. To accomplish this goal, teachers have their science classes create areas of beauty on campus through the planting of trees and other plants with benches for sitting. Walkways with areas for fragrant plants and plants with vibrant colors can be incorporated into the design. A pond or running water connects different areas. Each graduating class adds to the landscaping as part of an annual gift that future generations of students will enjoy and build upon. The design and maintenance of these gardens become a focus for interdisciplinary studies as well as a bridge to develop strong school-community-industry partnerships.

Aging and Longevity. The media blasts our senses with information on aging, but much of that information is incomplete, superficial, and tainted with misconceptions. Nonetheless, students have a genuine interest in aging and longevity. Teachers capitalize on student interest by exploring the factors contributing to the aging process. One way to accomplish this is by correlating these factors with longevity statistics from cultures around the world. Students can then look for patterns with respect to stress, technology use, and relationship with the natural environment.

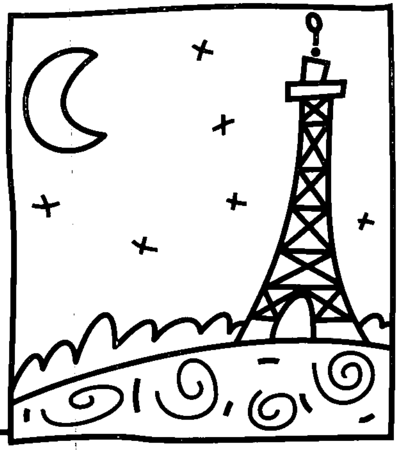
Afro-Americans process information from the environment differently than do other groups. Afro-American people tend to view things in their environment in entirety rather than in isolated parts. They tend to approximate concepts of space, number, and time rather than aiming at exactness or complete accuracy. (Shade 1982)

Isolated studies showed that Afro-American children seemed to have difficulty placing visual material into the more discrete groupings. Afro-American children tended to sort lists on a functional basis while Euro-American children used the more descriptive taxonomic approach. (Shade 1982 pg. 227-8)

It is necessary to explore humanistic and holistic approaches of knowledge delivery to Native American students. Central to this approach is the recognition that Native American world views emphasize the importance of grasping the "big picture" before one set about studying particular things or

SOLUTIONS

Soap Opera Sonata. Teachers create discovery stations in a science classroom for experimenting with altering the shapes of soap bubbles. The class relates these bubble shapes to architecture and develop a cultural theme; for instance, how do other cultures approach structure and form? Students relate these findings to function and form in living systems (DNA, physiology, and ecosystems).



subjects. An important component of successful math instruction for Native American students is transforming the learning of mathematics from a purely abstract logical exercise to a subject with a history and applicability to the complex web of life. (National Science Foundation November 1994, Wildcat 1993)

Women respond more energetically when problems are put in the context of helping people or the environment. It's not that women aren't interested in engineering. It's a question of context: Women aren't so interested in engineering as a technical matter, but as a practical matter. (Alper 1993, National Science Foundation November 1994)

A suggestion for instructing Hispanic students is to de-emphasize analysis of detail in favor of global perception. (Grossman 1984)

"Arithmetic is usually taught as all scales and no music." – Persis Herold (Tobias 1993 pg. 168)

SOLUTIONS

Avoiding Decontexualized Text. Like Native Alaskans, African-Americans placed the value of context far above that of decontextualized "text."

Looking at what happened with Native teachers and children in classrooms, where the expected and approved instruction often ran counter to community expectation, helped me better understand some points of classroom cultural conflict. Jerry Mohatt, a psychologist who has worked and conducted research in many Native American communities, has captured on videotape an interesting set of interactions contrasting an Anglo teacher in a classroom of Native children, and a Native American teacher in a similar setting.

What's interesting to me is the frequency with which the Anglo teacher's words do not match his actions: he frequently directs the children to do something while he is physically engaged in a completely different task himself. For example, he says, "copy the work from the board" while he is away from the blackboard looking through his desk for something or other.

The Native teacher, by contrast, almost always matched her words with her actions: if she says, "copy the words," she is at the blackboard pointing. The Anglo teacher asks that the children attend to what he *says,* not what he does; the Native American teacher, on the other hand, supports her words in related physical context. What gets *done* is at least as important as what gets said.

(Delpit pg. 98 1995)

A Solution Explores Technology's Role in Society.

Solutions emphasize that technology is one of many choices, and there are good and bad consequences associated with it. Low-tech or intermediate-tech examples are included in the solution as well as technology use in a variety of cultures. Military, aggressive, or destructive models or examples are omitted.

REFERENCES THAT CLARIFY/SUPPORT:

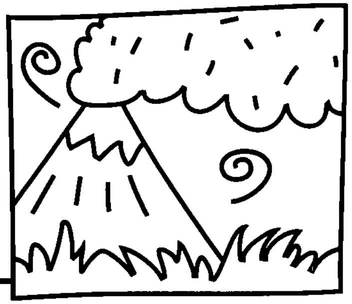
Most Western biologists–college trained, usually white, and usually lacking direct knowledge of the environment or cultural group they are researching–will tend to view wildlife as a resource, and the harvesting of animals as strictly an economic activity. They adopt the capitalist terminology of "maximum sustainable yield." (the number beyond which a herd might begin to diminish). The biologist essentially acts as a resource manager, like a corporate functionary, whose goal is to maximize production and contribute to profit. No effort is made to become sensitive to alternative views stemming from native traditions and culture.

To native people, animals are never viewed strictly in quantitative terms, or as "resources." They are part of a web of living systems that includes relationships among themselves and between them and human beings. These systems are passed on among natives through historical teachings and stories; they are further articulated through religious rituals; and they are part of native systems of social structures, status, and psychology. The ebbs and flows of the animal populations, therefore, are inseparable from the continuous activities of the people. While it is possible that the scientific "maximum sustainable yield" might turn out to be very close to the numbers of animals the Natives finally kill and use, the conceptual relationship to the animals , and process involved in making those decisions, are entirely different.
(Mander 1991)

Our mythology has been that native peoples live with the awful oppression of "subsistence economics"–a term that by its mere utterance invokes feelings of pity and images of squalor. Our machines, our technology, and our superior systems of economic management offer freedom from back-breaking labor, the opportunity for leisure, and protection against the arbitrariness of nature's cycles. Pre-technological peoples, living hand-to-mouth in a never-ending search for food and protection

SOLUTIONS

"Small is Beautiful" Chemistry. Colorado State University does "small is beautiful" chemistry. Small scale chemistry is cheaper, for one: CSU's costs for "consumables" in student labs has dropped, from more than $50,000 a year to less than $5,000. "Molecules are extremely small, and 50 billions of them do the same as 5000 billion," says Director Stephen Thompson. Then there's the waste disposal advantage. And best of all, students are forced to work with small-scale equipment draw large-scale lessons they won't forget. I want the students to see the relationships. For example, Thompson's students analyze a chemical not with a $15,000 gas chromatograph but with a 25-cent contraption that they build themselves using such low-tech gear as clothes pins and syringes. "Steve is trying to take the black-box mentality out of science and show that it's what's inside the black box that matters. (Cohen 1994)



from the elements, need and want what Western society brings. So goes the story.

Given this logic, most Westerners are shocked to find that the majority of native peoples on the earth do not wish to climb onto the Western economic machine. They say that traditional ways have served them well for thousands of years and that our ways are doomed to fail. (Mander 1991 pg. 246)

The assertion that technological society is something higher than what came before, and that it is bound to bring us a better world, has lately fallen open to grave doubts. The Industrial Revolution is about a century old, and we have had ample time to draw a few conclusions about how it is going. It is not too soon to observe that this revolution may not be living up to its advertising, at least in terms of human contentment, fulfillment, health, sanity, and peace. And it is surely creating terrible and possibly catastrophic impacts on the earth. (Mander 1991 pg. 7)

Western experts have often been criticized for imposing their sophisticated technology on "undeveloped" cultures. For example, while serving in the Peace Corps in Africa, marine biologist Rebecca Hoff observed how, instead of digging unexciting but functional wells, many projects put in big fancy water systems that quickly became white elephants. No one asked the women in the village (who were responsible for providing water to their families) what they needed or how it fit into their lives and culture. After a few months, the villagers could no longer turn the spigot and expect water to flow. They needed to buy and import diesel gasoline to operate the pump. Even with fuel, no one was trained to maintain the water system, no one could fix it when it broke, and they had no access to spare parts.

SOLUTIONS

Computer games based on cooperation, fantasy and music. Choosing software deserves careful consideration. Many programs stress competition and violence. Girls often prefer cooperation, fantasy and music. They are more likely to be attracted to programs where they can work together to compose a poem, draw a picture or solve a problem. Consideration of girls' typical interests can benefit all students by offering the broader opportunities. It enables educators to avoid violence as a payoff in computer games used in the classroom. (Gilliand 1984)

Low-tech Chemistry. At Clemson, students used low-tech equipment, an economic necessity in some cases and part of a growing trend in chemistry. (Culotta 1994)

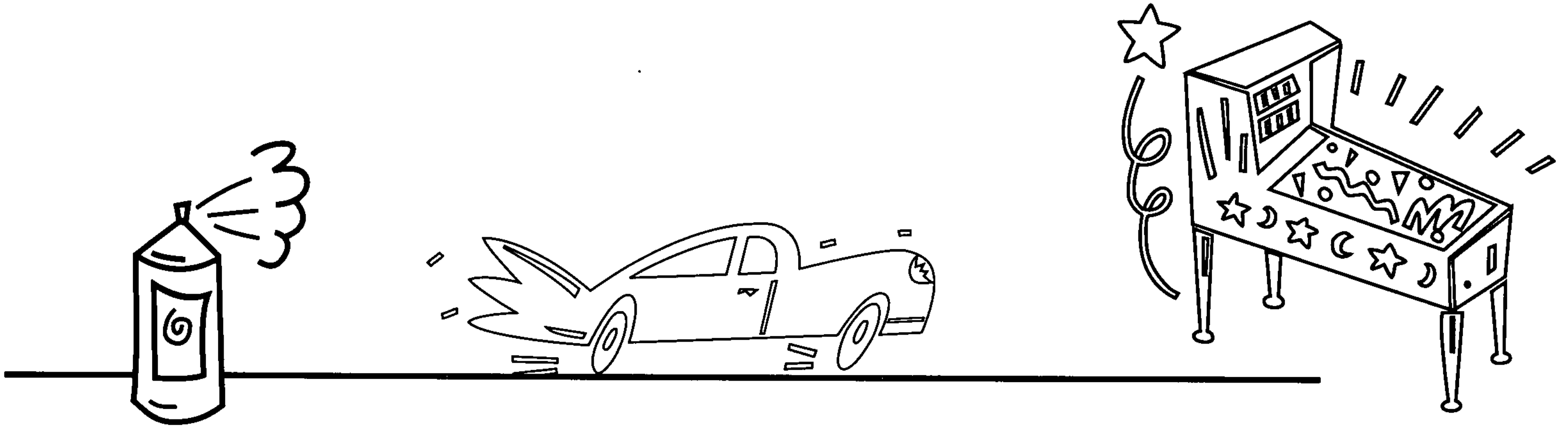
So the women returned to carrying parasite infested water for miles on their head. Wells were not glamorous, but they were practical.
(Shepherd 1993 pg. 150)

To return to a more human scale will not mean a return to the past but, on the contrary, will require the development of ingenious new forms of technology and social organization. Much of our conventional, resource-intensive, and highly centralized technology is now obsolete. Nuclear power, gas-guzzling cars, petroleum-subsidized agriculture, computerized diagnostic tools, and many other high-technology enterprises are anti-ecological, inflationary, and unhealthy. Although these technologies often involve the latest discoveries in electronics, chemistry, and other fields of modern science, the context in which they are developed and applied is that of the Cartesian conception of reality. They must be replaced by new forms of technology that incorporate ecological principles and are consistent with the new system of values.

Many of these alternative technologies are already being developed. They tend to be small-scale and decentralized, responsive to local conditions and designed to increase self-sufficiency, thus providing a maximum degree of flexibility.

SOLUTIONS

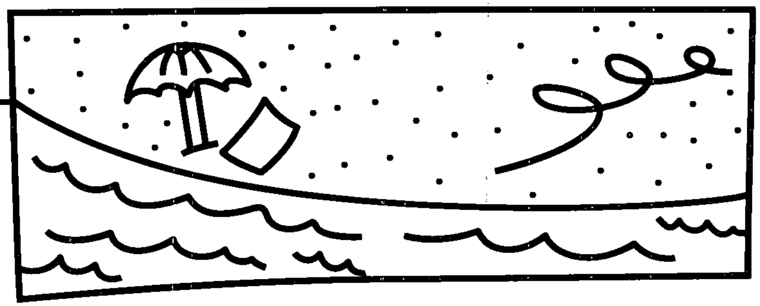
Value of Technology? Teachers ask their students to write an essay on how they will use technology 15 years later. (Gilliand 1984)



They are often called "soft" technologies because their impact on the environment is greatly reduced by the use of renewable resources and constant recycling of materials. Solar energy collectors, wind generators, organic farming, regional and local food production and processing, and recycling of waste products are examples of such soft technologies. Rather than being based on the principles and values of Cartesian science, they incorporate the principles observed in natural ecosystems and thus reflect systemic wisdom. As Schumacher has observed, "Wisdom demands a new orientation of science and technology towards the organic, the gentle, the non-violent, the elegant and beautiful." Such a redirection of technology offers tremendous opportunities for human creativity, entrepreneurship, and initiative. The new technologies are by no means less sophisticated than the old ones, but their sophistication is of a different kind. To increase complexity simply by letting everything grow is not difficult, but to recapture elegance and flexibility requires wisdom and creative insight.
(Capra 1982 pg. 399)

A Solution Promotes Social Interaction and Human Interconnections.

The solution includes social interactions, interpersonal relationships, fellowship, and community as part of teaching methodology. Solutions value interconnections between humans and with other parts of nature.



REFERENCES THAT CLARIFY/SUPPORT:

In a series of studies at the University of Alaska which sought to look at communication patterns and Native student retention, researchers found that the single characteristic that Native Alaskan students attributed to those professors they judged most positively was being "human." For those students, it was important to get a sense of the real human being playing the role of instructor.
(Delpit 1995 pg. 140)

Native Peoples tend to view nature as "being"; humans are seen as part of nature. in contrast, the dominant culture in the U.S. views nature as a "resource."
(Mander 1991 pg. 215-9)

As a geneticist, McClintock approached her object of study with reverence and humility. Rather than separate herself emotionally from her objects of study, she became intimately involved with her corn plants. In describing her work, her vocabulary is one of affection, kinship, and empathy, rather than that of battles, struggle, or a sense of opposition. She says, for example:

No two plants are exactly alike. They're all different, and as a consequence, you have to know that difference. I start with the seedling, and I don't want to leave it. I don't feel I really know the story if I don't watch the plant all the way along. So I know every plant in the field. I know them intimately, and find it a great pleasure to know them.
(Keller 1985; Shepherd 1993 pg. 70)

The women interviewed expressed their distrust of and alienation from science in a variety of ways:

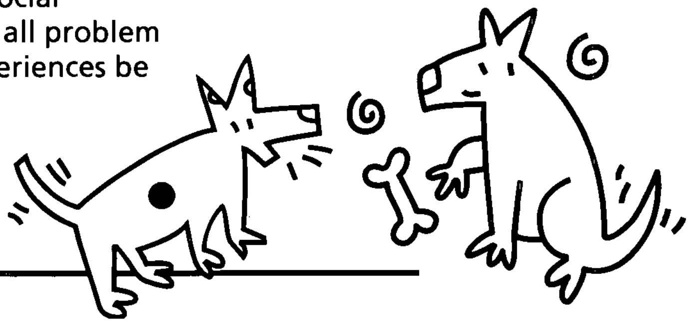
What's missing in science is a whole sort of human element. It doesn't seem to be infused with any morality. It doesn't even seem to be a world about people anymore.

I'm having a hard time with the premise that truth is scientific knowledge, because for me it isn't that at all. For me, truth is internal knowledge. I don't think we need scientific methods to ascertain what's right at all. I

SOLUTIONS

Integrate cooperative experiences into the existing curriculum. Research indicates that the competition associated with the traditional teaching of mathematics generates anxiety about math in many students. Math can present a conflict in values for female and racial and ethnic minority students who value cooperative social interaction, rather than competition, so some students choose to avoid subjecting themselves to mathematics when they can do so.

Creative problem solving is not an experience that requires competition with others. It is possible to present math content for small group problem solving while emphasizing cooperation and relying more on social interaction. This strategy does not suggest that all problem solving be cooperative, but the cooperative experiences be integrated with the existing curriculum.
(Institute for Responsive Education 1986)



think we need internal exploration and knowledge of self to know what's right and what is true.
(Belenky et al 1986 pg. 71)

Yet there is still a problem, one that has to do with how women view science: The science courses seemed dry and lifeless. This woman who dropped out decided she was a "people person." The students she knew who were majoring in science, she says, "were so dedicated to doing science that they didn't seem to have room for people in their lives." Science and engineering is viewed by many women as not being a good profession for women who are interested in working with people.
(Alper 1993 pg. 409, Sechi 1995)

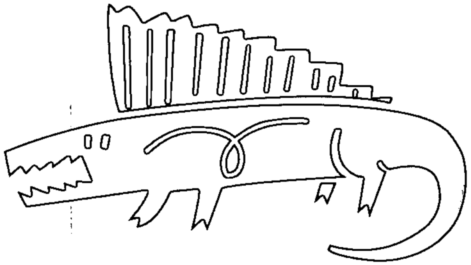
I was approaching the world as many women do: as an individual in a network of connections. In this world, conversations are negotiations for closeness in which people try to seek and give confirmation and support, and to reach consensus. They try to protect themselves from others' attempts to push them away. Life, then, is a community, a struggle to preserve intimacy and avoid isolation. Though there are hierarchies in this world too, they are hierarchies more of friendship and of power and accomplishment.
(Tannen 1990 pg. 25)

Connections between science and human beings are vitally important to women and they could serve as the link to attract more women and people of color

SOLUTIONS

Interview a character in a novel. Students select a character from science or math that has been depicted in a novel. For example: The Double Helix by James Watson. Students prepare an interview of the character to be performed in front of the class, providing insight and analysis of the character and his or her work.

Time capsule. Students create a time capsule with artifacts from a time in past, present, or future that coincides with math, science or technology.



and those white men not now attracted to science. Students in the traditional science classroom are the receivers of knowledge and have little opportunity to connect what they are learning to their own personal experiences or the real world. Insuring science and technology are considered in their social context with assessment of their benefits for the environment and human beings may be the most important change that can be made in science teaching for all people, both male and female. (Rosser 1990)

Chapter Five: Creates A Safe, Stimulating Environment

- Develops a Comfortable Classroom Environment
- Supports a Cooperative Learning Environment
- Vitalizes Physical Space
- Embraces Collaborative Conversation Styles
- Uses Technology Tools Holistically

77

CHAPTER FIVE: CREATES A SAFE, STIMULATING ENVIRONMENT

A Solution Develops a Comfortable Classroom Environment.

The environment is physically comfortable, nurturing, safe, inviting, and friendly to non-traditional students. It's O.K. to reach and fail; it's safe to ask questions and be tentative or wrong; a student is not criticized, put down or dismissed. The students' intelligence is respected. Information builds on prior knowledge, wisdom, and experience, and is constructed from student awareness.

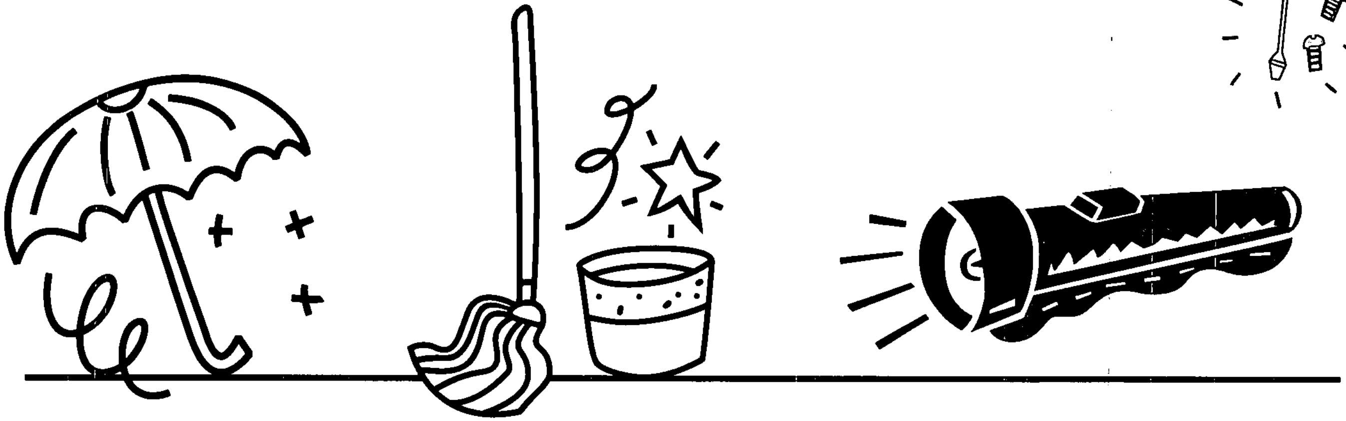
REFERENCES THAT CLARIFY/SUPPORT:

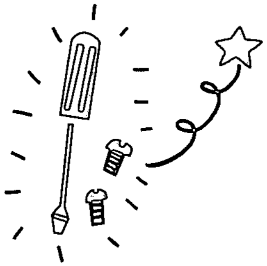
College students encounter the cold shoulder from science when they confront the do-or-die mentality of many science courses. Introductory science courses are often designed like initiation rites to eliminate the unworthy. Like the army, the objective is to separate the men from the boys. Surviving the course is a heroic achievement. Instead of motivating students by making science exciting and attractive, science professors announce to freshmen, "This is where you get weeded out."
(Shepherd 1993 pg. 159)

Science seems to place little value on things that make our journey through life more pleasant – comfortable surrounding, a cozy chat, helping a colleague – if they distract from the work. Modern science values efficiency, rapid generation of data, being first, critical review of ideas and theories, quick results...and progress. What could nurturing possibly have to do with science? At first glance it seems irrelevant, in another world apart from science. And that is precisely my

SOLUTIONS

Familiar Household Materials. Developing a curriculum that focuses on real-world problems may be useful in recruiting more women into science. Hands-on activities that use everyday household items may make science seem less intimidating. (Travis 1993)





point. Nurturing does not create instant rewards; it is a never-ending process. It requires patience and caring labor, connection to the object of care, empathy, compassion for the process of learning, gentle guidance, nourishing and protecting.
(Shepherd 1993 pg. 157-9)

Students want schools whose environments reflect order, beauty, and space and contain a wealth of materials and media. Everyone expresses a desire for clean, esthetically pleasing, physically comfortable spaces. They want to be served foods more typical of their homes and home cultures.

Students complain about lack of significant personal space, such as individual lockers, and overcrowding inside and outside classrooms. These problems make them feel unsafe and devalued.
(Poplin and Weeres 1993)

The women's college story is one or nurture, caring, discipline, high expectations, and appropriate rewards, all brought together in an environment that embraces the wholeness inherent in the academic, co-curricular, and extracurricular facets of the collegiate experience. Women's college graduates are more than twice as likely to receive doctorate degrees in any field.
(McCarthy 1994)

Because active learning frequently involves students in cooperative efforts – discussing, developing, and analyzing the contributions of others – rather than in isolated and competitive situations, the classroom becomes a more hospitable place for a variety of student perspectives. This context also invites teachers to reexamine old assumptions about the teaching and learning process and to try out new teaching strategies.
(Meyers and Jones 1993 pg. 5)

SOLUTIONS

Attracting Girls to Science. A variety of strategies teachers can use to increase the interest of girls in math and science are;

1) incorporate female role models who have been, or currently are, successful in science into the curriculum,
2) conduct class in cooperative groupings to breakdown competition,
3) Develop testing practices that create chances for self-confidence to increase.

For example, allow students to take a test, study their mistakes, then take a second test. Their final grade becomes

Over half of the Black engineers in this country come from historically black colleges and universities. (National Science Foundation 1993) If the historically black colleges and universities have taught us anything, it's that students will thrive if they feel nurtured and self-confident.

A 1991 study by the American Association of Science suggested that the biggest problem for underrepresented groups was the lack of a nurturing environment, especially at large research universities where the prevailing mentality is dog-eat-dog and faculty members worry more about grants than grading. The mantra of "only the best and the brightest will do" is hurting all students. They spend too much time trying to out-score their classmates and not enough time discussing the science with their peers. Courses that are seen as weeding out less qualified students may be tossing out both baby and bath water, especially when it comes to minority students and females. (Laren 1995 pg. 15)

Afro-Americans require a special antenna that helps them differentiate between situations and people. By being able to determine certain emotions, attitudes, and needed behaviors, Afro-Americans can determine which situations people are friendly and which are hostile. (Shade 1982 pg. 225)

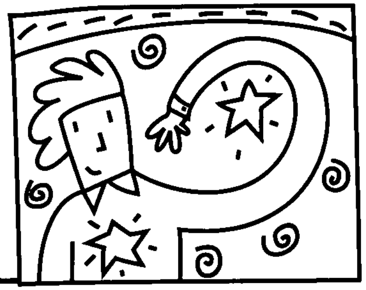
Child training mechanisms of the Afro-American kinship groups seemed to emphasize attending to cues and developing behavior that is compatible with learning to survive. As they receive status-oriented and inconsistent discipline, children learn to judge and adjust to moods of people in authority. At the same time, there exists a respect for the child as an individual, which permits the maintenance of a strong sense of an independent self. (Shade 1982 pg. 223)

Even when females do participate in classroom talk, their approach may suggest to teachers they have less command over the subject matter than males. Girls are more likely to ask questions, acknowledge the comments of

SOLUTIONS

an average of the two scores. This does not water down the difficulty but empowers the students. "By giving them self-confidence, they become more ambitious." Alot of these methods can be equally valuable to boys. (Asimov 1992)

Present Experience. A Native teacher explains, "I taught differently from the white teachers. I put a lot of Alaska into it. I taught the books, but I always put it in the present tense – showed the kids how what we read about was connected to me and to them...Some of the white teachers were very nice; it's just that they are so into the books, books, books."
(Delpit 1995 pg. 118-9)

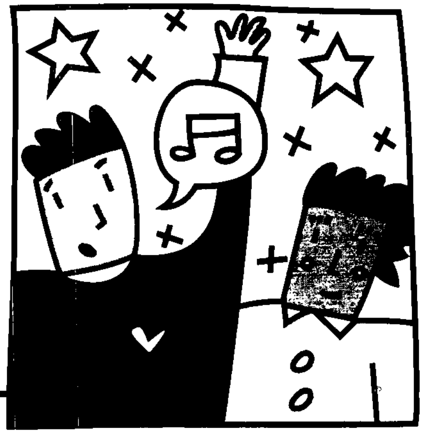


previous speakers, and refrain from interrupting exchanges in progress. In other words their classroom conduct is consonant with accepted sex-role behavior that compromises women's assertiveness. In comparing the participation patterns of males and females, teachers are apt to treat females' discourse contributions with less respect because girls exhibit less authority. In allowing classroom discourse to parallel sex-role differences in society, teachers unconsciously pass on negative expectations for girls. (Hendrick & Strange 1989, Schwartz and Hanson 1992)

Girls form leaderless groups, boys form hierarchies, Nancy Goldberger told a 1991 Educational Testing Service (ETC) conference. "Girls tend to see the role of peers as support. Girls acknowledge the uncertainty of knowledge and believe that peers, by listening to each other and sharing the floor, can create a relaxed and unpressured atmosphere in which disagreements can be addressed. Girls put less emphasis on reconciling disagreement than on understanding where others are coming from. Boys tend to see the role of peers as challengers and partners in argument. One speaks to show what one knows;

SOLUTIONS

Teaching Native Students. Studies of American Indians, while acknowledging individual differences, suggest that approaches to teaching that de-emphasize the distinction between lecturer and audience, provide opportunities for collaborative learning, tolerate some degree of silence, and include visual presentations of information and ideas, might make the classroom a more hospitable learning environment (Boseker and Gordon 1983, Browne and Bordeau 1991, Klienfield 1972, Meyers and Jones 1993).



one argues with others to sharpen one's position. Devil's advocacy is a strategy that is far more comfortable for and utilized by boys and men than girls and women." (Clark 1994)

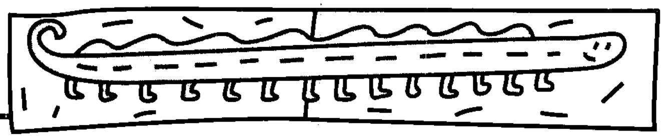
Women talk less in mixed groups and are interrupted more often. (Belenky et al 1986 pg. 17)

Cultural sensitivity to Native American values and behavior is crucial to successful classroom instruction. Direct eye contact, competitiveness, and boasting about oneself are taboos among most Native American peoples. (California State DOE 1991, National Science Foundation November 1994 pg. 40)

Teachers and administrators should strive to create a state of relaxed alertness in students. This means that they need to provide an atmosphere that is low in threat and high in challenge. (Caine and Caine 1990 pg. 69)

A Solution Supports a Cooperative Learning Environment

The solution uses and develops cross-curricular partnerships that model cooperation for students; emphasizes and nurtures collaborative learning environments with interdependency of group members; motivates by affiliation rather than competition.



REFERENCES THAT CLARIFY/SUPPORT:

Teaching too often has reflected an authoritarian, detached, and competitive style that leaves little room for the views of women and other cultures. The traditional classroom, in which professors talk and students listen, tightens the restraints of this dominant cultural straitjacket. Such an environment robs teachers of the opportunity to learn what women and students of color have to offer and disregards the fact that their intellectual development can take different forms as a function of their gender and culture. (Meyers and Jones 1993 pg. 9)

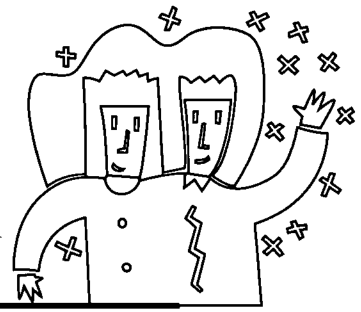
Mathematics, more than other subjects, is taught to students in isolation from one another. Flash cards, timed tests, and frequent exposure at the blackboard intensify that isolation and encourage competition. (Tobias 1993 pg. 79-80)

Research indicates that the competition associated with the traditional teaching of mathematics generates anxiety about math in many students. Math can present a conflict in values for female and racial and ethnic minority students who value cooperative social interaction, rather than competition, so some students choose to avoid subjecting themselves to mathematics when they can do so. Creative problem solving is not an experience that requires competition with others. It is possible to present math content for small group problem solving while emphasizing

SOLUTIONS

Sharing Equally. Teachers use procedures for making sure that each student gets a turn, that pairs of children working together learn to share equally, aside more hesitant ones, that computer use is not given only to the "bright" or to the "slow" child. (Gilliand 1984)

Seating for Cooperative Learning. Traditional rows of desks in a classroom create isolated learning spaces that tend to segregate students by ability. Various seating arrangements that cluster students have been developed and tested that support cooperative learning environments. (Kagen 1992)



cooperation and relying more on social interaction. This strategy does not suggest that all problem solving be cooperative, but the cooperative experiences be integrated with the existing curriculum.

Teachers and curriculum coordinators can revise most mathematics content to include cooperative experiences. Doing so acknowledges divergent learning styles, accommodates cultural values, and increases interaction within the math classroom. Cooperative experiences in the math classroom result in a sharing of approaches to solving problems. Students learn new approaches from their peers thus increasing their own repertoire of strategies.
(Institute for Responsive Education 1986 pg. 37)

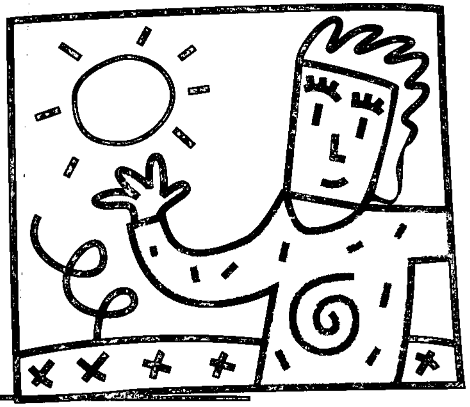
Plant physiologist Frits Went observes: "There is no violent struggle between plants, no warlike mutual killing, but a harmonious development on a share-and-share basis. The cooperative principle is stronger than the competitive one."
(Shepherd 1993 pg. 178, Went 1963 pg. 168)

In modern agriculture, weeds are considered to compete with the crop and so are eliminated by herbicides. Scientists at the University of California at Santa Cruz recently studied the traditional practices of Mexican farmers who prune back, rather than pull, a weed that commonly sprouts between rows of corn. Researcher found that the roots of the weed, *Bidens pilosa*, secrete compounds lethal to fungi and nematodes that destroy corn. The farmers simply trim the weed fifteen days after the corn emerges and every thirty days after that. Instead of competing with the corn, the weed controls the pests without significantly stealing soil nutrients from the corn. (Shepherd 1993 pg. 178, Corn's 1990)

What's most significant, perhaps, is that virtually all traditional tribal people share three primary political principles: 1) all land,

SOLUTIONS

The Power of Metaphors. Teachers encourage the use of vocabulary and metaphors in the science and math curriculum that are more inclusive of the entire human experience. In education, there is an emphasis on the vocabulary of sports and military metaphors that often excludes or alienates females. For example, the following comments are commonly heard as words of encouragement; "going the distance and tackling a problem." With computers, there is talk of commands, as if the wrong command will blow the thing up or kill somebody. By contrast, the word menu implies that you have a series of options and that if you make a mistake, you can choose another, which is a style more accessible to girls. (Clark 1994)



water, and forest is communally owned by the tribe; private ownership of land or goods beyond those of the immediate house hold is unthinkable; 2) all tribal decisions are made by consensus, in which every tribal member participates; and 3) chiefs are not coercive, authoritarian rulers, as we tend to think of them; they are more like teachers or facilitators, and their duties are confined to specific realms (medicine, planting, war, relationships, ceremonies). (Mander 1991 pg. 227)

In a community, unlike a hierarchy, people get to know each other. (Belenky et al 1986 pg. 221)

Research suggests that children of color value the social aspects of an environment to a greater extent than do "mainstream" children. In fact, these children are more effectively motivated by affiliation than by achievement or competition. (Delpit 1995 pg. 140)

Suggestions for classroom management techniques with Hispanics are to de-emphasize competition, utilize group participation and reward students for cooperative as well as competitive behavior. (Grossman 1984)

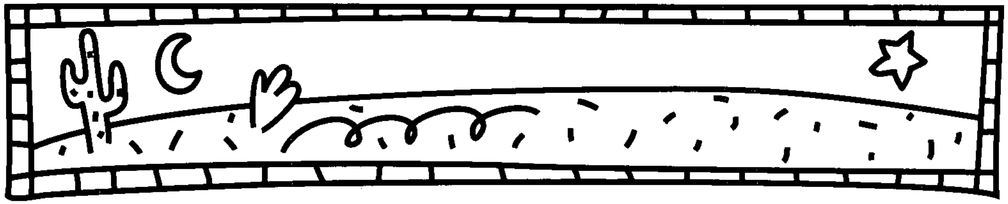
Hispanics tend to believe that it is bad manners to try to excel over others in the group or to attempt to be recognized for their individual achievement is an insult. Overt competition between individuals is discouraged. (Grossman 1984 pg. 223)

Researchers identified values common to the Mexican American culture. They found that Mexican American students preferred to work in groups whereas Euro-American students would rather work independently. Given the general climate of competition prevalent in American schools, it is reasonable to suggest that this factor alone may contribute to the poorer science scores of Hispanic students. What would be the effect of a cooperatively structured learning environment on the science achievement of Hispanic students? (Ramirez and Castaneda 1974)

In some successful programs for African Americans, school

SOLUTIONS

Working in groups. It is important to have techniques for checking on how well groups are working together and for ensuring that they composition of groups is conducive to teamwork and learning. For example, everyone speak once before someone can speak a second time. Also, ensure that groups are assessing how well they are working together to achieve their goal. One way of doing this in formal groups is to have groups answer two questions at the end of the class: "What is something that each member did that was helpful to the group?" and "What could each member do to make the group better next session?" (Eroclano 1994)



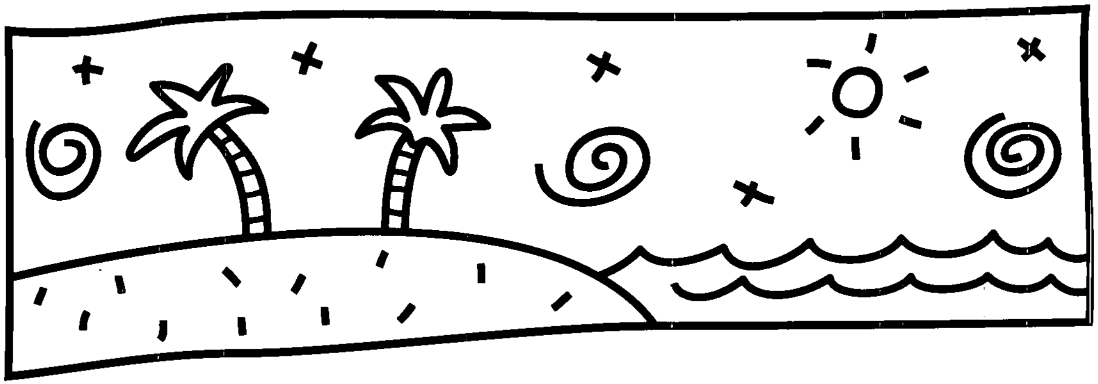
decisions were made by consensus rather than majority vote. In the voting process there are winners, losers, and often bad feelings; decision making by consensus led to the development of cooperative, collaborative ways of working rather than competitive, destructive, and harmful ways. (Comer 1989, p. 137)

One of the notable findings by the UCLA researchers was that women who attended smaller, more prestigious schools had the biggest decline in self-confidence – and the highest dropout rate. "The intense competition at these schools and the greater degree of contact with faculty were actually discouraging factors except in situations where there were large numbers of women students. The conclusion drawn by many researchers is that the presence of other women – creating a different environment from the competitive male domain of most science – is a key ingredient in women's success. And women's colleges do have a higher retention rate for female science majors than mixed schools. (Alper 1993)

Women learn more easily in a cooperative rather than competitive environment. While male students may thrive on competing, females prefer and perform better in situations where everyone wins.
(Shepherd 1993, Horner 1969, Shaver 1979)

Women may find themselves in a double bind: if they collaborate, they are seen as incapable of independent research; if they work independently, they lose the pleasure and benefits of interacting with others.
(Shepherd 1993 p. 198)

Engineering will never admit equal numbers of women as long as it remains principally a "male sports culture, a fraternity where even seemingly trivial comments can create a climate of intimidation and alienation." (Emmett 1992)



Because their imaginations are not captured by ritualized combat, women are inclined to misinterpret and be puzzled by the adversativeness of many men's ways of speaking and miss the *ritual* nature of friendly aggression. At the same time, the enactment of community can be ritualized just as easily as the enactment of combat. The appearance of community among women may mask power struggles, and the appearance of sameness may mask profound differences in points of view. Men can be as confused by women's verbal rituals as women are by men's.

Since recognizing these patterns, I have been amazed at how often men invoke the theme of aggression to accomplish affiliative ends. (Tannen 1990 pg. 150, 170)

Women are rooted in a sense of connection. In contrast to men's emphasis on separation and autonomy, women tend to define themselves in the context of relationships. Whereas men resolve conflict by invoking a logical hierarchy of abstract principles, women resolve conflicts through trying to understand the conflict in the context of each person's perspective, needs, and goals. (Shepherd 1993 pg. 35)

A Solution Vitalizes Physical Space.

The classroom (a) is constructed and decorated with various inviting colors/ textures, (b) includes items, colors, and decoration styles that reflect the students' cultures, (c) contains sufficient flexible space for free movement of students and furniture (d) promotes collaborative groups and reflects community, (e) has varied shapes, especially rounded and curved, (f) has hanging items, (g) contains natural lighting and indirect lighting, (h) is visually peaceful, inviting, and stimulating, (i) allows student and instructors to interact, and (j) nature is included. Suites of rooms are interconnected. Technology tools are peripheral to the focus of the learning space.

REFERENCES THAT CLARIFY/SUPPORT:

One day when I was discussing recruiting and retaining women engineering students with a local high school vice principal, I learned that her daughter was studying engineering at the Massachusetts Institute of Technology (MIT). This young woman had reported to her mother that even the rooms at MIT reeked of masculinity. I decided to make a tour of our classrooms. I found our engineering rooms undecorated, relatively joyless and stark, in contrast to the considerably more interesting rooms that women teachers call their own. By putting up calendars and posters and strategically placing a few plants, the rooms look more colorful, cheerful, and diverse. (Eagan 1994)

Researcher Harry Morgan documents in a 1990 study what most of us who have worked with African-American children have learned intuitively: That African-American children, more than white, and boys more than girls, initiate interactions with peers in the classroom in performing assigned tasks. Morgan concludes that a classroom that allows for greater movement and interaction will better facilitate the learning and social styles of African-American boys, while one that disallows such activity will unduly penalize them. (Delpit 1995 pg. 169)

Native Peoples have differences in architecture than Euro-Americans. Native tend to have space designed for communal activity. They have soft forms. The earth is not paved. In contrast, Euro-Americans tend to have space designed for separation and privacy, hard-edged forms, and earth covered with concrete. (Mander 1991 pg. 215-9)

People with right-brain styles tend to require sound (music, background conversation), tactile and kinesthetic learning, intake, and frequent mobility while studying. Students with left-brain

SOLUTIONS

Redecorate the Room. Each semester the class starts with the redecoration of the room. Students are grouped so that each identified area of the classroom has a group responsible for it. This project requires that the students take responsibility for their learning environment. Students will learn to cooperate with others to get their needs met in a work environment.

styles prefer bright light and formal design. (Dunn et al 1990)

Although "decorating the lab" sounds like a trivial issue, the traditionally nonpersonal lab environment reflects the compartmentalization of science itself, where the lab is exclusively a place for collecting scientific data. Anything else is considered to be irrelevant, distracting, and inappropriate.

In her study of high-energy physicists, anthropologist Sharon Traweek observed: "The physicists eschew any personal decoration or rearrangement of furniture that would differentiate their workplaces. This great visual uniformity, coupled with the clean, functional grey metal and glass decor of the building, creates a strong impression of stoic denial of individualism and great preoccupation with the urgent task at hand."

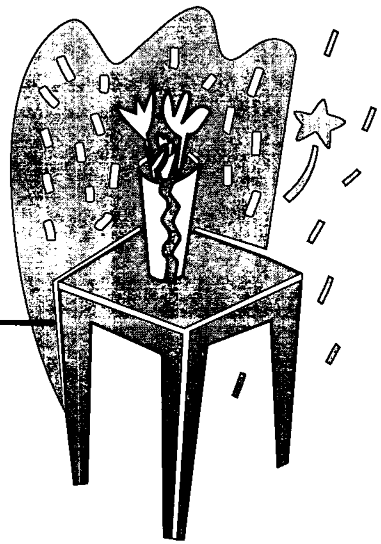
Anything personal is considered unprofessional. "Hanging things on the wall is frivolous, a waste of time," says the masculine voice in my head. "Art, family, community, hobbies, or political issues have no place in a laboratory. They get in the way of science. Science is serious business."
(Shepherd 1993 pg. 155-7, Traweek 1988)

The duality of the worlds at college were apparent to me both mentally and physically. One world, the engineering and science schools, were populated with mostly male students who attended classes in institutional-type buildings–some of stone and others of glass, plastic panels, and steel; some temporary gray-pained wooden barracks, others made of regulation slabs of concrete.

It seemed fitting that to get from the engineering department to the music department, I had to cross not only a mental bridge but an actual physical bridge as well. On the other side, across the gorge, the buildings were all quite different. Typically old Victorian houses that had been converted into teaching spaces, they were homey and informal, set into a wooded area surrounded by lawns and meandering paths. Here there were an equal number of men and women, and the teachers were much less formal in their dress and manner. (Herrmann 1993 pg. 4)

The Feminine Face of Science. Science laboratories and classrooms are often sterile and intimidating environments filled with hardware and technical manuals. These spaces can also reflect the fact that science and technology are human endeavors, and they need to be enlivened for creative work. For example, a woman visiting a number of scientists in their labs at the University of Washington in Seattle reported the following experience:

"In the halls of this department staffed partly by women, and containing about 50 percent women graduate students, I noticed that the bulletin boards reflected an integration of science with the community: amidst seminar notices were a Salvation Army sign-up sheet to adopt a family, petitions for pro-choice and death-with-dignity initiatives, and a volunteer sheet for a graduate student mentoring program.



SOLUTIONS

I was greeted by a woman scientist and taken to her office. She offered me my choice of tea brewed in a claypot or freshly ground coffee. While she found me a mug, I glanced about her office. All around me I glimpsed signs of her full and rich life: a picture of her daughter, postcards from friends, a schedule for a music festival next to a schedule for a cell biology meeting. Amidst technical books, journals, and notebooks of data were reminders of the beauty of nature–sea shells, sand dollars, and autumn leaves. A frog-faced clock humorously reflected her work on frog eggs. The side of her file cabinet framed a poster of young Einstein quoted as saying, "Imagination is more important than knowledge."

In her laboratory I immediately noticed that it was arranged communally by function, with stations for microscopes, electrophoresis, isotope labeling, and so on. The lab felt lived-in and productive. Speckling the walls between shelves of books and supplies were wildlife poster and postcards. A red plastic spider playfully stalked a recipe box of reagents by the pH meter. The plants on the windowsills blended with the rhododendrons outside the lab."

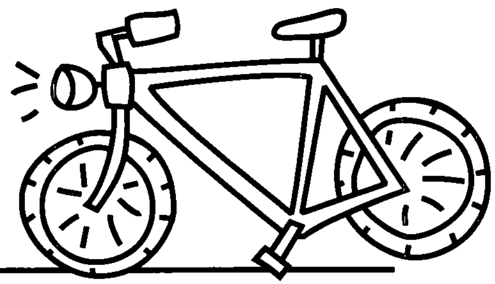
A lab such as this set the stage for a different style of interaction, a place where teachers and students can interact in a way that includes the whole person, not just the brain and pair of hands performing the experiments. (Shepherd1993)

SOLUTIONS

Anthropological Themes. To establish a classroom that is inclusive of diversity, teachers ask students, parents, and community members to bring in artifacts from theirs or other cultures and prominently display them throughout the room. The artifacts may include simple technology, masks, theater props, art, and musical instruments. These items may also be designed and built by students as part of a interdisciplinary unit on worldwide engineering and cultural perspectives.

SOLUTIONS

Bicycle Technology. Teachers and their students can create an exciting science and technology classroom simply by hanging bicycle parts (frame, wheels, tires, gears, sprockets, and chains) on the walls. Posters can be added which depict how cultures around the world use the principles of simple bicycle technology in everyday tasks. The students learn about the bicycle's universal appeal to accomplish other tasks (for instance, making wheelchairs or carts). One way to capture the essence of this appeal is to show how the materials that go into making bicycles come from different regions of the earth, showing that the bicycle is truly made from the earth. Teachers then correlate the materials and technological applications with a world map and sponsor a Bicycle Physics Olympic and Paralympic Games and perhaps schedule it with the national bike-to-work week.



A Solution Embraces Collaborative Conversation Styles.

The solution uses and encourages the use of an exploratory, non-linear, collaborative, and non-hierarchical conversation mode; enlightens students on defensive word-warrior dynamics of typical classrooms. The solution puts concepts in a story format.

REFERENCES THAT CLARIFY/SUPPORT:

For most women, the language of conversation is primarily a language or rapport: as a way of establishing connections and negotiating relationships. Emphasis is placed on displaying similarities and matching experiences. For most men, talk is primarily a means to preserve independence and negotiate and maintain status in a hierarchical social order. This is done by exhibiting knowledge and skill, and by holding center stage through verbal performance such as story-telling, joking, or imparting information. (Tannen 1990 pg. 77)

One reason many women find it difficult to get and keep the floor at meetings with men is that they won't compete for it. (Tannen 1990 pg. 237)

Imagine how often women who think they are displaying a positive quality – connection – are misjudged by men who perceive them as revealing a lack of independence, which the men regard as synonymous with incompetence and insecurity. (Tannen 1990 pg. 39)

Mary Catherine Bateson draws another parallel – between gossip and anthropology, the academic discipline that makes a career of documenting the details of people's lives. She recalls that her mother, Margaret Mead, told her she would never make an anthropologist because she wasn't interested enough in gossip. (Bateson 1984, Tannen 1990 pg. 97)

Suggestions for instructing Hispanic students are to not use debating, expressing opinions, and criticizing the opinions of others with students who are uncomfortable with these techniques. (Grossman 1984)

Mexican American and Afro-American students are more likely to be motivated by curriculum content that is presented in a humanized or story format than are mainstream Anglo students. (Banks 1988 pg. 465)

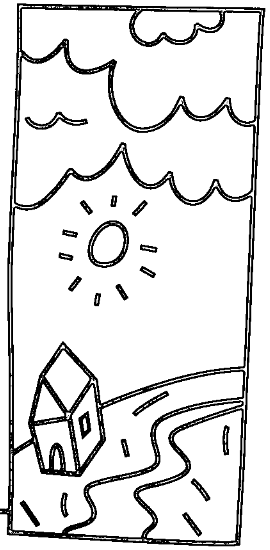
There is often a gross mismatch between the storytelling styles of African American children and those of their teachers. Many teachers from Eurocentric cultures have a linear storytelling style. Many African American children exhibit a spiraling style with many departures from an initial point, but with a return to make a whole. Many African children

SOLUTIONS

Being There. A Native Alaskan teacher commented to me that one of the most senseless rituals of schooling was the roll call: "We ask the children if they are here while looking at them!" But, of course, that conforms to the decontextualizing rituals of schools: we insist that children assert their existence through the *word*, their actual presence is insufficient.

This teacher, however, developed a different kind of ritual:

"What I do is to greet all the children in the morning and talk to them. I ask them how they slept and what they had for breakfast. I also ask them what they saw on the way to school. "did you see any clouds? Was the ground wet? Ooh, was it really cold out?" Every day I ask them about what they saw and pretty soon they begin to notice more and more because they know I'm going to ask. Then I can lead them to make connections – to learn that when a certain kind of feel is in the air then it will snow, or that when a certain kind of cloud is in the sky then the weather will change. They'll learn to learn from everything around them; they'll learn how to live in their place. And since I'm talking to them anyway, I'll mark them present! (Delpit 1995 pg. 99)



concentrate on many stimuli at one time rather than learning to concentrate on one. The misunderstanding of behavioral styles leads educators to misread achievement in academic subjects, such as creative expression. (Banks 1988, Delpit 1995, Guild 1994, Hilliard 1989, Shade 1982)

In studies, Afro-Americans seemed to develop a unique affective or personal orientation that manifests itself in attention to social cues, subjective meanings attached to words, preference for social distance, and sustained use of nonverbal communication. In studies, Afro-Americans tended to pay more attention to emotions displayed by people rather than their physical characteristics. Not only are Afro-Americans better at attending to facial cues, they also appear to detect different social reactions and nuances. (Shade 1982 pg. 221-2)

There is a sizable body of research reporting that during the course of conversation many African-Americans present information indirectly, through use of metaphor or reference to presumable shared experience. If listeners do not possess the background understanding needed to fill the gaps, accurate interpretation becomes a difficult task. (Delpit 1995 pg. 145)

SOLUTIONS

Town Council. To create a sense of collaborative work, teachers involve their students in a simulated council meeting centered around an environmental issue. Representatives from industry, science, community, and politics can be role-played. One of the goals of the council meeting is to develop strategies for solving problems using a conversation style that brings the different groups to a consensus.

Native Americans use stories a lot because they are a "gentler" way to teach than lectures or sermons. (Hurt 1996)

There is a great deal of evidence to show that speakers from many Native American groups typically recount an event by offering a series of perspectives on a topic, with the expectation that the *listener* should take on the responsibility of supplying background information, relating subtopics, and making relevant judgments. Western listeners, waiting for the speaker to "make the point," are often left confused by the conversation.
(Basso 1979; Delpit 1995 pg. 146)

There are also differences across cultures as to how long a speaker should be allowed to speak at one turn, the length of pauses between turns, and how to get the floor for a turn. Researchers have identified such barriers to communications between several Native American groups and Anglo-Americans.

In brief, the Native Americans usually expect to take long speech turns, and once getting the floor they expect not to be interrupted until all their points are made. The problems arise in part because the two groups have different notions about how long a pause is appropriate during one's turn and how long is appropriate *between* turns. (Delpit 1995 pg. 146)

Along with valuing context, Native Alaskan communities value children in ways that many of us would find hard to fathom. Non-Natives tend to think of children as unformed future adults. Non-Natives hear about the birth of a child and ask questions like, "What did she have?" "How much did it weigh?" and "Does it have any hair?" The Athabaskan Indians hear of a birth and ask, "Who Came?" From the beginning, there is a respect for the newborn as a full person.
(Delpit 1995 pg. 100)

The act of giving information by definition frames one in a position of higher status, while the act of listening frames one as lower. Children instinctively sense this – as do most men. Girls know how to issue orders and operate in a hierarchical structure; but they don't find that mode of behavior appropriate when they engage in task activities with their peers. They do find it appropriate in parent-child relationships, which they enjoy practicing in the form of play.

But when women listen to men, they are not thinking in terms of status. Unfortunately, their attempts to reinforce connections and establish rapport, when interpreted through the lens of status, can be misinterpreted as casting them in a subordinate position–and are likely to be taken that way by many men.
(Tannen 1990 pg. 46 & 139)

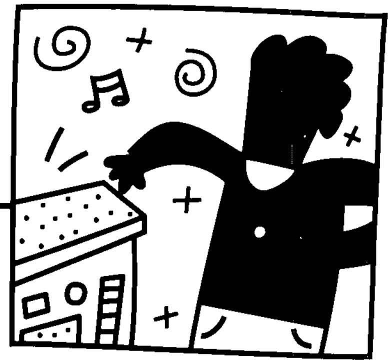
SOLUTIONS

Time Travel. Einstein once said, "Imagination is more important than knowledge." Imagine a gathering of famous scientists and mathematicians from different time periods and the conversations they would have with each other. Teachers have their students role-play the parts of these individuals and challenge them to solve a modern day problem using collaborative conversation and problem solving strategies.

Networking. The use of team building activities as ice breakers and as strategies for building high energy social interaction are effective. These activities transform passive interaction to active participation.

A Solution Uses Technology Tools Holistically.

Technology tools are only a part of the solution process, not a topic unto themselves; they support learning and doing. Students direct the use of technology in solving problems, keep ownership of their learning process, and personally validate their results. The use of technology tools requires human interactions or dialogues; technology tools bring people and/or various topics and subjects together, rather than isolate them. Technology that incorporates violence is not used.



REFERENCES THAT CLARIFY/SUPPORT:

Another way of thinking about how to incorporate computers into educational environment is to view them as tools that can be adapted to a wide variety of purposes in all subject areas – language, art, music, information gathering and organizing – in addition to their time-honored use in math, science, and technology. (Hawkins 1985)

The relationship to the environment is different for many Native Peoples compared to the dominant Euro-American culture. The Euro-American culture invests in high-impact technology created to change the environment and mass-scale development which yields a one-to-millions ratio in weaponry and other technologies. Native Peoples tend to honor low-impact technology, having a one-to-one ratio, even in weaponry. (Mander 1991 pg. 215-9)

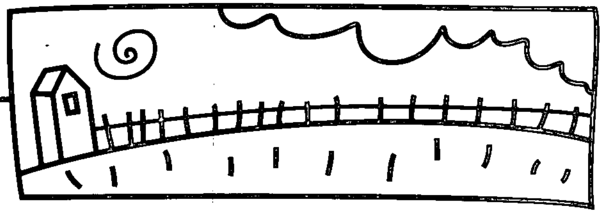
Too often, these game glamorize violence by rewarding it. These programs are unpalatable to most girls, and to many boys, and unacceptable to thoughtful educators.
(Gilliand 1984)

To get to the end of the game by killing everybody along the way just doesn't appeal to girls. At the lower grades, computer games have gotten much better. But when you linear get to junior high, its a different story. Even the educational games-this drives me crazy - tend to be very male-oriented. There's baseball math, all - star baseball, monster madness, where you have to kill the monsters to spell words. It's all dominance games where you have to trample someone. (quote from Gayle Beland) (Morse 1994 pg. 15-6)

SOLUTIONS

Antennas as an art form:
- Students compare antennas in nature such as insect antennas with other sensing devices.
- Students make a collage from magazine pictures and advertisements
- Students make antennas that are functional and allow them to make an artistic statement.

Toilet Technology. "From soft leaves to paper toilet tissue." Students ask each other what people did before toilets and toilet paper. Students interview people who remember earlier times. Students connect via the Internet with toilet manufactures and ask about their R&D and future designs. Students design a toilet of the future, considering the complete environmental impact. Students specify the parameters of a successful design and also design a toilet for living in a wilderness area.

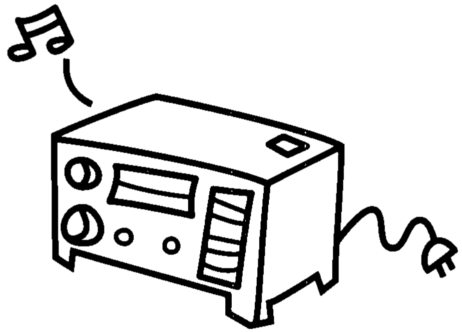


Girls seem to like computer applications that are useful. Whereas a boy will sit playing the computer for hours, girls tend to use computers to get something done. (Morse 1994)

Many factors in and outside the classroom result in girls' being turned away from computers. These factors include the media depicting men as experts in technology, societal expectations of different life goals for boys and girls, the structure of learning tasks, the nature of feedback in performance situations, and the organization of classroom seating. (LaFarge 1994)

Accoustics and Sound Technology:

- Students design and build a rock and roll sound stage or model of a symphony hall.
- Students invite a sound mixer to bring her equipment and show other students how it works.
- Students make boxes for their heads and line them with materials that have different sound properties; cotton wool to mirrors.
- Examples may come from bands, music, concerts, loss of hearing, deaf, hearing aides.



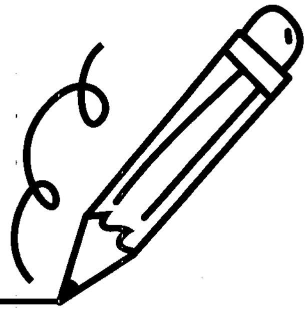
Creative Programming. Girls are fully capable of programming, although they are often turned off by its apparent regimented nature. Teaching programming as a creative process with many solutions can entice girls, as can integrating computers into the curriculum and using them for a variety of reasons. (Koch 1994)

Female Entreprenuers. Teachers build computer activities around girls' interests. For example, teachers have girls use computers to launch imaginary businesses. (Morse 1994 pgs. 19-23)

SOLUTIONS

Use English as a Foundation for Programming. High school teachers examine computer science classes for bias. Is advanced math, a subject more frequently taken by boys, used as a prerequisite for programming classes? Would English serve just as constructively? Is it possible to base some of the programming on language content rather than on mathematics content? Such a change might attract a new segment of the high school population to computer science classes. (Gilliand 1984)

Tools as Technology. Students brainstorm three lists: tools that existed 100 years ago, 500 years ago and 1000 years ago. Students consider both physical and intellectual tools, build a feeling for the development and persistence of technology over the ages. Some examples: Consider the role and place of tools in society to judge the effectiveness and generality of new tools. The Roman legal system and the hammer have persisted for thousands of years. Double entry book keeping has lasted 500 years in its original form.



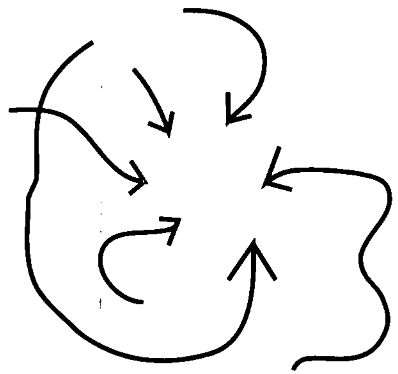
Chapter Six: Expands The Participant's Perspective

- Promotes Multi-perspectives
- Integrates Family and Community
- Encourages the Use of Original Resources
- Adapts to Diverse Learning Styles
- Uses a Variety of Assessment Tools

CHAPTER FIVE: EXPANDS THE PARTICIPANT'S PERSPECTIVES

A Solution Promotes Multi-perspectives.

The solution presents a new way of looking at something in the students' current life. Students look outside traditional paths and environments to solutions. Multiple perspectives close in on truths.



103

REFERENCES THAT CLARIFY/SUPPORT:

The rise of civilization
is directly related
to our ability
to be rational,
theoretical,
and abstract.

And so, teachers and
parents try
to help their children
to grow up, to be more
abstract.

But learning is not all
cognitive.
It is not all theoretical.
There is more to growing
up
Than increasing
rationality.

While it is very important
to do,
it is not all there is.

Real education means
more.
(McCarthy 1987 pg. 13)

SOLUTIONS

Archaeoastronomy. Astronomy provides opportunity of access to all cultures around the world. Interest in ancient astronomy is a powerful means for promoting science in communities of all ethnicities, because it illustrates the universal character of science. Ancient astromony as viewed by diverse cultures reveals the connection between science and world views in different cultures. It puts present-day technological differences between societies into a world historical context and it allows for interdisciplinary integration of science and technology curriculum with the humanities. (Whitlock 1995)

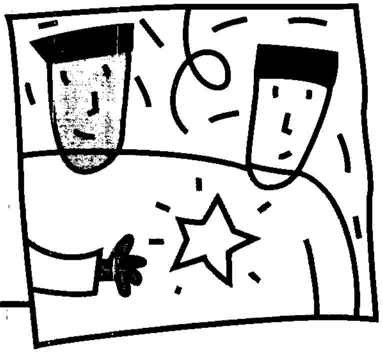
Multicultural Simulations. In schools with diverse populations, teachers have their students from different cultures, or who represent different perspectives, write simulation games, films, poetry or fiction related to the math and science curriculum. These assignments enhance student understanding of diverse perspectives. (Fried 1995)

Whether we are immediately aware of it or not, The United States is surely composed of a plethora of perspectives. I am reminded of this every time I think of my friend, Martha, a Native American teacher. Martha told me how tired she got of being asked about her plans for Thanksgiving by people who seemed to take no note that her perspective on the holiday might be a bit different than their own. One year, in her frustration, she told me that when the next questioner asked, "What are you doing for Thanksgiving?", she answered, "I plan to spend the day saying, 'You're welcome!" (Delpit 1995 pg. 176-7)

SOLUTIONS

Maskmaking. During an interdisciplinary thematic unit in a science, math or technology course students create masks that integrate their understanding of how different cultures view the physical universe. The mask can be molded to represent the science and technology paradigm of the culture.

Field Trip Reports. After an activity or field trip, students (or teachers) divide into groups to review and discuss their feelings and experiences. An interesting exercise is to divide groups by culture and/or gender, then let each group report separately, by talking, writing, or other forms of communication. Afterwards, the class compares and contrasts reports generated by the diverse groups.



Students are trained to look for correct answers to well-defined problems and are not used to thinking about contrasting approaches as valuable.
(Fried 1995 pg. 21)

One of the most serious problems in the nationwide effort of higher education to acknowledge and discuss diversity on campus is the inability of students to recognize legitimate differences of opinion and engage in discourse that leads to greater mutual understanding. (Fried 1995 pg. 25)

SOLUTIONS

Validating Different Perspectives. The instructor models nonjudgmental listening, clarifies points of view, and supports the validity of different perspectives. (This is a departure from emphasis on the search for correct answers.) Emphasis is placed on understanding different perspectives and learning to become aware when these differences make a student uncomfortable. Students learn how to acknowledge their own discomfort rather than labeling their peers as deficient or strange. (Fried 1995 pg. 22)

Language of Science. Science is a global enterprise that has developed from the contributions of the world's diverse peoples. To help promote a sense of the interconnectedness and diversity of the global scientific enterprise, teachers challenge their students to develop a language of science based upon the science and technology paradigms of a diverse grouping of the world's cultures.

In a study conducted by the Center for Children and Technology, in New York City, researchers asked both male and female technical experts to imagine future technological developments in their field. Their responses indicated clear gender differences in perceptions of technology.

The women envisioned devices that connect people, improve communication and collaboration, integrate public and private lives, and improve existing technologies. Many talked about portable devices.

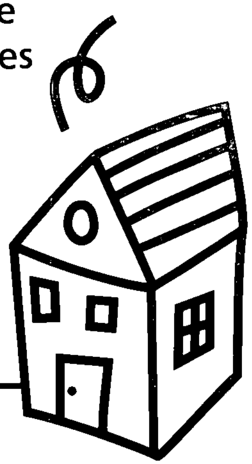
The men imagined unlimited power, tremendous speed, and absolute knowledge. The men were fascinated with the equipment itself and sought major technological advances.

Both sets of values and concerns are needed. The male gender has greatly advanced technology, although sometimes forgetting the needs of the user. On the other hand, the female gender focuses on the users and improving current technologies. Appreciation for both genders' learning styles and addressing them in instruction will help draw girls into technology. (Koch 1994)

Multicultural education focuses on the value of being different. In science education, multiculturalism means that teachers should teach culturally relevant material in ways that invite participation in culturally appropriate ways. (Melear 1995)

A Solution Integrates Family and Community.

The solution integrates the family and the outside community into the classroom, is sensitive to balancing family roles with learning; promotes desired behavior by community affiliation rather than authority.



REFERENCES THAT CLARIFY/SUPPORT:

When women are just beginning to make the transition into subjectivism, they are no longer willing to rely on higher status, powerful authorities in the public domain for knowledge and truth. Instead they consider turning for answers to people closer to their own experience — female peers, mothers, sisters, grandmothers — they begin to feel that they can rely on their experience and "what feels right" to them as an important asset in making decisions for themselves. (Belenky 1986, pg. 60-1)

That women identify less with authorities might be accounted for by the fact that the authorities they meet do not include women in their "we." The women we interviewed spoke, for instance, of science professors who communicated their beliefs that women were incapable of making science. (Belenky 1986 pg. 44)

Mexican Americans regard family and personal relationship as important and are comfortable with cognitive generalities and patterns. Such traits explain why

Mexican-American students often seek a personal relationship with a teacher and are more comfortable with broad concepts than component fact and specifics. (Guild 1994 pg. 17, Vasquez 1991)

Suggestions for instructing Hispanic students are to motivate them by stressing the fact that their families will be proud of them and share in their accomplishments and include more community projects, groups projects, groupwork and peer tutoring. (Grossman 1984)

SOLUTIONS

Family Connections. Research indicates that one reason that ethnic minorities are underrepresented in science and math is because they often lack appropriate role models within their families. To be successful in the science and math curriculum, it is vitally important that these students have support from their parents. They are most likely to garner that support if their parents are informed and feel included in the school culture. One way to accomplish this is for teachers to host a family science day or evening by setting-up discovery stations in their classrooms and have children and parents explore science concepts together. This can be structured in a way that allows families to make the connection of having fun together through learning. The community can be invited to sponsor these informal events through material donations.

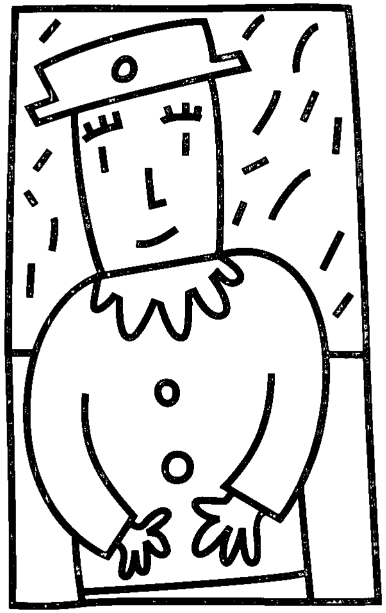
Afro-American kinship network is a multigenerational social network of relatives, friends, and neighbors. There is a concentration and particular stress on interpersonal relationships.
(Shade 1982)

Native Peoples have a tendency to have extended families; sometimes many families live together; several generations, also. In contrast, Euro-Americans tend to have nuclear two- or one-parent families.
(Mander 1991 pg. 215-9)

Native teachers also observed that their disciplinary styles were different from those of dominant culture teachers. They preferred to allow students to have opportunities to vent frustrations or to disagree with stated rules. When it was necessary to change behavior, they sought to do so by appealing to affiliation rather than authority. "Our people don't act like that" was often the unstated message.
(Delpit 1995 pg. 121)

SOLUTIONS

Elders In the Classroom. We live in a throwaway society. When things are worn out they are discarded and replaced. This philosophy is unfortunately also applied to people. The media are saturated with images of youth. When people retire they are often overlooked as no longer having any value to society. However, it is a myth that after a certain age a person's worth has diminished. To tap into the vast and rich resource of retired professionals, teachers can invite them into the classroom as volunteers and as resources. A network of these individuals can be created within the community. This is a wonderful way to educate our youth about the fullness and continuity of life and will help to reinforce the idea that life is a complete circle and that all ages have something valuable to share.

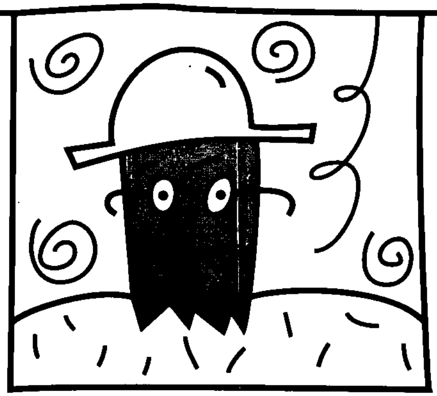


Observing Cultures of Others. Often members of a cultural groups tend to approach tasks in the same way, having developed patterns from childrearing practices and role expectations that are an integral part of the community. To reach these students, teachers observe the background from which their students come. Teachers to go to the neighborhood and observe geometric shapes in building designs, the kinds of plant life and rocks that are present; observe the types of stores and styles of music, the kinds of games that children play. Teachers record observations and use these as a starting point to build a bridge into the academic world for the students. (Grant and Sleeter 1989)

SOLUTIONS

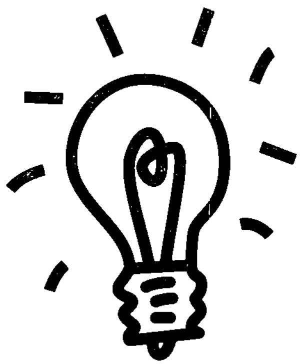
Community Graduation Project. To increase interest and motivation in the science and math curriculum teachers have their students use concepts from their math, science, and engineering classes to develop projects with various community agencies that have social benefit. For example, recycling centers, community gardens, peer tutoring for younger students (high school students mentoring middle school students, etc.).

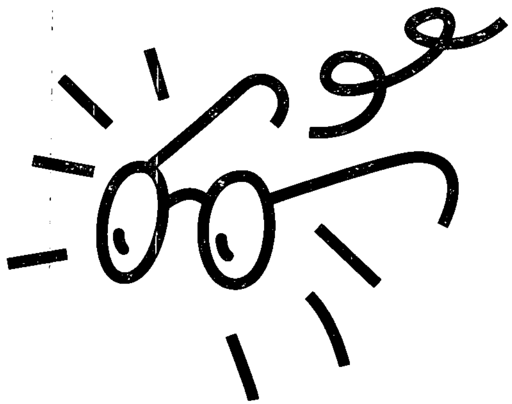
Responsibility for Grading by Students. Students often feel that the evaluation process is unfair or unclear, and as a result they lose motivation and interest. To help their students understand the assessment process, teachers have them work in cooperative groups involving family and community to design rubrics, lab practicals, simulations, role-plays, and other assessment tools for projects and thematic units for the math, science, and engineering curricula. When students have access to the standards of evaluation their motivation and performance levels will increase.



A Solution Encourages the Use of Original Resources.

The solution includes primary source readings (not the textbook), such as scientific reports, non-fiction, fiction, interviews, etc. The readings and writings are used to elicit student responses (oral, written, and artistic) that are personal or analytical. The mind is initially expanded, not contracted. Personal experiences and opinions of students are valued.





Chalk Dot. Teacher Donna Luther says an education system that teaches children "the right answer" turns out machines, not thinkers. On the first day of every year, I read to all freshmen a story from 'A Whack on the Side of the Head', about a teacher in a sophomore English class who put a chalk dot on the board and asks, 'What is it?' and the class just sat there and looked and looked and looked, and finally somebody said, 'it's a chalk dot.' and he said, isn't that interesting? I did this with a group of kindergartners yesterday, and they said it's an owl's eye, a cigar butt, a squashed egg, a pebble. Those Kindergartners just went on and on and on, and how interesting that in all of those years (from kindergarten to sophomore year), we've beaten out all the questions and looked for the right answer, and in so many cases there are so many more than one right answer. I think that's it's very important to help kids understand—that I [the teacher] am not an expert and what's a right answer for me may be very different for them, and that's OK. As long as we learn to respect each other's right answer.

One of the things they learn in that process is "to respect a lot of ideas along the way and understand that a lot of things are possible. It's not my idea, I'm saying to them. I'm not giving you the right answer. (Schneider 1993, von Oech 1992)

REFERENCES THAT CLARIFY/SUPPORT:

Most of us grow up believing that science is an organized collection of facts. However, science is better defined as a way of observing and thinking about the world, and communicating these thoughts to others. Experience and research show that young children are excited about science when they are given the chance to do science. To give your children a firm foundation in science they should be encouraged to think about and interact with the world around them. Concrete experiences that require the use of children's senses, such as planting and watching a seed germinate, provide a strong framework for abstract thinking later in life. (Rillero 1994)

SOLUTIONS

Calendar Creation. The class as a group designs and presents an international calendar. Student groups could choose a month, geographic, and cultural region of the world that is of interest to them and include scientific, technological, and cultural themes related to that region.

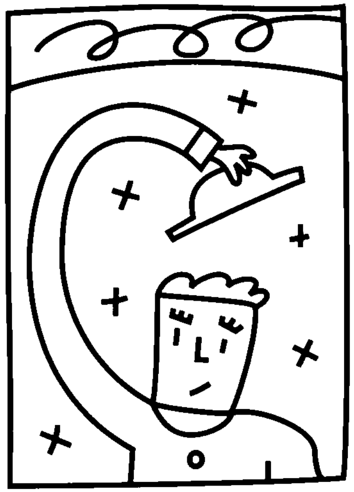
Students Develop a Language that is Visual.
Sometimes it is advantageous to use visual metaphors in the teaching of science and math concepts. However, it is effective when students are involved in the development. To achieve this, teachers have their students create a language for communicating science and math concepts whose symbols have visual meaning. Examples are the languages of the Chinese, the Japanese, the ancient Egyptians, American Sign Language, and other cultures whose language incorporates visual metaphors as resources for developing the language.

The hope should not be for gender-neutral science, gender-free science, but perhaps for gender-balanced science. Connecting students to the curriculum and allowing them to construct their own understandings based on personal experiences seems to be critical in creating meaningful science experiences for students, whether they are male or female. (Yager 1993 pg. 247)

A Solution Adapts to Diverse Learning Styles.

The solution is inclusive of a variety of learning styles. Teachers and students assume the roles of facilitator, coach, student, and lecturer at least once during the semester.

REFERENCES THAT CLARIFY/SUPPORT:



The left and right hemispheres of the brain process information and experience differently.

The left does the verbal things.
The left likes sequence.
The left sees the trees.
The left likes structure.

Left brains love school.

The right does visual-spatial things.
The right likes random patterns.
The right sees the forest.
The right is fluid and spontaneous.

Right brains hang around school *and hope they catch on.*
(McCarthy 198, pg. 73)

Central to the issue of learning style is recognition that the traditional education system is heavily weighted in favor of abstract learners. The abstract learner is able to receive and process information in conceptual form with the mind and without reference to physical surroundings. Reading, lectures, individual homework, and other traditional educational methods appeal to the abstract learner. Unfortunately, pure abstract learners may represent less than 10 percent of the population, and even if the definition of abstract learning is broadened, only 15-20 percent will be included.

Tech Prep has emerged as an initiative to reach out to the "other" 80 percent of the population. Tech Prep addresses various aspects of curriculum design and education reform, but the strategy involves reorganizing and using the preferred learning styles that are characteristic of non abstract learners.
(Eding 1995)

The structure of educational systems is historically and operationally left-hemisphere whereas Black students are predominately right-hemisphere learners. (Smith 1986)

SOLUTIONS

Math Essay. In math, writing may take the form of a "math autobiography" assignment on the first day of Algebra I, where girls tell not only their learning history, but their feelings about math as well. In science, there are abundant writing opportunities: formal lab reports, essay questions on tests, and research projects. This project can also cross gender boundaries. The act of keeping a journal will put students in touch with their own innate sense of problem-solving. This project will encourage creativity, individuality, and help students avoid mimicry and acceptance of generic approaches to thinking. (Kruschwitz and Peter 1995)

Afro-American children apparently are taught to concentrate on many stimuli at one time rather than learning to concentrate on one. Afro-American children did markedly better in one study if the formats had high variability. The study concluded that Euro-American children seemed to have been socialized to tolerate monotony or unvaried presentation of material. Afro-American children, however, required a great deal of stimulus variety. (Shade 1982 pg. 224)

People of different cultures differ in the cognitive style they use. Research reports that Mexican-American children indicate a preference for functions identified with right hemisphere processing. Recognition that students do not learn with only one side of the brain has developed into a growing movement toward "whole brain" and hemispheric integration" approaches. (Contreras 1985)

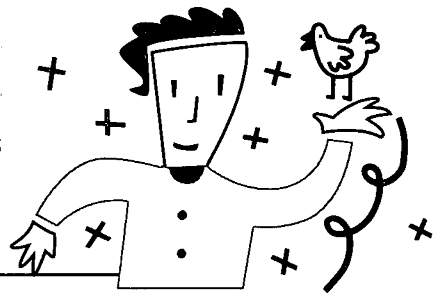
The total numbers of females who prefer the sensing/feeling dimension of perceiving is higher than males. Research indicates that approximately 58% of females prefer right-brained styles compared to 39% of the males. (McCarthy 1987)

Multicultural Classroom. All courses can be adapted to fit a multicultural climate with very little research by the instructor. Establishing a classroom environment that facilitates learning, reflects respect for all students, and demands that respect be displayed by other students is a first step. Providing an educational experience that is challenging and also promotes respect for all students can be accomplished by including the following: learning materials that reflect diversity, multiple assessment tools, mentor and peer support services, and recognition of differences in learning styles. (The Academic Senate for California Community Colleges 1991-1995)

LEFT HEMISPHERE	RIGHT HEMISPHERE
Responding to verbal instructions	Responding to visual instructions
Inhibited emotionally	Responds to emotion/feeling
Dependent upon words for meaning	Interprets body language
Produces logical ideas	Produces humorous ideas
Serious, systematic	Playful, uses humor
Abstract thinking	Concrete thinking
Likes to have a definite plan	Likes to improve
Not psychic	Highly psychic
Process verbal stimuli	Processes kinesthetic stimuli
Processes information logically	Processes information subjectively
Critical/analytical in reading	Creative, synthesizing in reading
Logical in solving problems	Intuitive in solving problems

SOLUTIONS

Imagine This: A Sensory Hunt. To honor the diversity of learning style approaches teachers can develop situations in the science and technology classroom in which students isolate and explore the array of sensory modalities to learn concepts. For example: 1) Using the auditory modality have students tape record ten sounds along a specific route; give the tape to another classmate and see if they can reproduce the route. 2) Using the kinesthetic modality have students move in a way that expresses the germination of a seed. (Samples 1994)



LEFT HEMISPHERE	RIGHT HEMISPHERE
Gives information verbally	Gives information through gesture
Uses language in remembering	Uses images in remembering
Linear time	Non linear time
Recognizing names	Recognizing faces
Responsive to logical/verbal appeals	Responsive to emotional appeals
Numerical	Spatial
Linear	Perceptual
Euclidean	Intuitive
Rational	Imaginative
Logical	Fantasy
Geometric	Imagery, Sensory

(Contreras 1985 pg. 5&6)

A Solution Uses a Variety of Assessment Tools.

The solution includes frequent evaluation by more than one assessment tool. The assessment includes the learning styles of "right-brain" groups. Stakeholders agree on clear criteria for assessment.

REFERENCES THAT CLARIFY/SUPPORT:

Culturally different students, especially Hispanics and Blacks, must be assessed and instructed in culturally appropriate ways. (Grossman 1984 pg. 11)

The equity checklist from Equity Benchmarks for Vermont requires that teachers use assessment strategies that are sensitive to diverse student populations. (WEEA 1995 pg. 23)

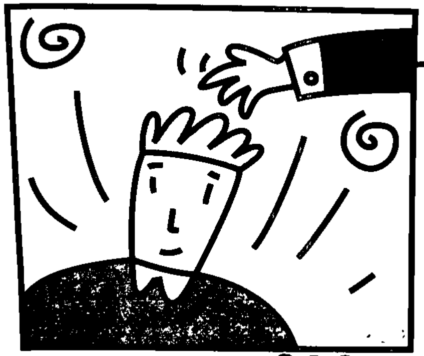
" If you don't understand the culture you are dealing with, you can really mess up an evaluation," quoted from Valerie Nelkin. (National Science Foundation 1993 pg. 74)

The cognitive structure of minority and female students is accommodated through cooperative learning and assessed through the use of portfolios. (Yager 1993 pg. 248)

SOLUTIONS

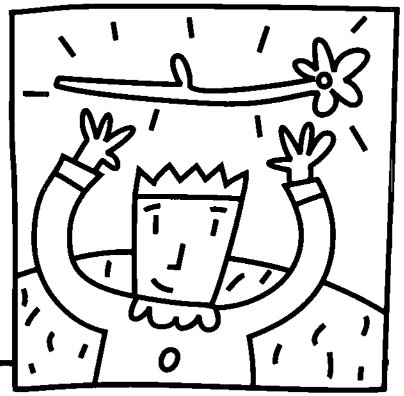
Student developed tests. Students have the responsibility of deciding which skills from a particular chapter will be evaluated, and develop appropriate criteria to assess themselves on those skills. Given a list of objectives for the chapter, students work in small groups to create their own questions and assign a difficulty level as well as demonstrate a solution to the question. Students elect to assess in any manner they feel is effective.

Student Develop Grading Criteria. Groups of students decide how a problem or test should be scored according to a grading criteria which they develop. There are various ways this can be implemented. Using examples from their classmates' work, students assign partial credit for incorrect work and in the process gain a fuller understanding of common errors in learning a particular concept. Student papers are identified with student numbers instead of names so that objectivity is not compromised. Variations are introduced. For example, students may qualify to sit on the grading committee by their performance on previous tests or by some other indicator decided upon by the students. Alternatively, they can be exempted from taking the examination or their grade for that section may be dependent upon some facet of the grading process, such as how well the students' grades based on student criteria correlate with grades based upon similar exercises given by the teacher.



SOLUTIONS

Student Interview Panel. Students prepare for job interviews using peer groups as a practice interview team. Students are organized into interview panels to evaluate each other for their final exam. The student being evaluated must answer a series of questions and demonstrate a skill that has been learned. Evaluation is based on a clear set of criteria that are given and discussed in class, in advance of the interviews.



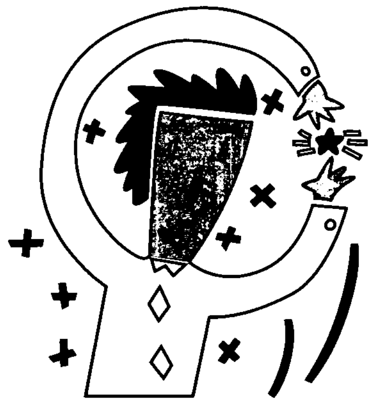
Chapter Seven: Motivates Students to Personally Experience and Interpret Material

- Engages Students
- Encourages Reflection
- Relevant to Students
- Involves Working in Groups and Develops Interpersonal Skills
- Values Feeling and Intuition

CHAPTER SEVEN: MOTIVATES STUDENTS TO PERSONALLY EXPERIENCE AND INTERPRET MATERIAL

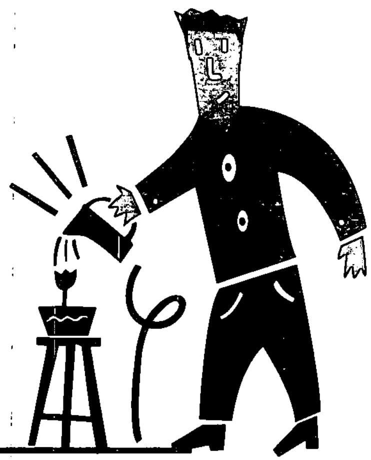
A Solution Engages Students.

Students are actively engaged in the process; no lecture only curriculum. Students feel good about accomplishing an activity. Student-teacher contacts and roles are expanded. Student engages more than the mind in the education process.



SOLUTIONS

Children CAN DO Science. Most of us grow up believing that science is an organized collection of facts. However, science is better defined as a way of observing and thinking about the world, and communicating these thoughts to others. Experience and research show that young children are excited about science when they are given the chance to do science. To give your children a firm foundation in science they should be encouraged to think about and interact with the world around them. Concrete experiences that require the use of children's senses, such as planting and watching a seed germinate, provide a strong framework for abstract thinking later in life. (Rillero 1994)

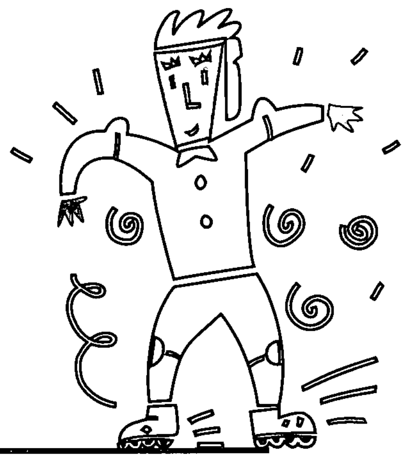


REFERENCES THAT CLARIFY/SUPPORT:

In writing about nature, scientists are expected to take the perspective of the detached observer. (Shepherd 1993 pg. 71)

In a study of the United States compared to 10 other countries, of all the countries studied, the United States has the longest list of content requirements in math. But while we go into greater depth topic by topic, the other nations teach math at much higher level of application. For example, other countries teach students how to use measurement systems with statistical numerical controls and robotics. All students have hands-on, applied learning experiences rather than just absorbing theory as students generally do in this country. American far exceeded the other nations in terms of the amounts of information covered under each physics content area but, just as in mathematics, the American curriculum is taught at a far lower level of application than in Europe or Asia. As an example, American

Students in the Community. High school and college students become actively involved and take responsibility for community projects such as city recycling programs, adopt a creek or beach or city park.



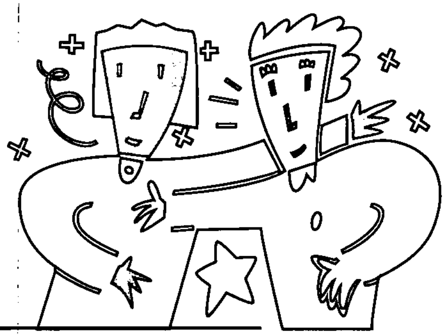
students are taught the theory of statics (force), power and energy, while in Europe and Asia more students learn about these concepts by using pneumatic and hydraulic systems. In the U.S. language arts curricula focus primarily on preparing students for the next course or level in English. In Europe, language arts focuses heavily on understanding of the culture, thus creating strong ties between language arts, the fine arts, and social sciences. In Asia, the central focus of curricula usually is on applying language arts to the workplace. (Daggett 1994 pg. 27)

In classes that include active-learning strategies, teaching and learning are more collaborative. The teacher ceases to be the center of attention, and traditionally passive students can assume a larger role in learning and applying most subject matter. Granted, students may need a little prodding and encouragement to get started with active

SOLUTIONS

Students as Experts. It is vitally important that the connections be examined, that the education professor highlight the narratives of the students of color and ask them to serve as resources for bringing to the fore differences in worldview, learning styles, social organization, language, and so forth.

This could be accomplished by having small, culturally diverse teams of students observe children in classrooms, interview parents, or, through some other activity, collect data in order to develop potential strategies for working with diverse groups of children. The students are encouraged to look to the "expert" in their group, the students or students from the same cultural groups as the children observed, for advice and guidance in completing their assignments. (Delpit 1995 pg. 126)



learning. But they often take to it enthusiastically after experiencing the immediate feedback that is characteristic of active learning and discovering how their contributions are valued. (Meyers and Jones 1993 p.xii)

What is important is to get students started on some hands-on activity, however mundane or unglamorous it may seem. (Ferhs and Czujko 1992 pg. 40)

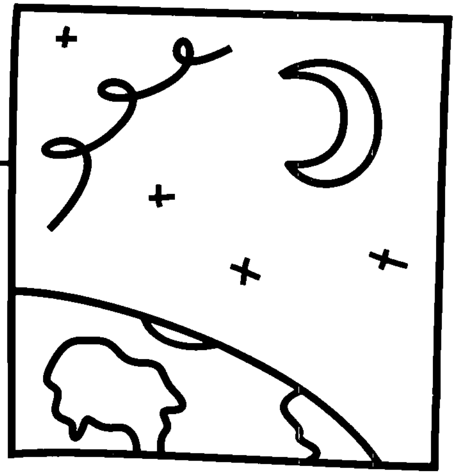
The learning style of Native Americans does not fit a time-bound notion of learning. The native American approach to learning encourages one to learn by doing and admonishes one to be patient if a task is not accomplished on the first try. (Megginson 1990)

When Native and Black teachers were asked to contrast their values/methods and those of the typical white system, a Native teacher responded: "If there's someone who doesn't understand what I'm teaching, I try to understand who they are." (Delpit 1995 pg. 118-9)

African American students often value oral experience, physical activity, and loyalty in interpersonal relationships. These traits call for classroom activities that include approaches like discussion, active projects, and collaborative work. (Guild 1994 pg. 17)

A Solution Encourages Reflection.

The solution encourages students to discuss and evaluate their work. The solution gives students the opportunity to reflect upon, revisit and revise their work during quiet time.



REFERENCES THAT CLARIFY/SUPPORT:

In a culture where we brag about "working hard and playing hard," we place little value on receptivity. On the scientific fast track, many scientists feel they cannot compete if they slow down enough to be receptive. Being receptive looks like they are not doing anything.

While receptivity requires a halt to busyness and activity, it is not passive. Rather than being in control and manipulating things, receptivity relies on observing, letting it happen, allowing something to unfold in its own time. (Shepherd 1993 pg. 78-9)

Native American people generally value and develop acute visual discrimination and skills in the use of imagery. They perceive globally, have reflective thinking patterns. Thus, schooling should establish a context for new information, provide quiet times for thinking, and emphasize visual stimuli. (Guild 1994 pg. 17)

Suggestions for instructing Hispanic students: (1) do not rush them if they do not answer quickly or work rapidly in class but not provide them with all the time they require to complete

SOLUTIONS

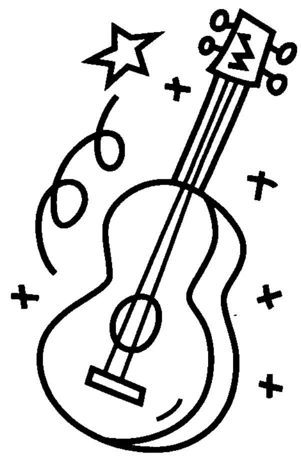
Reflective Journal. One problem that many teachers face is whether or not the assessment tools that they use actually evaluate how much their students know or how much they have learned. By varying the assessment, and having access to multiple forms of assessment, a more holistic appraisal of student work can be accomplished. One useful assessment tool is the reflective student journal. In addition to its value as an assessment tool, the reflective journal requires that students take an active role in what they learn which compels them to become more involved in their own educational development. The reflective journal is particularly useful as a tool for encouraging self-assessment and growth in the science, math, and technology curriculum.

classroom assignments, (2) de-emphasize the lecture approach in favor of a direct experience approach. (Grossman 1984)

Barbara McClintock, whose important work on the genetics of corn plants won her a Nobel prize, used the language of intimacy in describing her way of doing science. She told her biographer, Evelyn Fox Keller, that you had to have the patience "to hear what [the corn] has to say to you" and the openness "to let it come to you." McClintock could write the biography of each of her corn plants. As she said, "I know them intimately, and find it a great pleasure to know them." (Belenky et al 1986 pg. 143-4, Keller 1983 pg. 198).

SOLUTIONS

Musical Musings. Teachers can emphasize the importance of reflection in the science and math classroom through the use of background music, and by having their students associate the music with science and math concepts such as the use of resonance and patterns in music.



A Solution is Relevant to Students.

The solutions provide connections with real-life contexts that reflect home environment, as well as social, political, and economic conditions of the real world. Students' life experiences and previous knowledge provide a foundation for learning and exploring the subject matter.

REFERENCES THAT CLARIFY/SUPPORT:

Research on math proficiency supports the notion that minority students perform best on familiar (or real-world related) items, relating to real life. (Rakow and Bermudez 1993)

Native Peoples have a tendency to gain information from personal experiences. In contrast, in Euro-American individuals gain most information from media, schools, authority figures outside their immediate community or experience.
(Mander 1991 pg. 215-9)

Native American students have to be convinced that mathematics relates to their life, or they will avoid the subject and/or refuse to fully participate in the learning process. (Green 1989) The first challenge math instructors of Native American students must face is to create a classroom environment in which mathematics is seen as relevant and meaningful.
(Megginson 1990, National Science Foundation 1994, pg. 40)

Using their own understandings based on personal experiences seem to be critical in creating meaningful science experiences for students, whether they are male or female.
(Yager 1993 pg. 247)

SOLUTIONS

Cultural Relevance. D., a Native teacher, told me a story about being a bilingual aide in an Anglo teacher's classroom. The teacher wanted to bring the children's culture into the class. She asked D. to write the directions for making an animal trap on the blackboard so the children could make traps in class during their activity period. D. told me she had a hard time writing up the directions, but struggled through it. The kids, however, were the ones who really had a hard time. They found the direction impossible to follow. Finally, in utter frustration, D. went home and got a trap. She took it apart and let the children watch as she put it back together. Everyone made his or her own trap in no time.

A study of a faculty meeting at a secondary school found that the women's arguments did not carry weight with their male colleagues because they tended to use their own experience as evidence, or argue about the effect of policy on individual students. The men at the meeting argued from a completely different perspective, making categorical statements about right and wrong.
(Tannen 1990 pg. 91)

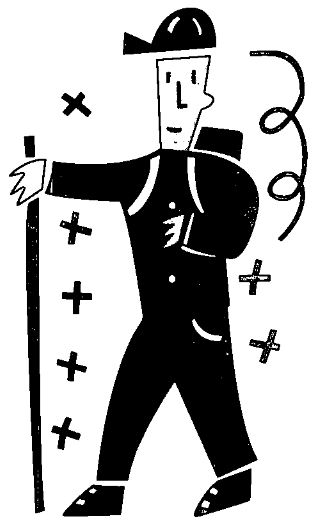
Math problems can reflect girls' experience (although they should not be limited to stereotypically female concerns, such as cooking and sewing) and can emphasize practical, real life applications.
(Schwartz and Hanson 1992)

Women interviewed wished to be treated at least as containers of knowledge rather than empty receptacles.
(Belenky et al 1986 pg. 217)

SOLUTIONS

Learning solely through the decontextualized word, particularly learning something that was so much a part of their home culture, was simply too foreign for the children to grasp without careful instruction about how to make the transition. Another Native teacher told me that she handled making this transition by having the children practice writing directions to go to or from a certain place in the village.

When the children finished, she took the class outside. Of course, the students wrote in ways that assumed a great deal of insider, contextual knowledge. This teacher had them laughing and trying harder and harder to be more explicit as she pretended that she was an outsider, a *gussak* (white person) trying to get her knowledge solely from the text. They soon understood that they had to use words in a different way in order to get their message across.



SOLUTIONS

She repeated the exercise with other familiar activities over the year, such as having the children write down how to make different Native foods and then having them watch her attempt to follow the directions. After a while, the children learned that they could make use of decontextualized literacy when they needed to. They did not learn, however, that they had to give up their own contextual way of experiencing the world.
(Delpit 1995 pg. 103)

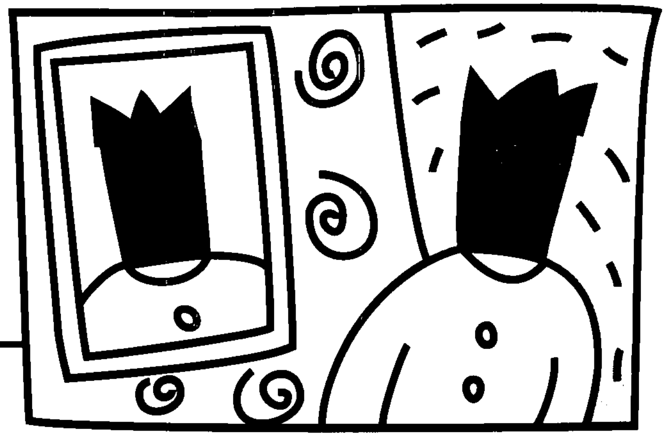
SOLUTIONS

Personal Needs and Media Issues. Educational reformers are urging that science curricula focus on personal needs, create career awareness, and include the study of science-technology-society in terms of problems and issues found in the community or discussed through media. (Blosser 1991)

Consumer Letter. Students brainstorm in groups about incidents in their lives as consumers that would warrant the writing of a consumer letter of praise or complaint. Students share their letters with a classmate and hand in the letter for instructor to read and mail. Students report on the response they receive.

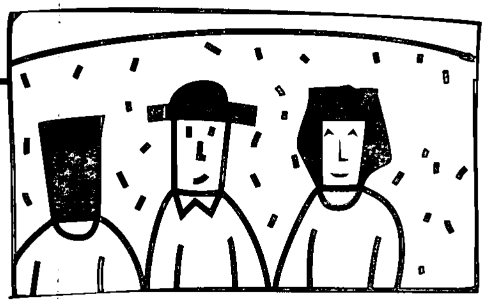
Typically, thirty percent receive a response. Some students get extraordinary results: One student had a problem with a wheel alignment service. After his letter was received, the owner of the shop called the student and arranged to pick up his car at his place of employment and re-align the tires, and return the car the same day to the place of employment, at no charge. Another student received a $25.00 gift certificate to compensate her for her difficulties with a rude salesclerk.

Job Interview. In lieu of a final project or paper, students prepare themselves for a job interview as a digital photography technician. A panel of students in the class is given questions to ask and a rating system to judge the quality of the answers. The interviewee also draws from a hat a photoshop technique to demonstrate to the panel. Panel members can ask for clarification if an answer is unclear but not introduce new questions. Students prepare themselves for the real world by presenting themselves as they would when seeking a job. They answer questions to show their knowledge of the subject and complete a task to demonstrate their skills.



A Solution Involves Working in Groups and Develops Interpersonal Skills.

Students (a) help to achieve the goals of a cooperative group, (b) communicate well with other members of the group, (c) make sure the group works well together, and (d) take on a variety of jobs within a group.

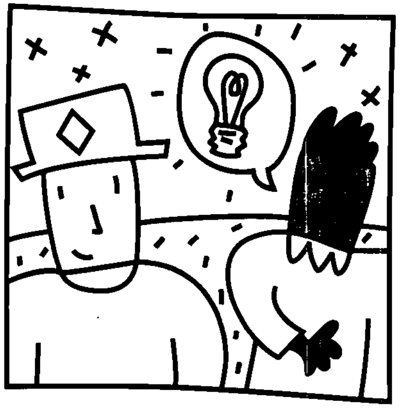


REFERENCES THAT CLARIFY/SUPPORT:

The new majority does not come to school with the same values and background as did the old majority. The new majority are not responding well to traditional educational structures. Traditional classroom structures, because they rely heavily on competitive tasks and reward structures, provide a bias in favor of the achievement and values of majority students who are generally more competitive in their social orientation than are minority students. Minority students [African-American and Hispanic students are cited particularly] are more cooperative in the social orientation and achieve better and feel better about themselves and school in less competitive classrooms. Certain cultural groups place a special value on working for the group. Individuals in those groups are more motivated to work hard if it will benefit the group than if it benefits themselves.
(Kagen 1992 pg. 2:7 & 3:1)

SOLUTIONS

Cross-Curricular Activity. To get students to see the connections between what they learn in their math, science, and engineering classes, teachers have students develop, in cooperative groups, links between what they are learning in science, math, technology, and engineering classes to subjects of art, music, literature, and history. Each group focuses on a different curricular area and then devises a strategy to share the results of their efforts. Groups are encouraged to look for patterns and relationships among a diverse group of ideas and fields of thought.



General differences in learning style are that women and many minorities have a more affective or feeling mode of learning. That is, these groups, more than many white men, like to use subjective values over objectiveness, in making decisions. They like to discuss and converse about topics, rather than have information, as facts, thrown to them.
(Melear 1995 pg. 24)

Afro-American people tend to prefer to attend to people stimuli rather than nonsocial or object stimuli. The reasons for these differences is found within Afro-American culture.
(Shade 1982 pg. 22)

Research has also shown that motivation in African-American children from low socioeconomic groups is more influenced by the need for affiliation than for achievement. (Holliday 1985, Delpit 1995 pg. 140)

After two decades as also-rans in higher education's rush to embrace coeducation, women's

SOLUTIONS

Writing a Resume. Crafting a resume is a real world skill that students can use to navigate through life. To gain experience, teachers have cooperative student groups create criteria for gaining entry into a group. The criteria are centered around desirable skills for particular professions. Groups swap criteria and write resumes to match group membership qualifications. This activity is concluded with groups conducting interviews.

Knowing the Ropes. Building trustful relationships between students develops student interest, motivation, and positive group dynamics for many students. Deep trust develops through shared experiences that involve an element of risk. A powerful way to develop this level of trust is to have students do a Ropes Course, in which people climb up a rock face or trees, depending on other people for support.

colleges are experiencing an unanticipated surge in enrollments and positive public attention. Teaching methods or curricula are based on "women's ways of learning," that stress collaboration, experiential learning and working in small groups. (Reeves and Marriott 1994)

Although these differences in self-definition do not necessarily divide along gender lines, it is clear that many more women than men define themselves in terms of their relationships and connections to others. (Belenky et al 1986 pg. 8)

Working in small groups and sharing information and thought processes respects girls' interest in connectedness and enhances mutual understanding. Students have a chance to learn, practice, and then teach one another.

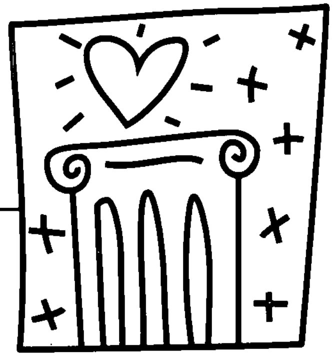
Group learning is natural for girls and begins early. (Kruschwitz and Peter 1995)

Clemson University developed a new cooperative section of Chem 101. Only 13% of the women dropped out of the cooperative sections, compared with 22% in the traditional sections (For men, it's 8% and 9%). (Culotta 1994 pg. 883)

Native American students prefer group oriented learning environments and view group cooperation and harmony as more important than the success of one individual. (Anderson and Stein 1992, National Science Foundation Nov. 1994)

A Solution Values Feelings and Intuition.

Feelings, sense of belonging, and intuition are valued. Solutions factor in the emotional component of intelligence.



REFERENCES THAT CLARIFY/SUPPORT:

Barbara McClintock won the Nobel Prize for her discovery of transposable elements in the DNA of corn. Rather than remaining detached from her experimental subject, McClintock spoke in terms of "listening" to what the corn had to tell, even when she "heard" things that violated the prevailing dogma, which included the notion that DNA sequences stay put. "She didn't adopt a masculine ideal, nor did the adopt a purely feminine ideal," says Keller. "She made use of the full range of human capacity...and all her intuitive strengths, in the service of science. And she adds: "It doesn't matter that she was a woman. One could find men in that tradition as well."
(Barinaga 1993)

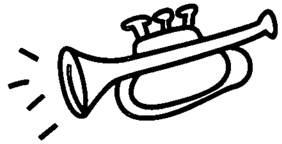
"Mathematicians use intuition, conjecture, and guesswork all the time except when they are in the classroom" –Joseph Waren, mathematician
(Tobias 1993 pg. 64)

Einstein separated himself from the logical positivists by repeatedly expressing his reliance on intuition: "There is no logical way to the discovery of these elementary laws. There is only the way of intuition."
(Holton 1988 pg. 305, Shepherd 1993 pg. 214)

Richard Feynman received the Nobel Prize for Physics in 1965 for work in redefining the basic principles of quantum

SOLUTIONS

Music that Reflects Concepts. Emotion and feeling are powerful expressions with links to creativity. To unlock and tap into this potential, teachers encourage students to bring music into the classroom that evokes a wide range of feeling (from rational and methodical to creative and intuitive) and imparts strong emotional impact. The students are challenged to find relationships among the music, the ideas and concepts they have learned in class, and the hemispheric nature of the brain. From this experience teachers have a compelling way of demonstrating the hemispheric nature of the brain (right-brain and left-brain) and encourage their students to develop whole- brain thinking.



electrodynamics. His friend, physicist Freeman Dyson, characterized his intuitive approach by saying that a comment about Newton applied equally well to Feynman. "His peculiar gift was the power of holding continuously in his mind a purely mental problem until he had seen straight through it. I fancy his preeminence is due to his muscles of intuition being the strongest and most enduring with which a man has ever been gifted." (Freeman 1979 pg. 56-7, Shepherd 1993 pg. 215)

Some scientists appreciate that intuition can be a remarkable tool. As one of the Apollo moon scientists said, "I wish I had more of my wife's intuition and less of my own tendency to be reasoning in my approach." (Mitroff 1983 pg. 124, Shepherd 1993 pg. 205)

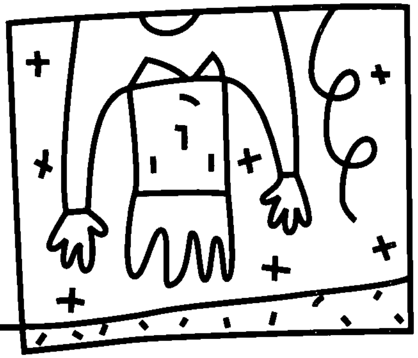
I accepted the statements such as, "emotions have no place in science," and "science is value-free." (Shepherd 1993 pg. 51)

We begin with the reminiscences of two ordinary women, each recalling an hour during her first year at college. One of them, now middle aged, remembered the first meeting of an introductory science course. The professor marched into the lecture hall, placed upon his desk a large jar filled with dried beans, and invited the students to guess how many beans the jar contained. After listening to an enthusiastic chorus of wildly inaccurate estimates the professor smiled a thin, dry smile, revealed the correct answer, and announced, "You have just learned an important lesson about science. Never trust the evidence of your own senses."

Thirty years later, the woman could guess what the professor had in mind. He saw himself,

SOLUTIONS

Cross-sensory Activities. The teacher develops a game that teaches a concept or family of concepts using the sense of sight, smell, touch, hearing, and taste. Teachers create portions of the game that link the different senses using intuition. The game involves navigating through spaces that have both physical and emotional components, such as a physical maze that has distinct smells.



perhaps, as inviting his students to embark upon an exciting voyage into a mysterious underworld invisible to the naked eye, accessible only through scientific method and scientific instruments. But the seventeen-year-old girl could not accept or even hear the invitation. Her sense of herself as a knower was shaky, and it was based on the belief that she could use her own firsthand experience as a source of truth. This man was saying that this belief was fallacious. He was taking away her only tool for knowing and providing no substitute. "I remember feeling small and scared," the woman says, " and I did the only thing I could do. I dropped the course that afternoon, and I haven't gone near science since."
(Belenky et al 1986 pg. 191)

Math anxiety people do not trust their intuition. If an idea comes into their heads or a strategy appears to them in a flash, they will assume it is wrong. They do not trust their intuition either they remember the "right formula" immediately, or they give up.

Mathematicians, on the other hand, trust their intuition in solving problems and readily admit that without it they would not be able to do much mathematics. The difference in attitude toward intuition, then, seems to be another tangible distinction between the math-anxious and people who do well in math. (Tobias 1993 pg. 66)

Relatively little attention has been given to modes of learning, knowing, and valuing that may be specific to, or at least common in, women. It is likely that the commonly accepted stereotype of women's thinking as emotional, intuitive, and personalized has contributed to the devaluation of women's minds and contributions, particularly in Western technologically oriented cultures, which value rationalism and objectivity. It is generally assumed that intuitive knowledge is more primitive, therefore less valuable, than so-called objective modes of knowing. Thus, it appeared likely to us that traditional educational curricula and pedagogical standards have probably not escaped this bias.
(Belenky et al 1986 pg. 5-6)

When Native children who have been brought up to trust their own observations enter school, they confront teachers, who, in their estimation, act as unbelievable tyrants. From the children's perspective, their teachers attempt to coerce behavior, even in such completely personal decisions as when to go

SOLUTIONS

Evaluation for Beauty and Elegance. Most assignments and projects in the science and technology curriculum are evaluated on objectively derived outcomes that have little to do with feeling or subjective criteria. These evaluations give the science and technology fields the reputation for being concerned only with the cold and seemingly sterile landscape of facts and correct answers. To dispel this myth, teachers have their students develop a set of criteria for evaluating a project based upon its beauty and elegance. The students use their subjective sense and feeling in the development of their criteria. The challenge is to use only the intuitively-derived beauty and elegance criteria to evaluate a project or unit built around a theme.

to the bathroom or when to get a drink of water. The bell rings, go to lunch; the lights blink, put your work away, whether you are finished or not. Despite the rhetoric of American Education, it does not teach children to be independent, but rather to be dependent on external sources for direction, for truth, for meaning. (Delpit 1995 pg. 101)

Afro-Americans process information from the environment differently than do other groups. Afro-American people seem to prefer intuitive rather than deductive or inductive reasoning. The reasons for these differences are found within Afro-American culture.
(Shade 1982 pg. 22)

The "feeling for the organism" does not replace the information gained by a statistical approach. Rather it complements it by using the feeling function to understand the importance and uniqueness of the individual. A feeling of connection to nature engenders an attitude of love and respect.
(Shepherd 1993 pg. 74)

Understanding involves intimacy and equality between self and object, while knowledge implies separation from the object and mastery over it.

Understanding entails acceptance. It precludes evaluation, and quantifies a response to the object that should remain qualitative.
(Belenky et al 1986 pg. 101)

A nurturing approach involves maintaining an openness to many possibilities, different ways of developing. It allows unconscious processes, the movement of the spirit, and the voice of the soul to speak rather limiting to limiting us to information from only rational sources.

Emotion and feelings can balance the one-sideness of science and make a positive contribution by:

- Drawing attention to values and ethics
- Helping to evaluate relevance and establish priorities
- Motivating research by love of nature, rather than desire for control
- Respecting nature, rather than using nature as a commodity
- Considering the feelings of other people

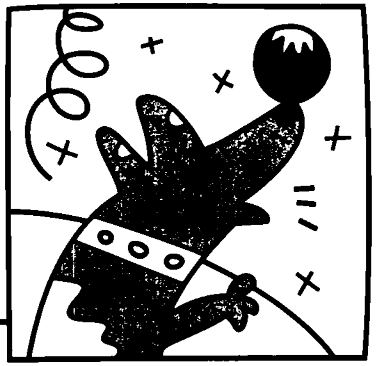
(Shepherd 1993 pg. 53& 166)

If I could pass one new "law" in the teaching of mathematics, it would be to have students graded

SOLUTIONS

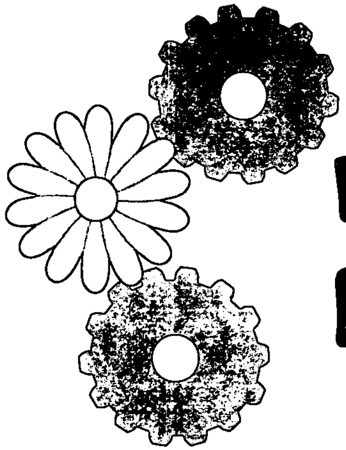
142

Silent Lecture. To access emotions that may be masked by conversations, teachers have their students design and choreograph a 10 minute silent lecture. The students are directed to design their silent lecture to illicit an emotional response concerning a subject or situation related to science.



on (1) how well they approach the problem to be solved: (2) how many different ways they can solve the problem; and (3) how thoughtful an essay they can write about what makes a particular problem mathematically interesting. It is in thinking about a problem before and after it's been solved that much mathematical imagination can be brought into play. And it is imagination, in the form of intuition and interesting analogies, that is the source of invention in math.
(Tobias 1987 pg. 11)

Those who have studied the intuitive process have observed four phases to the intuitive process: (1) Preparation or the "input" mode, in which a person directs a question to the unconscious and provides it with information. This is an intense period of conscious thinking, reading, and research. (2) Incubation or the "processing" mode, where the accumulated information simmers in the unconscious. All input has ceased and this is a time of relaxation, daydreaming, meditation, or sleep. (3) Illumination or the "output" mode, when a mysterious process produces the solution to the problem in a flash, seemingly from nowhere. (4) Verification mode, the phase in which fantasies are discerned from inspirations, and delusions are distinguished from insights.
(Harmon and Rheingold 1984, Shepherd 1993 pg. 212)



Part III: References

Part III: References

CHAPTER ONE

Academic Senate for California Community Colleges, *An Integrated Approach to Multicultural Education,* Educational Policies Committee and Affirmative Action/Cultural Diversity Committee, Sacramento, CA., 1991-1995.

Barinaga, Marcia. "Is There a 'Female Style" in Science?" *Science*, Vol. 260, pages 384-391, April 16, 1993.

Brush, Lorelei R. *Encouraging Girls in Mathematics, The Problem and Solution.* Abt Books, Cambridge Massachusetts, 1980.

Chahin, Jaime. "Hispanics in Higher Education: Trends in Participation." *ERIC Digest,* ED1.331/2:EDO-RC-93-5, March, 1993.

Ferhs, Mary and Roman Czujko. "Women in Physics: Reversing the Exclusion." *Physics Today,* page 3340, August 1992.

Finley et al. "Equity Issues in Science Education." *Science Education* , Vol. 76, No. 3, pages 282-291, 1992.

Geppert, Linda. "The Uphill Struggle, No Rose Garden for Women in Engineering." *IEEE Spectrum,* page 40, May, 1995.

Guild, Pat. "The Culture/Learning Style Connection," *Educational Leadership,* pages 16-21, April 1994.

Institute for Research on Higher Education at the University of Pennsylvania. "Riveters to Rocket Scientists: Exploring the Gender Gap in Quantitative Fields." *Change,* Vol. 26, Issue 6, p. 41, Nov/Dec 1994.
Kelly, Virginia Mayers. "Minority Grads Increase, But Numbers Still Low." ASEE PRISM, page. 9, November, 1995.

Melear, Claudia. "Multiculturalism in Science Education," *The American Biology Teacher,* Vol. 57, No. 1, page. 21-26, January 1995.

Mendoza, Jerilyn Lopez. "Cross-Cultural Experiences in College," *Higher Education Exchange,* The Kettering Foundation, pages. 27-29, 1995.

National Science Foundation. *A View From the National Science Board. Toward the Next Century: The State of U.S. Science and Engineering.,* February 1994.

National Science Foundation, *Women, Minorities, and Persons With Disabilities in Science and Engineering: 1994,* Document # NSF 94-333, November, 1994.

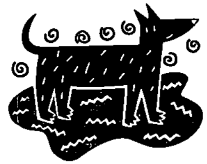
Rakow, Steven J. and Andrea B. Bermudez. "Science is "Ciencia:" Meeting the Needs of Hispanic American Students." *Science Education,* Number 77, Vol. 6, pages. 669-683, 1993.

Tannen, Deborah. *You Just Don't Understand.* New York: Ballantine Books, 1990.

Tobias, Sheila. *Succeed with Math: Every Student's Guide to Conquering Math Anxiety.* New York: College Board Publications, 1987.

Yager, Robert E. "Science/Technology/Society and Teacher Education: Solutions for Problems of Diversity and Equity," in *Diversity and Teaching, Teacher Education Yearbook I,* edited by Mary John O'Hair and Sandra J. Odell, New York: Harcourt Brace Jovanovich College Publishers, 1993.

CHAPTER TWO



Academic Senate for California Community Colleges, *An Integrated Approach to Multicultural Education,* Educational Policies Committee and Affirmative Action/Cultural Diversity Committee, Sacramento, CA., 1991-1995.

American Association of University Women (AAUW), *How Schools Shortchange Girls,* 1992.

Asimov, Nañette, "A Plan to Attract Girls to Math, Science," *San Francisco Chronicle,* page A3, March 9, 1992.

Banks, James A. "Ethnicity, Class, Cognitive, and Motivational Styles: Research and Teaching Implication." *The Journal of Negro Education,* 57, pages 452-466, 1988.

Barba, Roberta H. "A Study of Culturally Syntonic Variables in the Bilingual/Bicultural Science Classroom," *Journal of Research in Science Teaching,* Vol. 30, No. 9, pages 1053-1071, 1993.

Part III: References

Belenky, Mary, Blythe Clinchy, Nancy Goldgerger, and Jill Tarule. *Women's Ways of Knowing.* New York: Basic Books, 1986.

"Briefings: African Americans in Higher Education." (no author named) *ASEE PRISM,* pg. 10, April, 1995.

Brush, Lorelei, R. *Encouraging Girls in Mathematics, The Problem and Solution.* Abt Books, Cambridge Massachusetts, 1980.

Clark, Charles S. "Does the Educational System Short Change Females?" *CQ Researcher,* Vol. 4, Issue 21, page 481, June 3, 1994.

Culotta, Elizabeth. "New Modes for Making Scientists." *Science,* Vol. 266, pages 875-888, November 1994.

Davenport, Linda Ruiz. "The Effects of Homogeneous Grouping in Mathematics." *ERIC* (614) 292-6717, 1993.

Day, Jennifer Cheesman. *Population Projections of the United States, by Age, Sex, Race, and Hispanic Origin: 1993 to 2050.* Bureau of the Census, Current Population Reports, Washington, D.C.: U.S. Department of Commerce, pages 25-1104, 1993.

Delpit, Lisa. *Other People's Children. Cultural Conflict in the Classroom.* New York: New Press, 1995.

Duras, M. "Interview by Susan Hasserl-Kapit." *Signs: Journals of Women in Culture and Society,* Vol. 1, No. 2, pages 423-434, 1975.

"Educating Tomorrow's Engineers: Four Corporate Executives and an NSF Assistant Director Say It's Time to Educate a New Breed of Engineer." (no author named) *ASEE Prism,* pages 11-15, May/June 1995.

Ercolano, Vincent. "From Sleep to Success 101," *ASEE PRISM,* pages 25-28, September 1995.

Ferguson, Marianne. "Is the Classroom Still a Chilly Climate for Women?" *College Student Journal,* Vol. 26, No. 4, pages 507-511, December 1992.

Fisher, Arthur. "Crisis in Education Part 1, Science + Math = F." *Popular Science,* Vol. 241, Issue 2, page 58, August, 1992.

Fitzgerald, Nancy. "Teaching with Cases," *ASEE PRISM,* pages 16-20, March 1995.

Fried, Jane. "Monocultural Perspectives and Campus Diversity," *Higher Education Exchange,* The Kettering Foundation, page 18-25, 1995.

Geppert, Linda. "The Uphill Struggle, No Rose Garden for Women in Engineering." *IEEE Spectrum,* page 40, May, 1995.

Gollnick, D. and P. Chinn. *Multicultural Education in a Pluralistic Society (3rd ed).* New York: Merrill Publishing Co., 1990.

Grant, Carl A. and Christine E. Sleeter. *Turning on Learning, Five Approaches for Multicultural Teaching Plans for Race, Class, Gender, and Disability.* Columbus, Ohio: Merrill Publishing Co., 1989.

Griffiths, Philip A. "Breaking the Mold." *ASEE PRISM,* pages 27-31, November, 1995.

Grossman, Herbert. *Educating Hispanic Students.* Springfield, Illinois: Charles C. Thomas Publisher, 1984.

Hazelrigg, George A. "Rethinking the Curriculum." *ASEE PRISM,* page 56, December 1994.

Herrmann, Ned. *The Creative Brain,* The Ned Herrmann Group, 2075 Buffalo Creek Road, Lake Lure, North Carolina 28746, (704) 625-9153, 1993.

Hubbard, Pat Hill. "Women Scientists and Engineers in Industry: Why So Few?" National Research Council's Committee on Women in Science and Engineering, Presentation to the 18th Annual Asia and Pacific Sciences Conference, Beijing, China, June 5-9, 1995.

James, Joni. "Women Still Find College Chilly." *The Register-Guard,* Eugene, Oregon, page 1A, March 25, 1996.

Kaplan, Joel and David Aronson. "The Numbers Gap." *Teaching Tolerance.* pages 21-27, Spring, 1994.

Kalonji, Gretchen. "Collaborative Learning in Engineering, Proceeding of What Works: Building Effective Collaborative Learning Experiences"

Part III: References

National Center on Postsecondary Teaching, Learning and Assessment, The Pennsylvania State University, June, 1994.

Kelly, Virginia Mayers. "Minority Grads Increase, But Numbers Still Low." ASEE PRISM, page 9, November, 1995.

Kramaerae, C., & P.A. Treichler "Power Relationships in the Classroom." in S. L. Gabriel & I. Smithson. (Eds.) *Gender in the Classroom: Power and Pedagogy* Urbana and Chicago: University of Illinois Press, pages 41-59, 1990.

Laren, Kristine M. "Participation in Science by Minorities," *Mercury,* pages 14-16, May/June, 1995.

LeBuffe, Claire. "Softening Enrollments, Enrollments '94." *ASEE PRISM,* page 35, September, 1995.

Mason, William H. "A Complete Engineer." *ASEE PRISM,* page 52, October, 1994.

McIlwee, Judith S. and J. Gregg Robinson. *Women in Engineering: Gender, Power, and Workplace Culture.* Albany: State University of New York Press, 1992.

Megginson, R. *Mathematics and Native Americans.* Washington, D.C. Mathematical Association of America, 1990.

Mendoza, Jerilyn Lopez. "Cross-Cultural Experiences in College," *Higher Education Exchange,* The Kettering Foundation, pg. 27-29, 1995.

Meyers, Chet, and Thomas B. Jones. *Promoting Active Learning,* San Francisco: Jossey-Bass Inc., Publishers, 1993.

National Assessment of Educational Progress (NAEP), *The Science Report Card: Elements of Rise and Recovery.* Princeton, NJ: Educational Testing Service, 1988.

President's Council of Advisors or Science and Technology, President of the United States, "Nurturing Special Aptitudes: Developing Superb Scientists and Engineers," *SIRS Government Reporter:* Number PR 41.8:SCI 2/2, December, 1992.

National Council of Teachers of Mathematics (NCTM). "Curriculum and Evaluation Standards for School Mathematics." Reston, VA: Author., 1991, RAC 1989.

National Science Foundation, *Women, Minorities, and Persons With Disabilities in Science and Engineering: 1994,* Document # NSF 94-333, November, 1994.

O'Neil, John. "On Preparing Students for the World of Work: A Conversation with Willard Daggett." *Educational Leadership,* pages 46-48, May 1995.

Price, Jill S. and Abigail A. Hafer. "Some Gains, A Long Way to Go." *Mercury,* pages 11-16, May/June, 1995.

Ong, W. *Fighting for Life.* Ithaca: Cornell University Press, 1981.

Panitz, Beth. "Wanted: More Good Women." (Interview with Carolyn Meyers) *ASEE PRISM,* pages 22-27, February, 1995..

Pearson J. C. and R. West "An Initial Investigation of the Effects of Gender on Student Questions in the Classroom: Developing a Descriptive Base." *Communication Education,* 40, pages 22-32. (ERIC #EJ 419 817), 1991.

Petroski, Henry *To Engineer is Human,* , New York: Vintage Books, 1992.

Price, Jill S. and Abigail A. Hafer. "Some Gains, A Long Way to Go." *Mercury,* pages 11-16, May/June, 1995.

Rakow, Steven J. and Andrea B. Bermudez. "Science is "Ciencia:" Meeting the Needs of Hispanic American Students." *Science Education,* Number 77, Vol. 6, pages 669-683, 1993.

Samples, Bob. "Instructional Diversity." *The Science Teacher,* pages 14-17, February 1994.

Sandler, B. "The Classroom Climate: A Chilly One for Women?" Washington, D.C.; Association of American Colleges, 1982.

Sarantos, Sandra Todd. "Managing Change by Creating A Synergistic Environment." *Leadership Abstracts* published by the League for Innovation in the Community College, 26522 Ka Alameda, Suite 370, Mission Viejo, CA, Vol. 7, No. 11, November, 1994.

Schneider, Stephen H. "A Better Way to Learn." *World Monitor,* Vol. 6, Issue 4, page 30, April 1993.

Schwartz, Wendy and Katherine Hanson. "Equal Mathematics Education for Female Students." *ERIC,* #ED344977, pages 1-5, February, 1992.

Shalala, Donna, "Scientific Literacy," *ASEE PRISM,* page 48, November 1995.

Shepherd, Linda Jean. *Lifting the Veil, The Feminine Face of Science.* Boston: Shambhala, 1993.

Sternberg, Robert J. "Thinking Styles: Keys to Understanding Student Performance." *Phi Delta Kappan,* page 366, January, 1990.

Tannen, Deborah. *You Just Don't Understand.* New York: Ballantine Books, 1990.

Tobias, Sheila. "Reforming Freshman Science." *Technology,* May/June 1992.

Trankina, Michele L. "Racio-Ethnic Differences in Confidence in Science." *Psychological Reports,* Vol. 71, pages 235-242, 1992.

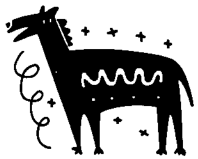
WEEA Publishing Center. "School-to Work Equitable Outcomes." Educational Development, 55 Chapel Street, Newton, Massachusetts, 1995.

Williams, Kimber. "Lessons Girls Learn." *The Register Guard,* Eugene, Oregon, pages D1-D2, October 9, 1995.

Yager, Robert E. "Science/Technology/Society and Teacher Education: Solutions for Problems of Diversity and Equity," in *Diversity and Teaching, Teacher Education Yearbook I,* edited by Mary John O'Hair and Sandra J. Odell, New York: Harcourt Brace Jovanovich College Publishers, 1993.

Zapata, Jesse T. "Early Identification and Recruitment of Hispanic Teacher Candidates." *Journal of Teacher Education,* pages 19-23, January/February, 1988.

CHAPTER THREE



Anderson, Bernice Taylor. "How Can Middle Schools Get Minority Females in the Math/Science Pipeline?" *Education Digest,* Vol. 59, Issue 2, page 39, October 1993.

Baker, Merl. "Innovations in Educational Methodologies for Attracting More Women into Engineering." *Proceedings of the 24th Annual Frontiers in Education Conference,* IEEE Catalog No: 93CH3373-8, pages 419-422, November, 1994.

Barba, Roberta H. "A Study of Culturally Syntonic Variables in the Bilingual/Bicultural Science Classroom," *Journal of Research in Science Teaching,* Vol. 30, No. 9, pages 1053-1071, 1993.

BBarinaga, Marcia. "Is There a 'Female Style" in Science?" *Science,* Vol. 260, pages 384-391, April 16, 1993.

Belenky, Mary, Blythe Clinchy, Nancy Goldgerger, and Jill Tarule. *Women's Ways of Knowing.* New York: Basic Books, 1986.

Delpit, Lisa. *Other People's Children. Cultural Conflict in the Classroom.* New York: New Press, 1995.

Emmett, Arielle. "A Women's Institute of Technology?" *Engineering Education,* pages 16-18, April 1992.

Ferhs, Mary and Roman Czujko. "Women in Physics: Reversing the Exclusion." *Physics Today,* page 3340, August 1992.

Ferguson, Marianne. "Is the Classroom Still a Chilly Climate for Women?" *College Student Journal,* Vol. 26, No. 4, pages 507-511, December 1992.

Geppert, Linda. "The Uphill Struggle, No Rose Garden for Women in Engineering." *IEEE Spectrum,* page 40, May, 1995.

Grant, Carl A. and Christine E. Sleeter. *Turning on Learning, Five Approaches for Multicultural Teaching Plans for Race, Class, Gender, and Disability.* Columbus, Ohio: Merrill Publishing Co., 1989.

Grossman, Herbert. *Educating Hispanic Students.* Springfield, Illinois: Charles C. Thomas Publisher, 1984.

Part III: References

Levander, Michelle. "Why Women Sour on Science, Engineering Jobs." *San Jose Mercury News,* Business Section, January, 16, 1994.

MacKay, Kenneth. "MESA: Pre-College Support for Minority Students," *Mercury,* page 31, May/June 1995.

Martinez, Joseph. personal conversation, Counselor, Hartnell College, Salinas, CA, 1995.

McCurdy, Deirdre. "Gender and the Numbers: Women Still Shy Away from Math and Science." *Maclean's,* pages 64-67 November 9, 1992.

Meyers, Chet, and Thomas B. Jones. *Promoting Active Learning,* San Francisco: Jossey-Bass Inc., Publishers, 1993.

Panitz, Beth, "WiSE Women," *ASEE PRISM,* page 15, March, 1995.

Rakow, Steven J. and Andrea B. Bermudez. "Science is "Ciencia:" Meeting the Needs of Hispanic American Students." *Science Education,* Number 77, Vol. 6, pages 669-683, 1993.

Rodríguez, Carlos Mario. "Minorities in Science and Engineering: Patterns for Success." Ph.D. diss., The University of Arizona, Department of Educational Administration and Higher Education, 1993.

Schiele, Jerome H. "An Epistemological Perspective on Intelligence Assessment Among African-American Children. *Journal of Black Psychology,* Vol. 17, No. 2, pages 23-26, Spring, 1991.

Schwartz, Wendy and Katherine Hanson. "Equal Mathematics Education for Female Students." *ERIC,* #ED344977, pages 1-5, February, 1992.

Shepherd, Linda Jean. *Lifting the Veil, The Feminine Face of Science.* Boston: Shambhala, 1993.

Tannen, Deborah. *You Just Don't Understand.* New York: Ballantine Books, 1990.

Trankina, Michele L. "Racio-Ethnic Differences in Confidence in Science." *Psychological Reports,* Vol. 71, pages 235-242, 1992.

CHAPTER FOUR

Alper, Joe. "The Pipeline is Leaking Women All the Way Along." *Science,* Vol. 260, pages 409-411, April 16, 1993.

Belenky, Mary, Blythe Clinchy, Nancy Goldgerger, and Jill Tarule. *Women's Ways of Knowing.* New York: Basic Books, 1986.

Capra, Fritjof. *The Turning Point: Science, Society, and the Rising Culture.* New York: Bantam Books, 1982.

Cohen, John. "Stephen Thompson: Call Him Czar of Small-Scale Chemistry." *Science,* Vol. 266, page 889, November 1994.

Culotta, Elizabeth. "New Modes for Making Scientists." *Science,* Vol. 266, page 875-888, November 1994.

Delpit, Lisa. *Other People's Children. Cultural Conflict in the Classroom.* New York: New Press, 1995.

"Educating Tomorrow's Engineers: Four Corporate Executives and an NSF Assistant Director Say It's Time to Educate a New Breed of Engineer." (no author named) *ASEE Prism,* pages 11-15, May/June 1995.

Fee, E. "Women's Nature and Scientific Objectivity." in M. Loew and R. Hubbard, eds. *Woman's Nature: Rationalizations of Inequality.* New York: Pergamon Press, pages 9-27, 1983.

Gilliand, Kay. EQUALS in Computer Technology, *The Computing Teacher,* page 42, April 1984.

Grossman, Herbert. *Educating Hispanic Students.* Springfield, Illinois: Charles C. Thomas Publisher, 1984.

Hilliard, Asa G. , III. "Cultural Style in Teaching and Learning." *The Education Digest,* December, pages 21-23, 1989.

Institute for Responsive Education. *Equity and Choice.* Vol. II, No. 2, pages 35-40, Winter, 1986.

Keller, Evelyn Fox. *Reflections on Gender and Science.* New Haven: Ale University Press, pages 164-5, 1985.

Part III: References

Kruschwitz, Kate and Carolyn McClintock Peter. "All-Girl Settings for Teaching Math and Science." *The Education Digest.* pages 60-62, February, 1995.

Mander, Jerry. *In the Absence of the Sacred: The Failure of Technology and the Survival of the Indian Nations.* San Francisco: Sierra Club Books, 1991.

Meyers, Chet, and Thomas B. Jones. *Promoting Active Learning,* San Francisco: Jossey-Bass Inc., Publishers, 1993.

National Science Foundation, *Women, Minorities, and Persons With Disabilities in Science and Engineering: 1994,* Document # NSF 94-333, November, 1994.

Panitz, Beth. "Wanted: More Good Women." (Interview with Carolyn Meyers) *ASEE PRISM,* pages 22-27, February, 1995.

Rosser, Sue V. *Female-Friendly Science: Applying Women's Studies Methods and Theories to Attract Students.* New York: Pargamon Press, 1990.

Sechi, Gabriella, personal conversation, Academic Dean, Cogswell Polytechnic College, Cupertino, CA, 1995.

Schneider, Stephen H. "A Better Way to Learn." World Monitor, Vol. 6, Issue 4, page 30, April 1993.

Shade, Barbara J. "Afro-American Cognitive Style: A Variable in School Success?". *Review of Educational Research*, Vol. 52, No. 2, pages 219-244, Summer, 1982.

Shepherd, Linda Jean. *Lifting the Veil, The Feminine Face of Science.* Boston: Shambhala, 1993.

Sternberg, Robert J. "Thinking Styles: Keys to Understanding Student Performance." *Phi Delta Kappan,* page 366, January, 1990.

Tannen, Deborah. *You Just Don't Understand.* New York: Ballantine Books, 1990.

Tobias, Sheila, *Overcoming Math Anxiety*. W.W. Norton & Company, New York, 1993.

Tobias, Sheila. *Succeed with Math: Every Student's Guide to Conquering Math Anxiety.* New York: College Board Publications, 1987.

Wildcat, Daniel, and Edward Necefer. "A Native American Model." in *Lessons for the Future: Minorities in Math, Science, and Engineering at Community Colleges*, edited by Enid B. Jones. Washington, D.C: American Association of Community Colleges, 1993.

Additional References Used to Design the Problem Definitions in Chapter Four

Allows a Discovery Process and Acknowledges Uncertainty in Acquiring Knowledge

Flanagan, Anna. "School Practices Vygotskian Principles." *The Council Chronicle* (National Council of Teachers of English), page 5, September, 1995.

Tobias, Sheila. "Keep Culture from Keeping Girls Out of Science." *The Education Digest.* pages 19-20, September, 1994.

Includes Open Ended Problems

Brush, Lorelei, "Mathematics Anxiety in College Students," *Journal of Counseling Psychology,* Vol. 19 page 551, 1978.

Culotta, Elizabeth. "New Modes for Making Scientists." *Science,* Vol. 266, pages 875-888, November 1994.

Doll, W. Jr. *A Post-modern Perspective on Curriculum.* New York: Teachers College Press, page 162, 1993.

Koberg, Don and Jim Bagnall. *The Universal Traveler.* Crisp Publications, Inc. 95 First Street, Los Altos, CA. 1991.

McCormick, Theresa Mickey. "Technology and Multicultural Nonsexist Teaching," in *Developing Multicultural Teacher Education Curricula*. Editors: Joseph M. Larkin and Christine E. Sleeter, State University of New York Press, pages 203-217, 1995.

Part III: References

Yager, Robert E. "Science/Technology/Society and Teacher Education: Solutions for Problems of Diversity and Equity," in *Diversity and Teaching, Teacher Education Yearbook I,* edited by Mary John O'Hair and Sandra J. Odell, New York: Harcourt Brace Jovanovich College Publishers, 1993.

Insures Subjects are Alive and Holistic

Barker, Joel Arthur. *Paradigms: The Business of Discovering the Future.* Harper Business, New York, 1993.

Bell, Yvonne R. "Culturally Sensitive Analysis of Black Learning Style." *Journal of Black Psychology,* Vol. 20, No. 1, page 47-61, Feb 1994.

Hart, Leslie A. "The Horse is Dead." *Phi Delta Kappan,* page 241, November, 1989.

Heisenberg, Werner. *Physics and Philosophy.* New York: Harper & Row, 1958.

Hilliard, Asa G. , III. "Cultural Style in Teaching and Learning." *The Education Digest,* December, pages 21-23, 1989.

National Science Foundation, *2nd National Conference on Diversity in the Scientific and Technological Workforce. Conference Proceedings.* Directorate for Educational and Human Resources, Omni Shoreham Hotel, Washington, D.C., October 28-30, 1993.

Whitlock, Gene. "Digging into Science, Archaeoastronomy in a Multicultural Science Curriculum," *Mercury,* pages 32-24, July/August, 1995.

Yager, Robert E. "Science/Technology/Society and Teacher Education: Solutions for Problems of Diversity and Equity," in *Diversity and Teaching, Teacher Education Yearbook I,* edited by Mary John O'Hair and Sandra J. Odell, New York: Harcourt Brace Jovanovich College Publishers, 1993.

Explores Technology's Role in Society

Cordes, C. "Technology as Religion?" *The Chronicle of Higher Education,* page A10, April 27, 1994.

Cowen, R. "President's Budget: Rosy Outlook for R&D," *Science News,* Vol. 139, No. 6, pages 87, 94, February 9, 1991.

McCormick, Theresa Mickey. "Technology and Multicultural Nonsexist Teaching," in *Developing Multicultural Teacher Education Curricula.* Editors: Joseph M. Larkin and Christine E. Sleeter, State University of New York Press, pages 203-217, 1995.

McLaren, P. *Life in Schools: An Introduction to Critical Pedagogy in the Foundations of Education.* White Plains, New York: Longman, 1989.

Needham, J. "History and Human Values: A Chinese Perspective for World Science and Technology," in H. Rose and S. Rose, eds., *Ideology of/ in the Natural Sciences.* Schenkman, Cambridge, Mass, pages 255-256, 1976.

Promotes Social Interaction and Human Interconnections

Cross, K. P, "Every Teacher a Researcher, Every Classroom a Laboratory." in *Tribal College: A Journal of American Indian Higher Education,* 2(4) , 7-12, Spring, 1991.

Hacker, Sally L. "The Culture of Engineering: Woman, Workplace and Machine." *Women's Studies International Quarterly,* Vol 4: pages 341-53, 1981.

Hacker, Sally L. "Mathematization of Engineering: Limits on Women and the Field." In Joan Rothschild (ed.), *Machina Ex Dea.* Elmsford, N.Y.: Pergamon Press, 1983.

Lockhead, M., M. Thorpe, J. Brooks-Gunn, P. Casserly, & A. McAloon. *Understanding Sex-ethnic Differences in Mathematics, Science, and Computer Science for Students in Grades Four to Eight.* Princeton: Educational Testing Service, 1985.

McIlwee, Judith S. and J. Gregg Robinson. *Women in Engineering: Gender, Power, and Workplace Culture.* Albany: State University of New York Press, 1992.

Meek, Anne. "On Creating *Ganas:* A Conversation with Jaime Escalante." *Educational Leadership,* pages 45-7, February 1989.

Nichols, Edwin J. "Cultural Foundations for Teaching Black Children." *Teaching Mathematics, Volume I; Culture, Motivation, History, and Classroom Management,* Oswald and Ratteray, editors. Washington, D.C.: Institute for Independent Educators, pages 10-16, 1986.

CHAPTER FIVE

Alper, Joe. "The Pipeline is Leaking Women All the Way Along." *Science,* Vol. 260, pages 409-411, April 16, 1993.

Asimov, Nanette, "A Plan to Attract Girls to Math, Science," San Francisco Chronicle, page A3, March 9, 1992.

Banks, James A. "Ethnicity, Class, Cognitive, and Motivational Styles: Research and Teaching Implication." *The Journal of Negro Education,* 57, pages 452-466, 1988.

Basso, K. *Portraits of the Whiteman: Linguistic Play and Cultural Symbols Among the Western Apache.* New York: Cambridge University Press, 1979.

Bateson, Mary Catherine. *With a Daughter's Eye: A Memoir of Margaret Mead and Gregory Bateson.* New York: William Morrow, 1984.

Belenky, Mary, Blythe Clinchy, Nancy Goldgerger, and Jill Tarule. *Women's Ways of Knowing.* New York: Basic Books, 1986.

Boseker, B.J., and S.L. Gordon. "What Native Americans Have Taught Us as Teacher Educators." *Journal of American Indian Education,* pages 20-24, May 1983.

Browne, D.B., and Bordeau. K. "How South Dakota Teachers See Learning Style Differences." *Tribal College,* 2 (4), 24-26, 1991.

Caine, Renate Nummela and Geoffrey Caine. "Understanding a Brain-Based Approach to Learning and Teaching." *Educational Leadership,* October, pages 6-70, 1990.

California State Department of Education. "Indian Value, Attitudes, and Behaviors, Together with Educational Considerations." *American Indian Educational Handbook.* 1991.

Clark, Charles S. "Does the Educational System Short Change Females?" *CQ Researcher,* Vol. 4, Issue 21, page 481, June 3, 1994.

Comer, James P. "Child Development and Education." *Journal of Negro Education,* Vol. 58, No. 2, 1989.

"Corn's Weedy Companion," *The Seattle Times,* page D2, September 3, 1990.

Delpit, Lisa. *Other People's Children. Cultural Conflict in the Classroom.* New York: New Press, 1995.

Dunn, Rita, Ronald I. Sklar, Jeffrey Beaudry, and Jean Bruno. "Effects of Matching and Mismatching Minority Developmental College Students' Hemispheric Preferences on Mathematics Scores." *Journal of Educational Research,* Vol. 83, No. 5, pages 283-288, May-June 1990.

Eagan, James L. "Engineering Openings–Women Wanted." *Innovation Abstracts,* volume XVI, No. 22, The National Institute for Staff and Organizational Development (NISOD), EDB 348, Austin, Texas 78712, October 7, 1994.

Eroclano, Vincent. "Learning through Cooperation." *ASEE PRISM,* November, 1994.

Emmett, Arielle. "A Women's Institute of Technology?" *Engineering Education,* pages 16-18, April 1992.

Gilliand, Kay. EQUALS in Computer Technology, *The Computing Teacher,* page 42, April 1984.

Grossman, Herbert. *Educating Hispanic Students.* Springfield, Illinois: Charles C. Thomas Publisher, 1984.

Guild, Pat. "The Culture/Learning Style Connection," *Educational Leadership,* pages 16-21, April 1994.

Hawkins, Jan. "Computers and Girls: Rethinking the Issues." *Sex Roles,* Plenum Publishing Corporation, Vol. 13, Nos. 3/4, 1985.

Hendrick, J. & Strange, T. "Do Actions Speak Louder Than Words? An Effect of the Functional Use of Language on Dominant Sex Role Behavior in Boys and Girls." *Technical Report,* 143, 1-29. Norman: University of Oklahoma, College of Education, 1989.

Part III: References

152

Herrmann, Ned. *The Creative Brain,* The Ned Herrmann Group, 2075 Buffalo Creek Road, Lake Lure, North Carolina 28746, (704) 625-9153, 1993.

Hilliard, Asa G. , III. "Cultural Style in Teaching and Learning." *The Education Digest,* December, pages 21-23, 1989.

Horner, Matina S. "Fail: Bright Women," *Psychology Today,* Vol. 3, pages 36-38, 1969.

Hurt, Suzanne. "Storytelling Puts Nature in Spotlight at Pow Wow" *Register-Guard*, Eugene, Oregon, page 2C, September 29, 1996.

Institute for Responsive Education. *Equity and Choice.* Volume II, Number 2, pages 35-40, Winter, 1986.

Kagen, Spencer. "*Cooperative Learning,*" Resources for Teachers, Inc., 1(800) Wee Co-op, 1992.

Kleinfeld, J. S. *Instructional Style and the Intellectual Development of Village Indian and Eskimo Students.* Washington, D.C., U.S. Office of Education, 1972.

Koch, Melissa. "Opening Up Technology to Both Genders." *Education Digest,* Vol. 60, Issue 3, page18, November 1994.

LaFarge Phyllis. "7 Keys to Learning." *Parents,* page 118-124, February, 1994.

Laren, Kristine M. "Participation in Science by Minorities," *Mercury,* page 14-16, May/June, 1995.

McCarthy, Abigail. "Women's Colleges Work: You Could Look It Up." *Commonweal,* page 8, May 6, 1994.

Mander, Jerry. *In the Absence of the Sacred: The Failure of Technology and the Survival of the Indian Nations.* San Francisco: Sierra Club Books, 1991.

Meyers, Chet, and Thomas B. Jones. *Promoting Active Learning,* San Francisco: Jossey-Bass Inc., Publishers, 1993.

Morse, Susan. "Why Girls Don't Like Computer Games." *AAUW Outlook,* pages 19-23, Winter, 1994.

National Science Foundation, *Women, Minorities, and Persons With Disabilities in Science and Engineering: 1994,* Document # NSF 94-333, November, 1994.

Poplin, Mary and Joseph Weeres. "Listening at the Learner's Level: Voices From Inside the Schoolhouse." *Education Digest,* September 1993.

Ramirez, M., and A. Castaneda. *Cultural Democracy, Biocognitive Development, and Education.* New York: Academic Press, 1974.

Schwartz, Wendy and Hanson, Katherine. "Equal Mathematics Education for Female Students." *ERIC,* #ED344977, pages 1-5, February, 1992.

Shaver, Phillip. "Questions Concerning Fear and Success and Its Conceptual Relatives," *Sex Roles,* Vol. 2, pages 205-220, 1979.

Shade, Barbara J. "Afro-American Cognitive Style: A Variable in School Success?". *Review of Educational Research*, Volume 52, No. 2, pages 219-244, Summer, 1982.

Shepherd, Linda Jean. *Lifting the Veil, The Feminine Face of Science.* Boston: Shambhala, 1993.

Tannen, Deborah. *You Just Don't Understand.* New York: Ballantine Books, 1990.

Tobias, Sheila, *Overcoming Math Anxiety.* W.W. Norton & Company, New York, 1993.

Travis, John. "Making Room for Women in the Culture of Science." *Science,* Vol. 260, pages 412-415, April 16, 1993.

Traweek, Sharon. *Beamtimes and Lifetimes: The World of High Energy Physicists.* Cambridge, Mass: Harvard University Press, pages 33, 1988.

Went, Frits W. *The Plants.* New York: Time-Life Books, page 168, 1963.

Additional References Used to Design the Problem Definitions in Chapter Five

Develops a Comfortable Classroom Environment

Blosser, Patricia R. "Procedures To Increase the Entry of Women in Science-Related Careers." ERIC/SMEAC Science Education Digest No. 1. #ED321977 90, (1-800-LET-ERIC), 1991.

Brush, Lorelei, R. *Encouraging Girls in Mathematics, The Problem and Solution.* Abt Books, Cambridge Massachusetts, 1980.

Flam, Faye. "Warm Climate for Women on the Mediterranean." *Science,* Vol. 263, pages 1480-1481, March 11, 1994.

Geppert, Linda. "The Uphill Struggle, No Rose Garden for Women in Engineering." *IEEE Spectrum,* page 40, May, 1995.

Hawkins, Jan. "Computers and Girls: Rethinking the Issues." *Sex Roles,* Plenum Publishing Corporation, Volume 13, Nos. 3/4, 1985.

McCurdy, Deirdre. "Gender and the Numbers: Women Still Shy Away from Math and Science." *Maclean's,* pages 64-67 November 9, 1992.

Price, Jill S. and Abigail A. Hafer. "Some Gains, A Long Way to Go." *Mercury,* pages 11-16, May/June, 1995.

Seymour, Elaine, and Nancy M. Hewitt. *Talking about Leaving: Factors Contributing to High Attrition Rates Among Science, Mathematics, and Engineering Undergraduate Majors.* Boulder: University of Colorado, Bureau of Sociological Research, 1994.

Sharp, Marcia K. "Women's Colleges and the Women's Movement." *The Education Digest*, pages 18-20, February, 1992.

University of California, Higher Education Research Institute. *Education:The Impact of Different College Environments on the Educational Pipeline in the Sciences.* Los Angeles, 1993.

Supports a Cooperative Learning Environment

Aronson, Elliot. *The Social Animal.* New York: W. H. Freeman and Company, 1995.

Barba, Roberta H. "A Study of Culturally Syntonic Variables in the Bilingual/Bicultural Science Classroom," *Journal of Research in Science Teaching,* Vol. 30, No. 9, pages 1053-1071, 1993.

Barinaga, Marcia. "Is There a 'Female Style" in Science?" *Science,* Volume 260, pages 384-391, April 16, 1993.

Brown, Ann L. and Robert A. Reeve. "Bandwidths of Competence: The Role of Supportive Contexts in Learning Development." in *Development Learning: Conflict or Congruence.* editor: Lynn S. Liben. Hillsdale, New Jersey: Lawrence Eribaum Associates, 1987.

Cohen, E. G. *Designing Groupwork: Strategies for Heterogeneous Classroom.* New York: Teachers College Press, 1986.

Feldman, David Henry. "Going for the Middle Ground: A Promising Place for Educational Psychology. in *Development Learning: Conflict or Congruence.* editor: Lynn S. Liben. Hillsdale, New Jersey: Lawrence Eribaum Associates, 1987.

Kaplan, Joel and David Aronson. "The Numbers Gap." *Teaching Tolerance.* pages 21-27, Spring, 1994.

Kruschwitz, Kate and Carolyn McClintock Peter. "All-Girl Settings for Teaching Math and Science." *The Education Digest.* pages 60-62, February, 1995.

McIlwee, Judith S. and J. Gregg Robinson. *Women in Engineering: Gender, Power, and Workplace Culture.* Albany: State University of New York Press, 1992.

Melear, Claudia. "Multiculturalism in Science Education," *The American Biology Teacher,* Vol. 57, No. 1, pages 21-26, January 1995.

Scott, Rose Mary. "Reading Methods Courses: A Multicultural Perspective." in *Developing Multicultural Teacher Education Curricula.* Editors: Joseph M. Larkin and Christine E. Sleeter, State University of New York Press, pages 118, 1995.

Slavin, R.E. *Cooperative Learning.* New York: Longman, 1983.

Tobias, Sheila. "Reforming Freshman Science." *Technology,* May/June 1992.

Part III: References

Vitalizes Physical Space

Koch, Melissa. "Opening Up Technology to Both Genders." *Education Digest,* Vol. 60, Issue 3, page 18, November 1994.

LaFarge Phyllis. "7 Keys to Learning." *Parents,* pages 118-124, February, 1994.

Samples, Bob. "Instructional Diversity." *The Science Teacher,* pages 14-17, February 1994.

Embraces Collaborative Conversation Styles

Academic Senate for California Community Colleges, *An Integrated Approach to Multicultural Education,* Educational Policies Committee and Affirmative Action/Cultural Diversity Committee, Sacramento, CA., 1991-1995.

Aries, Elizabeth. "Interaction Patterns and Themes of Male, Female, and Mixed Groups: Are Traditional Sex Roles Changing?" *Psychological Reports,* Vol. 51, pages 127-134, 1982.

Barinaga, Marcia. "Is There a 'Female Style" in Science?" *Science,* Volume 260, pages 384-391, April 16, 1993.

Basso, K. *Portraits of the Whiteman: Linguistic Play and Cultural Symbols Among the Western Apache.* New York: Cambridge University Press, 1979.

Edelsky, C. Who's Got the Floor? *Language in Society,* Vol. 10, pages 383-421, 1981.

Hendrick, J. & Strange, T. "Do Actions Speak Louder Than Words? An Effect of the Functional Use of Language on Dominant Sex Role Behavior in Boys and Girls." *Technical Report,* 143, 1-29. Norman: University of Oklahoma, College of Education, 1989.

Kramaerae, C., & Treichler, P.A. "Power Relationships in the Classroom." in S. L. Gabriel & I. Smithson. (Eds.) *Gender in the Classroom: Power and Pedagogy* Urbana and Chicago: University of Illinois Press, pages 41-59, 1990.

McCurdy, Deirdre. "Gender and the Numbers: Women Still Shy Away from Math and Science." *Maclean's,* pages 64-67 November 9, 1992.

Redpath. J., & Claire, H. "Girls & Boys Interactions in Primary Classrooms." Ealing Gender Equality Teams Occasional Paper No. 2., London: Elthorne Professional Centre, 1989.

Spacks, P. "In Praise of Gossip." *Hudson Review,* Vol 35, pages 19-38, 1982.

Uses Technology Tools Holistically

Gilliland, Kay. "Equals in Computer Technology: An Intervention." *The Monitor,* January/February 1986.

Koch, Melissa. "Opening Up Technology to Both Genders." *Education Digest,* Vol. 60, Issue 3, page18, November 1994.

WEEA Publishing Center. "School-to Work Equitable Outcomes." Educational Development, 55 Chapel Street, Newton, Massachusetts, 1995.

CHAPTER SIX

Academic Senate for California Community Colleges, An Integrated Approach to *Multicultural Education,* Educational Policies Committee and Affirmative Action/Cultural Diversity Committee, Sacramento, CA., 1991-1995.

Belenky, Mary, Blythe Clinchy, Nancy Goldgerger, and Jill Tarule. *Women's Ways of Knowing.* New York: Basic Books, 1986.

Brush, Lorelei, R. Encouraging Girls in Mathematics, The Problem and Solution. Abt Books, Cambridge Massachusetts, 1980.

Contreras, Maximiliano. "Hemishpheric Learning and the Hispanic Student." *Viewpoints* (120), ERIC Document #ED 277 505, June 1985.

Delpit, Lisa. *Other People's Children. Cultural Conflict in the Classroom.* New York: New Press, 1995.

Part III: References

Eding, Walter. "Learning Styles and Tech Prep, National Tech Prep Network," *Connections*, page 1, January 1995.

Fried, Jane. "Monocultural Perspectives and Campus Diversity," *Higher Education Exchange*, The Kettering Foundation, pages 18-25, 1995.

Grossman, Herbert. *Educating Hispanic Students.* Springfield, Illinois: Charles C. Thomas Publisher, 1984.

Guild, Pat. "The Culture/Learning Style Connection," *Educational Leadership*, pages 16-21, April 1994.

Koch, Melissa. "Opening Up Technology to Both Genders." *Education Digest*, Vol. 60, Issue 3, page 18, November 1994.

Kruschwitz, Kate and Carolyn McClintock Peter. "All-Girl Settings for Teaching Math and Science." *The Education Digest.* pages 60-62, February, 1995.

Mander, Jerry. *In the Absence of the Sacred: The Failure of Technology and the Survival of the Indian Nations.* San Francisco: Sierra Club Books, 1991.

McCarthy, Bernice. *The 4MAT System: Teaching to Learning Styles with Right/Left Mode Techniques.* EXCEL, Inc., 200 West Station Street, Barrington, IL, 1987.

Melear, Claudia. "Multiculturalism in Science Education," *The American Biology Teacher*, Volume 57, No. 1, page 21, January 1995.

National Science Foundation, *2nd National Conference on Diversity in the Scientific and Technological Workforce. Conference Proceedings.* Directorate for Educational and Human Resources, Omni Shoreham Hotel, Washington, D.C., October 28-30, 1993.

Rillero Peter. "Doing Science With Your Children" *ERIC Clearinghouse for Science, Mathematics, and Environmental Education*, Columbus OH, (1-800-LET-ERIC), 1994.

Samples, Bob. "Instructional Diversity." The *Science Teacher*, pages 14-17, February 1994.

Schneider, Stephen H. "A Better Way to Learn." *World Monitor*, Vol. 6, Issue 4, page 30, April 1993.

Shade, Barbara J. "Afro-American Cognitive Style: A Variable in School Success?". *Review of Educational Research*, Vol. 52, No. 2, pages 219-244, Summer, 1982.

Smith, Edward C. "Cultural Differences and Academic Achievement." *Pointer*, Vol. 30, No. 3, pages 28-31, Spring, 1986.

Vasquez, J. A. "Cognitive Style and Academic Achievement." in Cultural Diversity and the Schools: Consensus and Controversy," edited by J. Lynch, C. Modgil, and S. Modgil. London: Falconer Press, 1991.

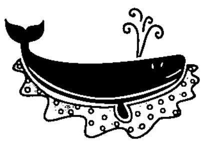
vonOech, Roger. *A Whack On the Side of the Head: How You Can Be More Creative.* Creative Think: Box 7354, Menlo Park, California, 1992.

WEEA Publishing Center. "School-to Work Equitable Outcomes." Educational Development, 55 Chapel Street, Newton, Massachusetts, 1995.

Whitlock, Gene. "Digging into Science, Archaeoastronomy in a Multicultural Science Curriculum," Mercury, pages 32-24, July/August, 1995.

Yager, Robert E. "Science/Technology/Society and Teacher Education: Solutions for Problems of Diversity and Equity," in *Diversity and Teaching, Teacher Education Yearbook I*, edited by Mary John O'Hair and Sandra J. Odell, New York: Harcourt Brace Jovanovich College Publishers, 1993.

Additional References Used to Design the Problem Definitions in Chapter Six



Promotes Multi-perspectives

New, Clara, A. "Oral Histories: An Interactive Link in Teaching Language Arts," in *Developing Multicultural Teacher Education Curricula*. Editors: Joseph M. Larkin and Christine E. Sleeter, State University of New York Press, 1995.

Part III: References

Shepherd, Linda Jean. *Lifting the Veil, The Feminine Face of Science.* Boston: Shambhala, 1993.

Traweek, Sharon. *Beamtimes and Lifetimes: The World of High Energy Physicists.* Cambridge, Mass: Harvard University Press, 1988.

Integrates Family and Community

Banks, James. A. *Multiethnic Education, 3rd edition,* Boston: Allyn and Bacon, 1994.

Claxton, C.S. "Learning Styles, Minority Students, and Effective Education," *Journal of Developmental Education,* Vol. 14, pages 6-8, Fall, 1990.

Cordes, C. "Technology as Religion?" *The Chronicle of Higher Education,* page A10, April 27, 1994.

Larkin, Joseph M. "Rethinking Basic Skills Instruction with Urban Students," *Forum,* Vol. 57, No. 4, pages 13-19, Summer, 1993.

National Science Foundation, *2nd National Conference on Diversity in the Scientific and Technological Workforce. Conference Proceedings.* Directorate for Educational and Human Resources, Omni Shoreham Hotel, Washington, D.C., October 28-30, 1993.

Adapts to Diverse Learning Styles

Anderson, Bernice Taylor. "How Can Middle Schools Get Minority Females in the Math/Science Pipeline?" *Education Digest,* Volume 59, Issue 2, page 39, October 1993.

Banks, James A. "Ethnicity, Class, Cognitive, and Motivational Styles: Research and Teaching Implication." *The Journal of Negro Education,* 57, pages 452-466, 1988.

Cameron, Julia, *The Artist's Way.* Jeremy P. Tarcher/Putnam Book, New York, NY, 1992.

Dunn, Rita, Ronald I. Sklar, Jeffrey Beaudry, and Jean Bruno. "Effects of Matching and Mismatching Minority Developmental College Students' Hemispheric Preferences on Mathematics Scores." *Journal of Educational Research,* Vol. 83, No. 5, pages 283-288, May-June 1990.

Edwards, Betty. *Drawing on the Right Side of the Brain.* J.P. Tarcher, Inc. Los Angeles, CA 1979.

Gilligan, C. *In a Different Voice.* Cambridge, Mass: Harvard University Press, 1982.

Herrmann, Ned. *The Creative Brain,* The Ned Herrmann Group, 2075 Buffalo Creek Road, Lake Lure, North Carolina 28746, (704) 625-9153, 1993.

LaFarge Phyllis. "7 Keys to Learning." *Parents,* pages 118-124, February, 1994.

Nance, Theresa and Anita Kathy Foeman. "Rethinking the Basic Public Speaking Course for African American Students and Other Students of Color," *Journal of Negro Education,* Vol. 62, No. 4, pages 448-458, Fall, 1993.

Rakow, Steven J. and Andrea B. Bermudez. "Science is "Ciencia:" Meeting the Needs of Hispanic American Students." *Science Education,* No. 77, Vol. 6, pages 669-683, 1993.

Ramirez, M., and A. Castaneda. *Cultural Democracy, Biocognitive Development, and Education.* New York: Academic Press, 1974.

Rico, Gabriele, *Writing the Natural Way.* J. P. Tarcher, Inc. Los Angeles, 1983.

Rios, Francisco A. and Gerardo M. Gonzalez. "Psychological and Developmental Perspectives in a Multicultural Framework: Exploring Some Possibilities," *Developing Multicultural Teacher Education Curricula.* Editors: Larkin and Sleeter. Albany: State University of New York Press, pages 79-104, 1995.

Schiele, Jerome H. "An Epistemological Perspective on Intelligence Assessment Among African-American Children. *Journal of Black Psychology,* Vol. 17, No. 2, pages 23-26, Spring, 1991.

Schroeder, Charles, C. "New Students–New Learning Styles." *Change,* page 21, September/October, 1993.

Uses a Variety of Assessment Tools

Hein, George. *The Assessment of Hands-on Elementary Science Programs.* Center for Teaching and Learning, University of North Dakota, Grand Forks, ND, 1990.

Marzano, Robert J., Debra Pickering, and Jay. McTighe. *Assessing Student Outcomes.* Association for Supervision and Curriculum Development, Alexandria, Virginia, 1993.

Myers, Carol A. "What's the Difference Between Authentic and Performance Assessment?" *Educational Leadership*, Vol. 49, No. 8, page 39, May, 1992.

National Science Foundation, *2nd National Conference on Diversity in the Scientific and Technological Workforce. Conference Proceedings.* Directorate for Educational and Human Resources, Omni Shoreham Hotel, Washington, D.C., October 28-30, 1993.

Newmann, Fred M. and Gary G. Wehlage. "Five Standards of Authentic Instruction." *Educational Leadership*, Vol. 50, No. 7, pages 8-12, April, 1993.

Paulson, F. Leon, Pearl R. Paulson, and Carol A. Meyer. "What Makes a Portfolio a Portfolio?" *Educational Leadership*, Vol. 48, No. 5, pages 60-63. February 1991.

Rakow, Steven J. and Andrea B. Bermudez. "Science is "Ciencia:" Meeting the Needs of Hispanic American Students." *Science Education*, No. 77, Vol. 6, pages 669-683, 1993.

Schneider, Stephen H. "A Better Way to Learn." *World Monitor*, Vol. 6, Issue 4, page 30, April 1993.

Zessoules, R., and H. Gardner. "Authentic Assessment: Beyond the Buzzword and into the Classroom." *Assessment in School: Issues and Possibilities.* Washington, D.C.: Association for Supervision and Curriculum Development, 1991.

CHAPTER SEVEN

Anderson, L., and W. Stein. "Making Math Relevant." *Tribal College* 3(3): 13, 18-19, 1992.

Barinaga, Marcia. "Feminists Find Gender Everywhere In Science." *Science*, Vol. 260, pages 392-393, April 16, 1993.

Belenky, Mary, Blythe Clinchy, Nancy Goldgerger, and Jill Tarule. *Women's Ways of Knowing.* New York: Basic Books, 1986.

Blosser, Patricia R. "Procedures To Increase the Entry of Women in Science-Related Careers." ERIC/SMEAC Science Education Digest No. 1. #ED321977 90, (1-800-LET-ERIC), 1991.

Culotta, Elizabeth. "New Modes for Making Scientists." *Science*, Vol. 266, pages 875-888, November 1994.

Daggett, Willard R. "Everything New Looks Old Again, Technology Alone Can't Fix What's Broken in Education." *Vocational Education Journal*, pages 26-28, September, 1994.

Delpit, Lisa. *Other People's Children. Cultural Conflict in the Classroom.* New York: New Press, 1995.

Ferhs, Mary and Roman Czujko. "Women in Physics: Reversing the Exclusion." *Physics Today*, page 3340, August 1992.

Freeman, Dyson. *Disturbing the Universe.* New York: Basic Books, 1979.

Green, M. F. *Minorities on campus: A handbook for enhancing diversity.* Washington, D.C. American Council on Education., 1989.

Grossman, Herbert. *Educating Hispanic Students.* Springfield, Illinois: Charles C. Thomas Publisher, 1984.

Guild, Pat. "The Culture/Learning Style Connection," *Educational Leadership*, pages 16-21, April 1994.

Harmon, Willis and Howard Rheingold. *Higher Creativity: Liberating the Unconscious for Breakthrough Insights.* Los Angeles: Jeremy P. Tarcher, pages 24-28, 1984.

157

Part III: References

McCarthy, Bernice. *The 4MAT System: Teaching to Learning Styles with Right/Left Mode Techniques.* EXCEL, Inc., 200 West Station Street, Barrington, IL, 1987.

Holliday, B. "Toward a Model of Teacher-Child Transactional Processes Affecting Black Children's Academic Achievement," in M.B. Spencer, G.K. Brookings, and W.R. Allen, eds., *Beginnings: The Social and Affective Development of Black Children,* Lawrence Erlbaum & Assoc., Hillsdale, N.J., 1985.

Holton, Gerald. *Thematic Origins of Scientific Thought: Kepler to Einstein,* Cambridge, Mass: Harvard University Press, 1988.

Kagen, Spencer. *"Cooperative Learning,"* Resources for Teachers, Inc., 1(800) Wee Co-op, 1992.

Keller, E. F. *A Feeling for the Organism: The Life and Work of Barbara McClintock.* New York: W. H. Freeman, 1983.

Kruschwitz, Kate and Carolyn McClintock Peter. "All-Girl Settings for Teaching Math and Science." *The Education Digest.* pages 60-62, February, 1995.

Mander, Jerry. *In the Absence of the Sacred: The Failure of Technology and the Survival of the Indian Nations.* San Francisco: Sierra Club Books, 1991.

Megginson, R. *Mathematics and Native Americans.* Washington, D.C. Mathematical Association of America, 1990.

Melear, Claudia. "Multiculturalism in Science Education," *The American Biology Teacher,* Vol. 57, No. 1, pages 21-26, January 1995.

Meyers, Chet, and Thomas B. Jones. *Promoting Active Learning,* San Francisco: Jossey-Bass Inc., Publishers, 1993.

Mitroff, Ian. *The Subjective Side of Science: A Philosophical Inquiry into the Psychology of the Apollo Moon Scientists.* Seaside, California, Intersystems Publications, 1983.

National Science Foundation, *Women, Minorities, and Persons With Disabilities in Science and Engineering: 1994,* Document # NSF 94-333, November, 1994.

Rakow, Steven J. and Andrea B. Bermudez. "Science is "Ciencia:" Meeting the Needs of Hispanic American Students." *Science Education,* No. 77, Vol. 6, pages 669-683, 1993.

Reeves, Sandra and Anne Marriott. "A Burst of Popularity: Most Women's Colleges are Flourishing by Offering Students a Sense of Empowerment." *U.S. News and World Report,* September 26, 1994.

Rillero Peter , "Doing Science With Your Children" ERIC Clearinghouse for Science, Mathemat*ics, and Environmental Education,* Columbus OH, (1-800-LET-ERIC), 1994.

Schwartz, Wendy and Katherine Hanson. "Equal Mathematics Education for Female Students." *ERIC,* #ED344977, pages 1-5, February, 1992.

Shade, Barbara J. "Afro-American Cognitive Style: A Variable in School Success?". *Review of Educational Research*, Vol. 52, No. 2, pages 219-244, Summer, 1982.

Shepherd, Linda Jean. *Lifting the Veil, The Feminine Face of Science.* Boston: Shambhala, 1993.

Tobias, Sheila, *Overcoming Math Anxiety.* W.W. Norton & Company, New York, 1993.

Tobias, Sheila. *Succeed with Math: Every Student's Guide to Conquering Math Anxiety.* New York: College Board Publications, 1987.

Yager, Robert E. "Science/Technology/Society and Teacher Education: Solutions for Problems of Diversity and Equity," in *Diversity and Teaching, Teacher Education Yearbook I,* edited by Mary John O'Hair and Sandra J. Odell, New York: Harcourt Brace Jovanovich College Publishers, 1993.

Additional References Used to Design the Problem Definitions in Chapter Seven

Engages Students

Anderson, Bernice Taylor. "How Can Middle Schools Get Minority Females in the Math/Science Pipeline?" *Education Digest,* Vol. 59, Issue 2, page 39, October 1993.

Part III: References

Carruthers, George R. "Outreach Programs for African-American Students in Washington, D.C." *Mercury,* pages 29-32, May/June, 1995.

Ferhs, Mary and Roman Czujko. "Women in Physics: Reversing the Exclusion." *Physics Today,* page 3340, August 1992.

Institute for Responsive Education. *Equity and Choice.* Volume II, No. 2, pages 35-40, Winter, 1986.

Lang, Mozell P. "Preparing Teachers For Multicultural Science Integration," in *Developing Multicultural Teacher Education Curricula.* Editors: Joseph M. Larkin and Christine E. Sleeter, State University of New York Press, page 173, 1995.

McKeachie, W. J. Teaching Tips: *A Guidebook for the Beginning College Teacher.* (8th ed.) Lexington, Mass. : Heath, 1986.

Mosele, Sara. "A City School Experiment that Actually Works," *The New York Times Magazine*, page 27, May 28, 1995.

Pollio, H. R., "What Students Think About and Do in College Lecture Classes." *Teaching-Learning Issues,* No. 53. Knoxville: Learning Research Center, University of Tennessee, 1984.

Strauss, Sidney. "Educational-Developmental Psychology and School Learning." in Development Learning: Conflict or Congruence. editor: Lynn 5. Liben. Hillsdale, New Jersey: Lawrence Eribaum Associates, 1987.

Travis, John. "Making Room for Women in the Culture of Science." *Science*, Vol. 260, pages 412-415, April 16, 1993.

Verner, C. and G. Dickinson. "The Lecture: An Analysis and Review of Research." *Adult Education,* 17(2), 85-90, 1967.

Yager, Robert E. "Science/Technology/Society and Teacher Education: Solutions for Problems of Diversity and Equity," in *Diversity and Teaching, Teacher Education Yearbook I,* edited by Mary John O'Hair and Sandra J. Odell, New York: Harcourt Brace Jovanovich College Publishers, 1993.

Yusuf, Mian M. "Mathematics and Multiculturalism." in *Developing Multicultural Teacher Education Curricula.* Editors: Joseph M. Larkin and Christine E. Sleeter, State University of New York Press, pages 188, 1995.

Encourages Reflection

Yager, Robert E. "Science/Technology/Society and Teacher Education: Solutions for Problems of Diversity and Equity," in *Diversity and Teaching, Teacher Education Yearbook I,* edited by Mary John O'Hair and Sandra J. Odell, New York: Harcourt Brace Jovanovich College Publishers, 1993.

Caine, Renate Nummela and Geoffrey Caine. "Understanding a Brain-Based Approach to Learning and Teaching." *Educational Leadership,* October, pages 6-70, 1990.

Relevant to Students

Campoy, R. "The Role of Technology in the School Reform Movement," *Educational Technology,* page 21, August, 1992.

Fennema, E., & J. Sherman. "Sex Related Differences in Mathematics Achievement and Related Factors: A Further Study." *Journal for Research in Mathematics Education,* 9, 189-203, 1978.

Hauser, Diana, Eric Halsey, John Weinfield, and Julia Fox. "What Works & What Doesn't in Undergraduate Teaching." *ASEE PRISM,* pages 21-25, November 1995.

McCormick, Theresa Mickey. "Technology and Multicultural Nonsexist Teaching," in *Developing Multicultural Teacher Education Curricula.* Editors: Joseph M. Larkin and Christine E. Sleeter, State University of New York Press, pages 203-217, 1995.

McIlwee, Judith S. and J. Gregg Robinson. *Women in Engineering: Gender, Power, and Workplace Culture.* Albany: State University of New York Press, page 52, 1992.

National Science Foundation. *Partnering to Build A Quality Workforce: Critical Issues in Environmental Technology Education at Two-Year Colleges.* March, 1994.

Rosser, S. V. *Female-friendly Science; Applying Women's Studies Methods and Theories to Attract Students.* New York: Pergamon Press, 1990.

vonOech, Roger. *A Whack On the Side of the Head: How You Can Be More Creative.* Creative Think: Box 7354, Menlo Park, California, 1992.

Part III: References

WEEA Publishing Center. "School-to Work Equitable Outcomes." Educational Development, 55 Chapel Street, Newton, Massachusetts, 1995.

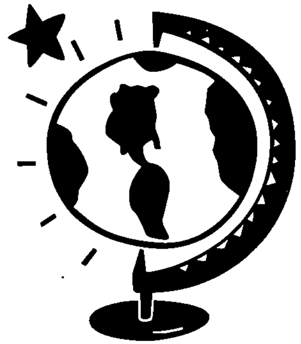
Involves Working in Groups and Develops Interpersonal Skills

Price, Jill S. and Abigail A. Hafer. "Some Gains, A Long Way to Go." *Mercury,* pages 11-16, May/June, 1995.

Values Feelings and Intuition

Herrmann, Ned. *The Creative Brain,* The Ned Herrmann Group, 2075 Buffalo Creek Road, Lake Lure, North Carolina 28746, (704) 625-9153, 1993.

Hoffmann, Banesh and Helen Dukas. *Albert Einstein, Creator and Rebel.* New York: New American Library, page 222, 1973.



Credits

Written by: Charlotte Behm

Solutions Compiled by: Gwen Quail, Diane Procell, Eric Smith

Layout: Denny Burzynski, Wade Ellis, Lin Marelick, Hozi Ringor, Charlotte Behm

Design and Desktop Publishing: Lin Marelick

Published by: Mission College Printing Department,
3000 Mission College Blvd., Santa Clara, CA 95054

SE060255

[redacted]

ERIC

U.S. Department of Education
Office of Educational Research and Improvement (OERI)
Educational Resources Information Center (ERIC)

REPRODUCTION RELEASE

(Specific Document)

I. DOCUMENT IDENTIFICATION:

Title: Connections Across Cultures

Author(s): Charlotte Behm, Pac-TEC Project

Corporate Source: Mission College, 3000 Mission College Blvd, Santa Clara, CA 95054

Publication Date: 1996

II. REPRODUCTION RELEASE:

In order to disseminate as widely as possible timely and significant materials of interest to the educational community, documents announced in the monthly abstract journal of the ERIC system, *Resources in Education* (RIE), are usually made available to users in microfiche, reproduced paper copy, and electronic/optical media, and sold through the ERIC Document Reproduction Service (EDRS) or other ERIC vendors. Credit is given to the source of each document, and, if reproduction release is granted, one of the following notices is affixed to the document.

If permission is granted to reproduce and disseminate the identified document, please CHECK ONE of the following two options and sign at the bottom of the page.

☑ Check here **For Level 1 Release:** Permitting reproduction in microfiche (4" x 6" film) or other ERIC archival media (e.g., electronic or optical) *and* paper copy.

The sample sticker shown below will be affixed to all Level 1 documents

PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY

Sample

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

Level 1

The sample sticker shown below will be affixed to all Level 2 documents

PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN OTHER THAN PAPER COPY HAS BEEN GRANTED BY

Sample

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

Level 2

☐ Check here **For Level 2 Release:** Permitting reproduction in microfiche (4" x 6" film) or other ERIC archival media (e.g., electronic or optical), but *not* in paper copy.

Documents will be processed as indicated provided reproduction quality permits. If permission to reproduce is granted, but neither box is checked, documents will be processed at Level 1.

"I hereby grant to the Educational Resources Information Center (ERIC) nonexclusive permission to reproduce and disseminate this document as indicated above. Reproduction from the ERIC microfiche or electronic/optical media by persons other than ERIC employees and its system contractors requires permission from the copyright holder. Exception is made for non-profit reproduction by libraries and other service agencies to satisfy information needs of educators in response to discrete inquiries."

Sign here→ please

Signature: Charlotte E Behm

Printed Name/Position/Title: Charlotte Behm, Principal Investigator, PacTEC Project

Organization/Address: Mission College, MS.18, 3000 Mission College Blvd, Santa Clara, CA 95054

Telephone: 408-748-2764

FAX: 408-496-0482

E-Mail Address: pactec@[illegible]wvm

Date: 5/[illegible]/97