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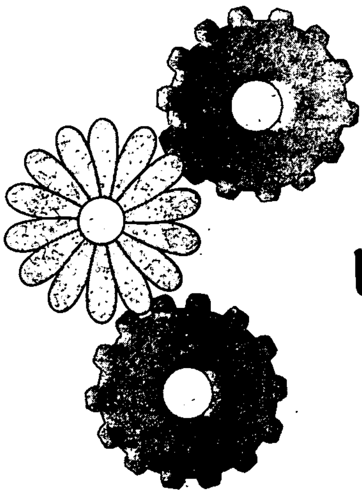
ABSTRACT

This document is an introduction to a larger manual on the Pac-TEC project. The Pac-TEC project 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 and 15 of those teachers are 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. Contains 22 references. (DDR)

Connections Across Cultures

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



Let Us Hear From You

- This publication is written as an introduction to a larger manual of 160 pages.
- If our brochure is of interest to you, we would be glad to send you a copy of the manual.
- Because the production of the manual was supported in part by a grant from the National Science Foundation's Advanced Technological Education Program, we can send the manual to you at no cost.

Also:

- The Pac-TEC project is interested in hearing comments, questions, and suggestions concerning its work.
- We are interested in establishing partnerships with other people or groups interested in our work.
- What has worked well in your classroom? We'd love to hear about it!

You can contact us at the addresses below:

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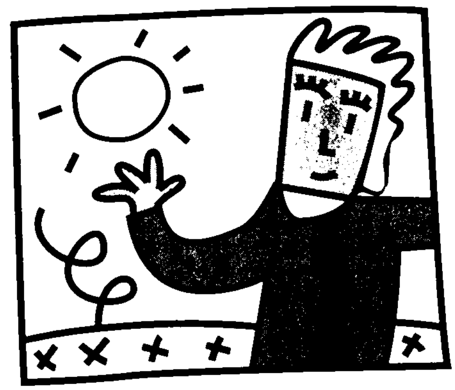
What Questions Are We Asking?

- What about the science, math, engineering, and technology fields is uncomfortable to students?
- Do students feel that they do not fit in or are unwelcome?



- Native Americans, African Americans, Hispanics, and women 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, math, engineering, and technology. Why?
- Do women and people of minority cultures have something different to offer — perhaps new perspectives — that can benefit these disciplines?
- How can technical fields value and utilize the unique talents and skills that students from underrepresented groups have to offer?
- What would an African American-centered, Native American-centered, Hispanic-centered or women-centered technology style look like?
- What can we learn from schools and academic fields that successfully attract and retain members of these groups that are underrepresented in science, math, engineering, and technology?
- What motivates students to study and remain in science, math, engineering, and technology? What leads others to chose something else or leave these fields?

Who is the Pac-TEC Project?

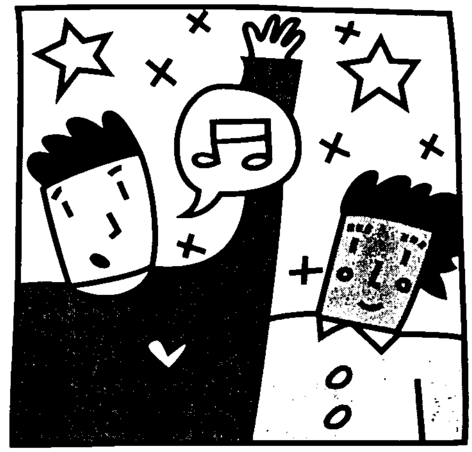
The Pac-TEC Project started with a network of twenty-six classroom teachers. Fifteen are members of groups which are underrepresented in science, math, engineering, and technology. Sixteen work in technical fields, ten specialize in humanities.

Teachers from elementary, middle, and high schools, colleges, and a university are included in the project.

Introduction

What Is Our Process?

Our process has consisted of interviews, classroom trials, literature research, discussions, textbook analysis, and visits to classrooms of innovative and award-winning teachers. We use the diversity of our own group to explore and understand varying preferences, perspectives, and styles.



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

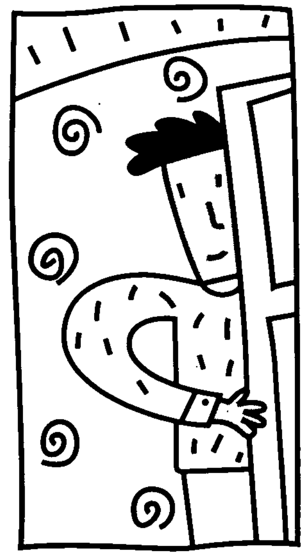
What Did We Find and What Did We Do With the Information?

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 science, math, engineering, and technology education, it follows that these fields do not offer the optimum learning environment for the majority of Hispanics, Native Americans, Africian Americans, and women.

The Pac-TEC project used this information to create a variety of criteria that teachers can use to develop solutions that add balance and support 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 by establishing new and creative teaching methods (see pages 5 to 8).

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

The conditions which motivate us to pursue this work are well documented.



1. Declining student interest in math and science based careers causes concern and demands innovative change.
2. Traditional methods of teaching are not effective for many students.
3. New options for incorporating diversity in the classroom are needed.
4. The skills needed in the workplace are changing.

REFERENCES THAT CLARIFY and SUPPORT:

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)

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 work force expands, it will be increasingly minority and female, the very groups who are currently underrepresented in technical fields. (Fisher 1992, Day 1993)

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

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)

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)

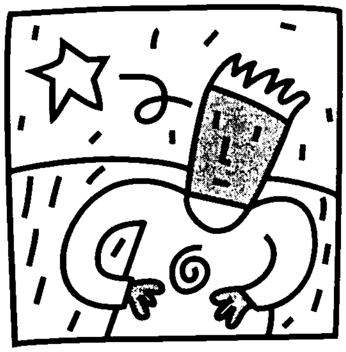
Usually, we are supposed to learn it the way men see it. Men move quickly to impose their own conceptual schemes on the experiences of women. (Belenky et al 1986 pg. 202, Duras 1975 pg. 111)

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)

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 curricula, they haven't changed that much since 1950. (O'Neil 1995)

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)

1. Survival Skills:



Many students from underrepresented groups make significant personal adjustments in order to survive in the educational system.

2. Different Styles: What Is Missing?

Many members of underrepresented groups have particular styles and preferences which are absent in many 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 a group as being the same.

REFERENCES THAT CLARIFY and SUPPORT:

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

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)

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)

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 American children 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)

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)

The architecture of Native Peoples differs from that of Euro-Americans. Native People 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)

A SOLUTION PRESENTS THE WORLD AS A DYNAMIC SYSTEM OF 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. The solution acknowledges that science is continually discovering new ideas and that scientific models are not the same as "truth."

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.

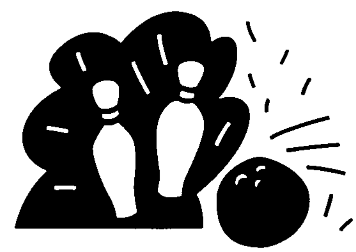
Includes Open Ended Problems.
The solution uses problems with multiple possible outcomes and routes to get to those outcomes. The entire solution must not be known (to the teacher) at the beginning. The solution provides a variety of tasks with conclusions that are not pre-determined.

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

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

SAMPLE SOLUTIONS

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 them to create their own solutions from their own experience.



A SOLUTION 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 okay 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 motivates by affiliation rather than competition. The solution uses and develops cross-curricular partnerships that model cooperation for students. It emphasizes and nurtures collaborative learning environments that encourage interdependency between group members.

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 interaction or dialogue. Technology tools bring people and various topics and subjects together, rather than isolate them. Technology that incorporates violence is not used.

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

Vitalizes Physical Space.
The classroom (a) is constructed and decorated with various inviting colors and 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 and inviting, but also stimulating, (i) allows students and instructors to interact, and (j) includes nature. Suites of room are interconnected. Technology tools are peripheral to the focus of the learning space.

SAMPLE SOLUTIONS

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)

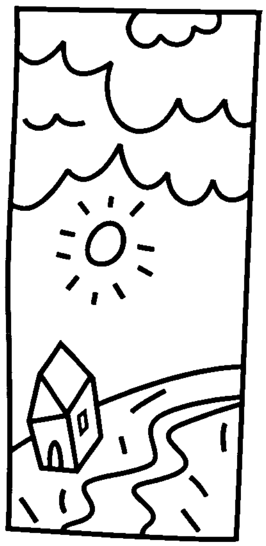
Is it possible to base some of the programming on language content rather than on mathematics content? Such a change might attract a new segment of the high school population to computer science classes. (Gilliand 1984)

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.

A SOLUTION EXPANDS PARTICIPANT PERSPECTIVES

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

Integrates Family and Community.
The solution integrates the family and the outside community into the classroom and is sensitive to balancing family roles with learning. It 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, and interviews. The readings are used to elicit oral, written, and artistic student responses 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 with an interest in student assessment work together to develop clear criteria for assessment.

SAMPLE SOLUTIONS

In math, writing may take the form of a "math autobiography" assignment on the first day of Algebra I, where students 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. The act of keeping a journal will put students in touch with their own innate sense of problem-solving. This project will encourage creativity and individuality, and will help students avoid mimicry and acceptance of generic approaches to thinking. (Kruschwitz and Peter 1995)

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.

A SOLUTION MOTIVATES STUDENTS TO PERSONALLY EXPERIENCE AND INTERPRET MATERIAL

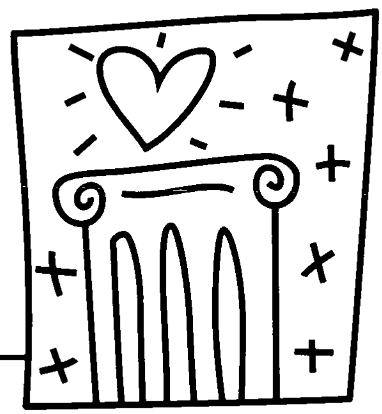
Engages Students.
Students are actively engaged in the process; no "lecture-only" curriculum. Students feel good about accomplishing an activity. Student-teacher contacts and roles are expanded. Students engage more than their minds in the education process.

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.

Is Relevant to Students.
Solutions provide connections with real-life contexts that reflect the 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 for exploring the subject matter.

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

Values Feelings and Intuition.
Feelings, a sense of belonging, and intuition are valued. The solution factor in the intuitive, emotional component of intelligence.



SAMPLE SOLUTIONS

When asking students to write about important events in their lives, the teacher asks, "How did you feel?" in addition to the usual questions about time, date, and list of events. For instance, a teacher asks, "How did you feel during and after the earthquake of 1989?"

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

Teachers encourage students to make connections between their technical and humanities classes. In cooperative groups, students develop 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 subject 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 set of ideas and fields of thought.

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