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ABSTRACT

This double issue of "Equity Coalition" deals with issues related to the need for inclusive science training and encouraging the interest of women and minorities groups in science. The following articles are included: (1) "Say Yes to Science" (Percy Bates); (2) "Science and Equity: Why This Issue Is Important" (Eleanor Linn); (3) "Race Equity and Science Education: An Interview with Charles Payne" (Elizabeth M. Mimms); (4) "Gender and Science: A Review of the Research Literature" (Mary Antony); (5) "Making Science Learning Meaningful for Language Minority Students" (Norma Barquet); (6) "Families and Science" (Judith L. Greenbaum); (7) "Model Science Equity Programs" (Marta Larson); (8) "The Checklist: How Equitable is Your Science Education Program?" (Martha A. Adler); (9) "Twelve Answers to the Question 'What Can I Do in My Science Program?'" (Tasha Lebow); (10) "Africans' Contributions to Science: A Culture of Excellence" (Salome Gebre-Egziabher); (11) "Looking at Science Holistically: The North American Indian Perspective" (Iva A. Smith); (12) "Funding for Equity in Science Education" (Ted Wilson); and (13) "Recommended Resources on Science Education and Equity" (annotated list of 36 resources). References follow the articles. (Contains one figure.) (SLD)

Equity Coalition for Race, Gender, and National Origin
Double Issue: Fall 1993-Spring 1994

Science Education and Equity

EQUITY COALITION

For Race, Gender, and National Origin

Science Education and Equity

Double Issue: Fall 1993 - Spring 1994

Say Yes to Science

by Percy Bates, Director

FOR TOO LONG the field of science has seemed to be reserved only for the "bright," the "smart," the elite in our schools. Although science is viewed as a positive force among us, the image of becoming a scientist has not been readily internalized by women and minorities. How were these perceptions formed, and how can we go about changing our image of who can become a scientist? We explore these questions in this issue of *Equity Coalition*.

We can no longer afford to deny a sizable portion of our population access to scientific knowledge, thought, and training. As a nation striving for equity in so many ways, we can not continue to move forward as a world leader while shutting off valuable resources in the area of science. Selectively categorizing our school age populations on the basis of race, gender and national origin as somehow ineligible for a scientific education will only hamper our growth as a nation and undermine our position among world leaders. One has only to look to recent advances by other nations to understand the urgency for us to become all inclusive as far as science training in our schools is concerned. It would seem fair to say that this recent growth by other nations is due in part to their science training for all students, majority and minority, male and female alike.

We can not overemphasize the need for science training to be inclusive rather than exclusive. The American work force is surely changing and "Browning," and, as repeatedly stated, by the year 2000 women and minorities will be a majority of our new workers. Will they be trained in the science and technology of the 21st century?

Photo courtesy of Kankakee (IL) School District #111

Science education has not been made equally accessible to all groups of students in our schools. Even where there has been some success in increasing the involvement of women and minorities in science courses and activities, this involvement has been minimal. The disparity between boys and girls in their involvement in math and science continues. Evidence from the National Center For Education Statistics (June, 1992a) shows that

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Who Are We?

PROGRAMS FOR EDUCATIONAL OPPORTUNITY is one of 10 regional Desegregation Assistance Centers funded by the United States Department of Education under Title IV of the 1964 Civil Rights Act. Housed at the University of Michigan School of Education in Ann Arbor, we offer technical assistance regarding race, gender and national origin equity to public schools in Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin.

In these six Great Lakes states 3,266 school districts enroll over 8 million children, 1.6 million of whom belong to racial or ethnic groups which often experience discrimination. African Americans are the largest group (70%), Hispanics the next largest (19%), followed by Asian Americans (8%), and American Indians (3%).

Half a million children in our region live in families for whom English is not the primary language, and one-third of these students have limited proficiency in English. Spanish is by far the largest language group, with many speakers of Arabic, Cambodian, Chaldean, German-Amish, Hindi, Hmong, Hmong-Lao, Japanese, Korean, Polish, Urdu, and Vietnamese.

Of the 8 million public school students in our region, 3.9 million are female, the largest population facing discrimination. Despite problems such as sexual harassment and a participation gap in science, mathematics and athletics, females are nearly invisible in many equal education plans.

Young women and men of all races, language backgrounds, and cultures should learn together from a diverse teaching staff, participate in all activities, and feel welcome in their school. To this end we:

- Provide technical expertise and training to educators who are desegregating local school programs along the lines of race, gender, and national origin,
- Develop and distribute materials that foster greater understanding of equity-related issues in education, and
- Collaborate with state officials and other service providers to promote educational policies and practices that support the spirit and intent of federal civil rights law.

To learn more about our services, please write or call:

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Science Education and Equity

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Science and Equity:
Why This Issue Is Important

by Eleanor Linn, Associate Director for Gender Equity

CLOSE YOUR EYES and imagine a scientist. Then open your eyes and read on.

If you're already an equity advocate, and you're actively involved in working to increase the participation of women and under-represented minorities in science, you probably imagined a woman or a minority man engaged in the scientific activity that you like best. But it's much more likely that, just like thousands of other people who have taken this simple projective test, you imagined a white man in a lab coat with a smoking test-tube in his hand. He probably wore glasses, had uncombed hair and a ghoulish grin. At his most benign, he looked like an aging Albert Einstein. But be honest, didn't he look more than a hint like Dr. Frankenstein or the "mad scientist" in some science fiction movie?

To Dr. Jane Butler Kahle, who developed the Draw-a-Scientist test, the problem of equity and science lies right here in our pre-conceived notions of *what is science* and *who is a scientist*. If we do not expand our notion of the legitimacy of many kinds of work as real science, and if we do not expand our image of people who are scientists to all of humanity, we will continue to marginalize many potential scientists and lose a great deal of fine scientific work. (Kahle, 1990).

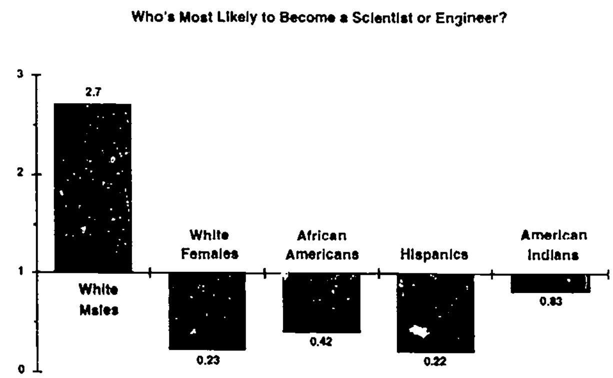
Then why is it so important for us to promote science for women and under-represented People of Color? Because scientific thinking and specific skills in science are crucial for our children's success and for the future of our society. Equity in science education is both an issue of fairness and an issue of national self-interest. In addition to these reasons, other parts of this publication will show you how eminently achievable it is. What's more, the time is right for you to take action now.

Three Important Reasons

1. Scientific jobs pay wages that are almost 50% higher than those of non-scientific jobs that require the same number of years of education. Compare the salaries of two high school graduates, say an electrician and a typist; or two college graduates, such as an engineer and a teacher; or even two doctoral degree holders like a veterinarian and a historian. You'll readily see how much more money scientists earn. Then look at the labor force participation data (figure 1) and see how few white women and People of Color are employed in science related job categories. Preparation for a career in science can be an excellent way for students to become successful wage earners.

2. Scientific thinking is critical thinking. When science is taught through an inquiry method, students learn to think independently. They learn to observe, describe, analyze, and predict events in the world around them. They learn processes for problem-solving that can be used in many aspects of their lives. They gain confidence in themselves as learners and thinkers, rather than as memorizers of received knowledge. The low academic self-esteem that stems from an unchallenging, rote curriculum is a major contributor to the lack of academic success of young women and minority students. Inquiry method science can enhance students' self-esteem and make them better thinkers.

John Dewey (1915) saw problem-solving science as a way of teaching rational decision-making, a skill



The numbers compare each group's representation among engineers and scientists in the workforce with its representation in the adult population as a whole. For example, there are nearly three times (2.7) as many white male engineers and scientists and only about one-quarter (.23) as many white female engineers and scientists in the workforce as expected given each group's representation in the adult population.

Source: National Research Council, Washington, D.C.

needed by citizens of a participatory democracy. Marilyn Frankenstein (1992) pushes the advantages of scientific understanding even further. Science, she says, is liberating for students, for it is a way to give them the skills to critically analyze society and the energy to act upon their convictions.

3. Our economy needs highly-skilled technical workers. Industry no longer needs abundant numbers of unskilled laborers. Instead it needs people who can learn complex new skills quickly and easily. The traditional pool of middle-class white males is simply not large enough to fill these needs, so for the first time in history, corporations, scientific organizations, and government regulatory agencies are calling for increased equity in science education and the recruitment of nontraditional scientists. Morality and fairness are only part of their concern. National security and American economic prosperity are their chief focus (Task Force on Women, Minorities and the Handicapped in Science, NSF 1989).

How Fair Are We?

Even though official policies state that science education is open to everyone, a closer look reveals that girls and minority students have far fewer opportunities to learn science. Student enrollment in high school science classes differs significantly by race, gender, ethnicity and socioeconomic status. Girls and minority students are particularly less likely to be in chemistry and physics courses. They are less likely to be encouraged to take science courses, even if their achievement test scores and grades are equal to those of white boys. They are less likely to be involved in science clubs and extracurricular activities and less likely to have toys and out-of-school experiences that help foster their interest and skills in science (Weiss 1978, Kahle 1985, Kelly 1987). Students from poor families are also more likely to be in schools with limited resources, or in tracks that provide them with fewer hands-on science experiences.

At the same time, girls, minority boys, poor children, and children with disabilities are more dependent on school to provide them with a myriad of unacknowledged privileges that many affluent white boys receive from the culture at large: images of people like themselves doing science; close personal contact with friends, relatives and neighbors who work in scientific fields; opportunities to see people like themselves engaged in scientific pursuits; discussion about the process of doing science and the courses needed to become a scientist; help with scientific projects; strategies for overcoming specific difficulties in coursework and career choices; and time to tinker and enjoy a wide variety of science related toys and equipment (McIntosh, 1988).

A New Agenda

In recent years, public policy and funding in science has been moving from a notion of scarce resource distribution to a more compensatory model. In times past, science funds were spent primarily on the identification and education of only those students who were considered most likely to succeed. Unlike reading and language programs, which for generations have acknowledged the need for basic literacy, and home and community-based interventions, public and private science improvement programs have, until recently, focused on teaching to the few, assuming that other children either could not, or did not need to understand science. New guidelines in federal and state programs, corporate and foundation initiatives show an increased interest in scientific literacy, and an emphasis on compensatory programs for under-served and under-represented populations.

In keeping with these changes, the National Science Teachers Association and the National Science Foundation have developed a new secondary school science curriculum template entitled *The Content Core*. Plans for new national and state-wide student assessment in science are also changing how science is taught in elementary and secondary schools. The new programs put more emphasis on integrated science, the process of learning to do science, hands-on student experiences, and the relationship of school science to careers and problem-solving to help humanity. But these programs may be implemented without concern for equity, unless equity advocates persuade science curriculum developers at the national, state, and local level to include such well-proven educational equity elements as cooperative learning, culturally relevant multilingual activities, career role models who come from students' own communities, and science related parent outreach activities. The time is ripe for equity advocates to move in science education.

> Enrollment in high school science classes differs significantly by race, gender, and ethnicity.

Many educators will remember that previous waves of science education reform, especially the one after the Soviet launching of Sputnik, also called for a hands-on inquiry approach to science. Those recommendations were never universally adopted, in part because they were never connected to issues of fairness or to the employment problems of our post-industrial economy. They were also considered too expensive in terms of staff development, student contact hours, and classroom equipment, and hence only reached the most privileged groups of children.

But culturally relevant, hands-on, inquiry method science is a necessity for all our students today, if we truly want them to become productive workers and informed citizens. And since poor, minority, and female children have more limited access to and less success in existing hands-on science programs, we must provide them with a science education that includes not only hands-on experimentation and challenging thinking skills, but that also provides them with significant contact with culturally appropriate role models, career information, awareness of their own and other people's attitudes about science and scientists, and a broadened definition of what constitutes legitimate scientific endeavors. Add to that long-term encouragement and we will have developed a more equitable approach to educating all our children in science. ❖

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Race Equity and Science Education

An Interview with Charles Payne

by Elizabeth M. Mimms, Field Service Specialist

CHARLES PAYNE has been Director of the Multicultural Program for Secondary Teachers at Ball State University, Muncie, Indiana, for the last twenty years. He also heads a dissemination site for EQUALS and is a certified trainer in FAMILY MATH and FAMILY SCIENCE. His previous positions include being a math and science teacher at George Washington Carver High School in Hollow Springs, Mississippi, and a professor of Chemistry at Mississippi Valley State College. Dr. Payne holds a bachelor's degree in chemistry from Rust College, a master's degree in science education from Tuskegee Institute, and a doctorate in science education from the University of Virginia. He is an active consultant to school districts, universities, and community groups on multicultural education.

Dr. Charles Payne, Ball State University

EM: Dr. Payne, what led to your initial interest in equity and science education?

CP: It was the combination of having a love for science and, yet, seeing the interaction between science and people of different cultures. The 60's, when I was in school, was the era of Black history. *Multicultural education* was a term that was beginning to come out as I was graduating. And I almost instantly saw a difference between *ethnic studies* and *multicultural education.*

If you're talking history, you're talking largely about the contributions of a people—their experiences — which is important. But when you talk of culture, you're talking about, "What have a people learned as a result of their history?" And that, then, is what becomes important in the classroom.

As I began to work with Black kids, rural Black kids, I had to change a lot of my strategies—what I had been taught at Rust to teach. And I had to change a *lot* of it. I had to change the content— not change the concepts, but the content. I changed the content to be farm related. So I had to relate the chemistry and the physics I was teaching to farming, to electricity on the farm, to fertilizer and the like.

So to me it became kind of fascinating, how I could take what was in the community, bring it into the classroom, and make it make sense [to these rural Black kids]. And I became fascinated with that idea. Then, when multicultural education came out, I said "That's it! That is what I was talking about. That is what I was trying to do."

Now in the twenty years I have been here at Ball State, the national perception of multi-cultural education has probably changed. I believe that, when the term *multicultural education* came out, people were really using it synonymously with *ethnic studies*. Now, as I read the literature, I do see an evolution. I see people are getting closer and closer to the idea of *culture* as opposed to *skin color.*

If you look at race as skin color, then you are not looking at behavior. You are not looking at what the kid has learned, what the kid has been taught. You are only looking at the skin color. Secondly you don't see the differences within groups. For instance, African Americans are a very diverse people. If you only look at skin color, you won't pick that up and you get very frustrated when they don't fit that one model that you have.

So teachers have to be able to distinguish between what you mean by *culture* and *ethnicity* and *race*. Those three terms mean the same thing for a lot of people, but for me, they are really different. If you don't separate those concepts then you have a faulty perception of what you're doing [in the classroom].

EM: Are there some unique needs that African American students have with regard to science education that a teacher should be concerned about?

CP: Well I don't know if it's unique or not, but, from what I hear in schools and from what I see, it seems that a lot of Black kids were made afraid of science because they heard t was something that was supposed to be hard. So a lot of kids are afraid of it.

I remember that I was told, when I was in college and high school, that science was abstract and that as Blacks we couldn't think abstractly. We had to think concretely. And I think that's one of the messages that we have learned from our experiences.

Then, too, one of the excuses I hear a lot from kids is that "science is for white people." I think that is very self-defeating.

In terms of their ability to do science, many of the kids are very capable. But if the confidence is not

> When you talk of culture, your're talking about, "What have a people learned as a result of their history?"

there, and if there isn't a value that tells you that this is important to you, then you don't learn. I think that we primarily learn those things that we consider to be of value. And it's culture that tells us what's of value to us.

EM: So, given the ability, how do you help African American students to have the confidence and interest?

CP: Now, this is is where we go back to the content that you teach. When teaching science to Black kids in this day and time, it's important for them to know that Blacks have made significant contributions to the field of science, and that they read the biographies of people who have done this. And in particular, that they learn about the persistence and the pursuit and the love of knowledge that these people had to have in order to be able to do it.

And then the learning style of the African American kid has to be considered, too. As is true for several other groups, African American kids seem to be more global learners than analytical learners. Global learners tend to see the bigger picture but not the details; they see the set. But science requires an analytical approach to it, you need to see the subset within the set. Therefore the

African American kid who is really interested and really wants to do it, first of all has to be told that, "Hey! Here's the style you're going to need and here is how I am going to help you get there." You can teach people how to become analytical, but first of all they have to be [made] aware [of their own thinking styles].

EM: How do you make students aware of their thinking styles?

CP: By dialogue with them. Showing them, "Hey! Look! Did you see you left this whole piece of information out? Here's what you are going to have to do." As an example, take helping them to distinguish between mass and weight. People use them interchangeably; they think of those as the same. But they really are not similar concepts; they are very different. The global learner won't separate them. So you have to have a series of experiences that really causes them to focus on the difference between mass and weight.

EM: How do you get them interested in science?

CP: As educators we have to believe that the only way you can be a free person is to understand the physical environment. And therefore we have to teach science from a perspective of how this helps you to become a free person, in terms of safety, in terms of your health, making money—in terms of any number of different things that directly relate to your life—and that science is not just for people who see it as a career.

I think some humor can be helpful, too. For instance many scientists that we study, particularly the earlier ones, weren't in science for the science. They were in it to make money. I think we need to explain that kind of humorously. They knew that if they were going to make money, they had to understand science.

EM: What are some optimum teaching strategies for African Americans?

CP: I'd say a teaching strategy that has emotion built into it, that has some kinesthetics built into it, and some excitement. And I'm thinking of elementary level all the way through (K-12). Now at the college level, as people get older, they can entertain a different style. But at the junior high level, it seems to me that African American kids find appeal in emotion and in things that are kind of exciting, particularly if it's clever. They love a clever idea, and I don't mean trickery or simple mindedness.

This need to have a lot of clever things around can get you back to understanding nature. For example, have you seen the FAMILY SCIENCE activity where you take the two bottles and you blow between them? Most people think that those bottles are going to fly apart, but in fact, they come together. That fascinates them. Then you show them *why* it works like that. Then you say, "When you stop at a train track, when you wait in your car for a train to go by, you'd better be careful how close you get, because exactly the same thing will happen!" A physicist would say the air behind you pushes you in because the air between you and the train is exerting less force than the air behind you.

EM: How do you make sure that students have the qualifications they need for upper level science as they go through elementary school and get into middle and high school?

CP: This then goes back to the elementary curriculum and being sure that it is done right. Again, I think educators will have to get off of this notion that only certain people can understand science. Because, if they start putting kids in talented and gifted programs at first or second grade, teaching *them* the concepts and leaving the majority of the kids out, then it's no wonder we don't have any more kids in science than what we do. So I think it has to begin at that level.

I would say, if we're really going to begin to prepare African American kids as well as other kids, I think kindergarten teachers need to understand science fundamentals. This is where I think they either get turned off or turned on. I'm talking kindergarten, first grade, second grade. Because, before they start getting to the fourth or fifth grade they begin to develop the attitude of either, "I like science" or, "I don't like science."

EM: What can districts do to make sure they get teachers who have the science background and sensitivity to minorities?

CP: They almost *have* to depend on the University. So looking at transcripts is one thing they can do, though that is no guarantee. Then look at their track record. Maybe you need a portfolio from them. In the interview you need to ask them how they feel about science. Or you need the teacher to give you a demonstration lesson in which you have them talk about science.

Then, too, districts need good science supervisors. I don't mean a supervisor who is trying to supervise a hundred and fifty to two hundred teachers, either! My experience is that if the science supervisor is secondary, that's where his or her attention needs to go. So maybe you need an elementary science supervisor and a secondary science supervisor.

EM: *Could you speak to the classroom teacher who is under pressure to close the gap in achievement in his or her science classroom?*

CP: I can answer that in a couple of different ways. One is if you're dealing with an attitude problem. In other words if the kids' culture has taught them that this is something they can't understand, this is something that is not important to them, that gap will probably be closed over a period of years—unless you have some way of really getting to the kids and convincing them that this is not true. So you may have to do a lot more affective teaching than content teaching. And that's probably where I would start if it was an attitude problem.

Then, also, teachers need to know, "What standardized tests are my kids going to have to take?" Secondly, they need to know "What concepts are being tested on that standardized test?" Now, I am not saying they need to know the items. For instance, if they're going to have to balance equations, then I think the teacher needs to know that it's expected that they're going to balance equations. If they're going to have to do problems in calculating molarity or density, I think the teacher needs to know that. Because there are so many things that students can be tested on that you may not have taught. You could still have taught a good course, but your kids weren't tested on what you taught. So it makes you look bad and it makes the kids look bad. So I think teachers need to be aware of the concepts. Now some people accuse me of saying, "Teach to the test." I am not saying that at all. I am saying, "*Somebody* has said that *these* concepts are important. *You* need to know what they are." I am not saying teach the items. I will be the first to say, "No, you don't teach them the items." But you certainly teach them the concepts. Otherwise it becomes a crap shoot! Because I may want to teach *this*, you may want to teach *that*, and somebody somewhere else who is writing the test says, "But you should have taught *this*!".

EM: *If you were to speak to parents about their children's future in science, what would you advise them to do?*

CP: Parents need to show an appreciation and a love for science. They don't have to be scientists to do that. They need to encourage their children in areas of science—take them to museums, talk to them about things that they know about science. My son wanted to know why I was out waxing the van. I explained to him, "Well, it's a new van. So I'm waxing it." He said, "If it is new, why are you waxing it?" I explained to him what wax was and what it was supposed to do for the van: "Some people think it's to make the van shiny. That just happens. It's really protecting the paint from the grit, sand, salt, sun and all of that." So I think it's explaining to kids why you do what you do—and a lot of that is science.

EM: *How can counselors be involved here? How can they help, especially at the middle school level?*

CP: I think counselors primarily do what the school sets up for them to do. If the science teachers are saying only certain kids can come in their classes and can understand science, then there is not much counselors can do with that. But in the instances where counselors know that kids are just purposely avoiding a course, they can encourage them to go in, maybe even work with the teachers. This has to be a total school effort. It just can't be one little division. Because as a counselor, I may put you down in Algebra I, but if the Algebra I teacher sees you as a loser, then you won't be down there very long. So there has to be some relationship between the counselors and the teachers. But I also think guidance counselors can make kids aware of careers, of what is needed in those careers. For instance, there are a lot of kids who would say, "I want to be a medical doctor" or "I want to be an engineer," but they have no idea what it takes to get there. I think a lot of parents need to become aware of the fact that many of the decisions you make around the sixth grade will affect you for the rest of your life! And I'm not so sure how many parents realize that. In particular, in junior high, when you start going in different directions, you need to be careful about what direction you choose. And, I would say, as I have tried to do for my own kids, whether you want to go into natural science or not, I want you to follow the math curriculum because that becomes the basis for everything else you do. As I was telling my daughter last night, "I want you to have the options you choose. I don't want your options limited because you didn't take the right courses."

EM: *You do consulting in this area of science education and equity. What kind of requests do you get?*

CP: A lot of what I do is with EQUALS and FAMILY MATH and FAMILY SCIENCE. I don't get a lot of requests for just pure science. I also get requests for how to infuse multi-cultural education into science and across the curriculum. What you run into is that science teachers, for whatever reasons, seem to be so content specific that it is difficult to get them to see the cultural dimensions. I guess I am stereotyping and I realize that. Science teachers, particularly physicists, tend to be left brained and everything is just very sequential.

EM: ***So how do you get science teachers to see the cultural dimension?***

CP: You just have to use a lot of logic, just explaining things and giving examples. One teacher I was talking, a very good science teacher, one of the top one hundred in his field, said, "I just hadn't thought of it the way you are saying it." He said, "It makes good sense." He said he had just been so content oriented that it had never occurred to him that these kinds of things would go on in the minds of people. So I think how we approach people makes a lot of difference.

EM: ***Could you describe an intervention that you had where you have worked with a particular teacher or a science department?***

CP: The model that I use is to first say, "What concepts are you teaching?" So I am not trying to change the concepts that they teach, because I believe that the concepts are important for all kids. So once they identify the concepts, I say, "Ok, now you explain the concepts the way you would normally explain them. But once you do that, when you get to the place where you are trying to develop the concepts, let's bring in some cultural experiences—different ways in which you have seen the concepts. Because this becomes the pedagogy of multicultural education." I don't think you understand a concept if you can't see it in more than one way. So it becomes very much a part of good learning and good teaching to identify that same concept and use it in a totally different way. Then, I may ask them, "What is the history of the concept? Who first discovered it?" And then you can bring in the cultural dimensions from that standpoint. And what you begin to see is that science is very multicultural in terms of the contributions made by different people.

I have one article I recommend to people who are interested entitled "Education and the Cultural Concept" by a fellow from Britain named Musgrove who ran one of the British schools in Africa. He was talking about teaching the concept of gravity to students who frankly didn't believe in gravity. Their culture had never taught them that. So he went on to say that the reason the English boys believed in gravity was because their culture has been teaching it for the last three hundred years. In other words, it has become a cultural deposit.

And then Musgrove also says that what we do as teachers is affirm what kids already know, particularly if they are from the same culture. One of the mistakes that we make when we teach kids from our own culture is assume that they know certain things. In fact they might *know* them, but they don't *understand* them. For instance, take gravity again. You throw something up and let it fall, and ask the kids, "What is it called?" and they say, "Gravity". Because they said, "Gravity," we assume that they understand it. But they don't, they just know the word. And so one of the things that I have said in my classes here at Ball State, having read Musgrove's article is, maybe we have to approach every kid as if he or she knows nothing about the concept. Otherwise we are only affirming what we think they already know or what they already believe. We cut out that questioning kind of sphere that we would like to develop within them.

EM: ***Do you have any closing thoughts that you would like to make about looking to the future?***

CP: Yes. Looking into the future, any person, particularly a young person, who is going to enter the twenty-first century without being mathematically and scientifically literate is going to be in serious trouble. Now I don't mean that they've got to be scientists, but they have to be able to understand the basics of math and science. That is the direction that the world is going. If we allow groups of people to enter the twenty-first century without being mathematically and scientifically literate, I think we are setting them up for trouble. ❖

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Gender and Science:
A Review of the Research Literature

by Mary Antony, Research Assistant

EDUCATION HAS DIFFERENT OUTCOMES for boys and girls. Nineteen years after Title IX, women continue to be underrepresented in science. Unfortunately, large numbers of girls who do not enroll in high school physical sciences not only limit their educational experiences but in the process also close the door to many future educational possibilities. By conforming to a female stereotype that excludes science and math they are confined to the low pay and low status accompanying traditional women's occupations (Kelly, 1981).

This article reviews the current status of women in science, examines some of the theories that have been offered to explain the gender gap and finally suggests some strategies to enhance the participation of girls in science.

Participation and Achievement

1. K-12 Education. While overall gender differences in achievement do not appear at the elementary level in either mathematics or science, teachers are reportedly more likely to assign high ability boys to top math groups than they are to assign high-ability girls (Hallinan and Sorenson, 1987). Elementary girls report that they have fewer science experiences (Mullis and Jenkins, 1988). They also show less positive attitudes towards science and science careers than do boys. This pattern continues into middle school with girls remaining more negative about science than boys and continuing to have fewer science experiences.

While there are small or no gender differences at age 9 for any science assessment, by age 13 and 17 the average science proficiency of females is significantly lower than that of males (N.C.E.S., 1992).

Girls also take less science and math in school than boys. In 1988, high school females reported completing an average of 3.6 years of math coursework compared to the 3.8 years of males. Females also have fewer years of study in natural science than do males, in 1988 these averages were 3.1 and 3.3 years respectively.

Although the number of years of study does not differ substantially, females tend to take less advanced coursework than do males. While almost all females and males take biology, females were much less likely to take physics, 35 vs. 51 percent (NSF, 1990). College bound females are also less likely to take achievement tests in science and math than are all college bound seniors.

2. College Education. In college, women choose science majors at lower rates than do men even when they are equally prepared. White women are the least represented female group in science majors. Black women on the other hand, constitute a substantially larger proportion of black science majors than do women of other racial and ethnic groups (Commission on Professionals, 1986).

Even though women science majors had higher overall grades during their first two years in college than did men, they drop out of science in greater percentages than their male peers (Oakes, 1990). Consequently, women have a lower rate of attaining scientific bachelors degrees, are less likely to select scientific majors in graduate school, and therefore have a lower rate of participation in the doctoral programs.

3. Employment. Women and non-Asian minorities are underrepresented in the science, mathematics and technology workforce. In 1988 women accounted for 16 percent of the Science and Engineering workforce, but this representation varied with only 1 in 25 being engineers (NSF, 1990). Furthermore 25 percent of women, compared to 14 percent of men, were employed in work unrelated to science. Among academic scientists, men are far more likely than women to hold tenure track positions, and to achieve full professorships. Women are more likely to be engaged in part-time work.

Some Possible Explanations

Explanations for the underrepresentation and under-participation of women in science can be broadly classified under three categories (Oakes, 1990). The first deals with individual attributes and includes both cognitive abilities and attitudes. The second looks at factors in the school and classroom that might affect the participation of girls, and the third focuses on societal factors.

1. Cognitive Ability. For a while the research on cognitive ability was guided by the deficit hypothesis that postulated that biological differences were responsible for the gender gap. Arguments in favor of the genetic superiority of males in math and science are not supported by any conclusive evidence. On the other hand there is evidence that the male advantage may not be genetic at all (AAUW, 1992). Girls' performance can be enhanced and the gap reduced by changing teaching practices.

are also studies demonstrating that cognitive abilities can be learned and that both girls and minorities can acquire them. Thus, even if group differences do exist, they are not unalterable, and interventions can overcome the differences in achievement (Oakes, 1990).

2. Affective Factors. Among males and females of equal achievement levels, difference in interest in math and science, difference in perceptions of its utility, and difference in self-confidence are some of the factors that appear to affect student choice. There is some work that suggests that girls and minorities show a greater interest in people while white boys show more interest in objects. Because math and science are often taught as abstract subjects, disconnected from people, these subjects may be less appealing to girls.

Photo courtesy of Kankakee (IL) School District #111

NAEP[9] data show that 9, 13 and 17-year-old girls express attitudes to science that are more negative than their male counterparts (NAEP, 1991). Gender differences in liking science, however, are less pronounced in high achieving students. Furthermore, it is doubtful that there is any simple or direct relationship between liking science and math and doing well in these subjects because liking math and science do not appear to lead to high achievement and increased participation for minority students (Oakes, 1990).

It has been suggested that even if students do not enjoy science and math, they will persist if they believe that it will be useful to their careers. Many students believe that math is more useful for males than it is for females (Eccles *et al.*, 1985), and that boys understand science better (Zimmerer and Bennett, 1987). Such sex stereotyping of math and science occurs as early as the primary grades. Although many girls may be convinced that math is open to everyone, boys more often see math as masculine and place girls in more traditional roles (Fennema and Sherman, 1978). This opinion of male peers can possibly be a negative influence on girls' choices. The fact that all advanced math and all science courses are more likely to be taught by men than women may further contribute to the perception of these fields as masculine.

Even if boys and girls are equally motivated to do well, girls appear to be less confident that they will be successful. Women report lower confidence even when they perform as well as males and their confidence drops during the critical early years in college (University of Michigan, 1992). Male students often attribute their failures to something external while girls attribute it to their own lack of ability. Many females thus drop out of science and math despite their ability to do the work.

Girls may be further turned off by the apparently high social costs to women who aspire to science and math careers (Chipman and Thomas, 1984). Expectations that science and family may conflict later in life may prevent high achieving girls from pursuing coursework and therefore careers in science. There is some work that suggests that women college students who do remain in science-related majors often hold non-traditional views of sex roles (Matyas, 1985). Women interested in science careers must, therefore, break the stereotype mold of sex-appropriate careers.

3. Schooling Experiences. Classrooms where the process of schooling largely occurs are often sites for sexist socialization. Although the actual amount of time actually spent on science in the elementary grades is small, when it does occur the nature and quality of participation by boys differs from that of girls in several respects (Mullis and Jenkins, 1988). Responses to a NAEP survey showed that girls participate in extracurricular science activities fewer times than do boys. Play activities of males are more likely to provide practice at spatial visualization tasks which are useful later in both science and math classes (Matyas, 1985).

In middle and high school, girls are more apt to be exposed to biology-related activities and less apt to engage in mechanical and electric activities. Boys often report that they use many more science instruments in class than do girls (Zimmerer and Bennett, 1987) even though girls say they would like to use them (Kahle and Lakes, 1983). These differences are especially pronounced in the use of physical science tools such as power supplies and prisms. In secondary schools girls use computers less frequently than boys. These experiences are reinforced when children are always allowed to select science topics based on familiarity or interest.

Teachers of either gender are more likely to call on boys to help with demonstrations. And when students ask for help with projects, boys usually get added instruction while teachers show girls how to proceed or even complete the task for them. Teachers thus exhibit higher educational expectations for boys than for girls.

Female students have fewer interactions with science teachers and thus receive less attention (Barba and Cardinale, 1991). Females are asked fewer questions, and the questions are predominantly low-level ones. By asking males high-level questions the teachers may be providing cues to those students that they are high ability students. Females may thus attribute failure to their own lack of ability.

Another factor that might be turning girls off science is conventional teaching strategies that are based on competition. Peterson and Fennema (1985) found that competitive classroom activities contributed to boys math achievement but were detrimental to that of girls'.

Girls may also be discouraged from pursuing science careers by school counselors who have higher expectations of math achievement for boys. Evidence suggests that girls and minorities receive less encouragement and information about courses and careers in science fields.

Females are asked fewer questions, and the questions are predominantly low-level ones.

4. Social Factors. Historically, well qualified women have not been able to translate school attainments into commensurate employment or salary rates. Women anticipating such discrimination may opt out of science. Parents and teachers who convey less conventional ideas about appropriate behavior for women may encourage them in non-traditional pursuits (Ware, 1985).

Despite the complexity of the problem, race, class and gender issues continue to be ignored in science education research. This exclusion may account for some of the dissemination and implementation problems educators face as they try to put research findings into practice in urban schools (McDowell, 1990).

Increasing the Participation of Girls

Some of the strategies (SEMS, 1991) that have been found to encourage interest and achievement among females are:

- Using inquiry-based science instruction
- emphasizing hands-on activities related to everyday experiences
- Using cooperative rather than competitive group work
- Using text, curricular materials and language that illustrate women and girls as well as men and boys carrying out science work and experiments
- pairing girls with girls so that they are not always serving as data recorders but get chances to manipulate science equipment
- monitoring the distribution of science equipment. Giving all children the opportunity to interact with equipment that they might not have encountered before or are not likely to encounter at home
- asking higher order questions of both boys and girls
- narrowing the experience gap by giving additional opportunities to try out science experiments and solve problems
- providing out of school opportunities for science experience
- appropriate counseling on the importance of science and math for the future
- appropriate career counseling that provides real-life role models of women in science

Girls and boys enter school science classrooms with different prior experiences, interests, expectations and attitudes. Teachers cannot dismiss the problems of girls underachievement in science by treating boys and girls identically. This is not to argue that all females need to be pushed into science careers. Rather they need to leave a wide variety of options open for later more informed career decisions. Furthermore, the adoption of equitable curricular materials and teaching strategies that actively encourages interest and achievement in females can also prove beneficial to all children. ❖

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Making Science Learning Meaningful for Language Minority Students

by Norma Barquet, Associate Director for National Origin

BUSINESS AND INDUSTRY NEED a well educated and skilled work force in order to compete in a highly technological world economy, but large numbers of our students continue to graduate with minimal preparation in the area of science (Mullis & Jenkins, 1988). Hence, science education has become a priority in most educational reforms at the local, state, and national levels (Rutherford & Ahlgren, 1990).

One reason we face this problem is that we have thought for too long that science, like math and global languages, is difficult and therefore should only be required of our most "talented" students, those who for the most part are already privileged as a result of the socio-economic and educational status of the families into which they were born. As Oakes (1986) points out, "There is no presumption that high status knowledge is equally appropriate for all" (p.74). We also seem to underestimate the relevance of science in every aspect of our lives and in the many professions that draw on scientific knowledge and research.

Such beliefs have proven to be formidable obstacles to students from less privileged families, especially national origin/language minority students (NOLM). As the number of these students increases in our schools, their lack of participation in science education and their low representation in careers in science will further exacerbate efforts to promote science education.

Issues Related to Equity

NOLM students are also concentrated in large urban districts or highly rural areas which often lack adequate financing, and the classrooms where these students are taught science often lack adequate textbooks, materials, and equipment. Due to the difficulty encountered by poor urban districts in attracting and retaining highly qualified and trained teachers, the teachers assigned to teach minority and poor students are often the least qualified (Oakes, 1990a, p. 181).

Many observers also suggest that in addition to the educational deprivation and discrimination to which these students are subjected by virtue of being poor, limited-English students and their teachers are caught in a double bind by being isolated within the schools in which they are found. As a result of being a non-status group in their schools, bilingual teachers and their students are often given the worst classrooms, and when new materials and state of the art equipment are available they do not have access to them.

Photo by Marilyn Nolt Souderton PA

In addition to issues of discrimination, language minority students also lack the necessary role models and support that their middle class white peers have with regard to science education and careers in science. Hispanics, for instance, comprise nine percent of the total population, but they represent only two percent of all employed scientists and engineers in this country (Task Force on Women, Minorities, and the Handicapped in Science and Technology, 1989).

Although not always conscious of their prejudices, educators often have pre-conceived ideas regarding the interests, abilities, and overall potential of students based on their race or ethnicity, gender, and socio-economic status. As a result counselors and teachers tend to have higher expectations regarding the academic achievement and career goals of students who are light skinned, male, and from middle and high socio-economic backgrounds (Oakes, 1990a, 1990b; Secada 1989).

If we look at the research in the area of tracking, we begin to see how these preconceived ideas create inequitable opportunities and access to science education within schools. Language minority students, like racial minorities, girls, and poor children in general, have been historically excluded from participating in science classes or tracked into lower level courses (Rosenbaum, 1980). Their lack of access to quality science instruction at all levels of the educational system is at present a common area of concern for equity conscious educators and advocates for these groups.

NOLM students who are not proficient in English are often excluded from science classes because: a) the learning of English is seen as the primary educational goal for these students and therefore science is not a priority in scheduling them, b) the schools do not have teachers who can instruct these students in science in the language in which they are most proficient, and c) science teachers are either apprehensive, reluctant, or unwilling to teach non-English speakers in their content area.

Although the parents of these students have high aspirations for them, their children slowly lower their expectations as they come to accept the stereotypes set by our society regarding who is capable of scientific work. Consequently, white girls are encouraged to become teachers and nurses, while white boys become scientists and doctors. Minority girls are tracked early on into low-paying careers such as child-care workers, hairdressers or, at best, technicians.

Rarely do we find schools that systematically debunk the existing stereotypes in science education by encouraging girls, minority students, and poor children to take higher level courses and pursue careers in the area of science. We seem to be caught in a vicious cycle of under-achievement since we know that only by increasing the numbers of minority and women in the science professions will we see a change in the expectations of our society regarding the learning of science.

Removing Barriers

First, we must address issues relative to the language of instruction. For students who are limited-English proficient (LEP), the ideal situation is to have qualified science teachers who are bilingual and fluent in English and in the primary language of the students. In a study comparing the effects of monolingual English and bilingual science instruction with native American students, it was found that bilingual instruction made a significant difference in the achievement of Choctaw speakers in the areas of science and social studies (Doebler and Mardis, 1980-1981). Learning (English) words and definitions does not constitute learning science (Yager, 1983). It is possible for students to know words without understanding the concepts behind them and understand concepts without knowing the terminology used to describe them. We know that children learn concepts better when they learn them in the language they know best and that once they acquire the required vocabulary in their strongest language making the transition into English is much easier. Delaying their instruction until they acquire academic English skills or simplifying the curriculum are not acceptable strategies to teach children who are not proficient in English.

While it is important to acknowledge that there is a great shortage of teachers who are both bilingual and qualified to teach science, we must insist that teacher training institutions establish programs to recruit Hispanics and other language minority students and train them as science teachers. But we must start early by developing and implementing Pre-K through 12 science curriculum and programs such as mentoring and career day to motivate students to chose careers in science.

In the meantime, when qualified bilingual teachers are not available, science teachers can still instruct LEP students with the help of bilingual aides and English-speaking students using techniques such as cooperative learning and peer tutoring. This does not mean that we relegate the teaching of LEP students to students and aides but that we use them as translators and tutors under the direct supervision of a science teacher. While learning science concepts and their application through inquiry and experimentation, LEP students can acquire the technical and scientific vocabulary necessary for future study. Since science introduces more new vocabulary on a regular basis than a foreign language, science instruction could provide an opportunity for native English speakers and limited-English speakers to work together while they increase their vocabulary.

Cultural Relevance and Inclusion

If we study the original cultures of these children, we can learn much about the contributions of their ancestors to science. For instance, the Indians of North, Central, and South America contributions to agriculture, astronomy, geology, botany, and nutrition remain a source of knowledge for scientists today. The irrigation systems, sun dials, calendars, nutritional, and medicinal practices of native people are examples of these contributions in science.

In his book, *Indian Givers: How the Indians of the Americas Transformed the World*, Jack Weatherford (1988) writes about how Indian cultures revolutionized world civilization and theorizes that the impact could have been even greater if native cultures had been valued and not destroyed by the Europeans who colonized the Americas. In fact, David Bathrick, director of the Agricultural Office of the U.S. Agency for International Development, has said that ancient Indian technology such as the pre-Columbian "platform farming" method found around Lake Titicaca may be the key to cultivating infertile land in Africa, Asia, and South America (Ann Arbor News, December 15, 1988). Ancient African, Arab, Indian, and Chinese cultures are among others which have contributed to the areas of math and science.

In the area of medicine we have recently seen a resurgence of non-traditional methods of healing that date back to ancient practices in China and India. These methods are characterized by an integration of the physical, the spiritual, and the psychological. The medicinal plants known to ancient cultures such as the Aztec might still hold promise for the cure of diseases not yet conquered by modern medicine.

By using the prior knowledge of students to build on science instruction we can begin to make science meaningful and infuse culture into the teaching of science. All children, including minority children and girls, must also learn about the past and present contributions of their groups and of other cultural groups in order to be able to recognize their own potential as future contributors in the area of science and reduce the *risk* of ethnocentrism.

Thus, the contributions of American Indians, Arabs, Asians, Hispanics, and women must be incorporated into the science curriculum. When teaching nutrition, for example, teachers can have students research the nutritional habits of some of the indigenous people of the Americas and determine some of the benefits of their diets. (For other suggested activities refer to later pages in this issue.)

Instructional Strategies

Aside from issues related to language and culture, the science curriculum should emphasize mastery learning, higher order thinking skills, active student involvement, the use of relevant/real-life materials and situations, project-oriented tasks rather than discrete-skills orientation, and use of computers and technology to enhance student support.

Cooperative learning groups and out-of-class experiences are strategies that increase the motivation and learning of children in general, but for LEP students they are critical elements of a successful learning experience Since monolingual teachers often cannot communicate effectively with their LEP students, the students must rely more heavily on visual, kinesthetic, and other non-language based modes of learning. Therefore, the use of manipulatives, visual aids, models, and workbooks have also proven to be more successful than the use of dittoes and formal lectures.

In summary, to ensure the success of language minority students in the area of science we must: (a) ensure that they are full participants in quality science education from pre-kindergarten through 12th grade, (b) recognize and meet the linguistic needs of these students, (c) be willing to learn and integrate in our teaching the contributions of all cultural groups represented in our classrooms, and (d) use instructional strategies that acknowledge different learning styles.

Finally, students should be reminded that, despite past and present contributions in the areas of science and technology, there is still much more to be learned and discovered about our world and that they are all capable of making a contribution.

Demographics, World Economy, and Future Trends

We already know the demographic projections for our nation and the world. People of color and women are becoming a more significant part of every sector of our society. This trend is not likely to reverse or level out in the future. Thus, only by encouraging and preparing women and minorities in areas such as science will we ensure that large numbers of our school population will be self-confident and able learners. The resulting effect will be an increase in the self-sufficiency and ability of our adult population to contribute effectively to the larger society.

As a nation we must be able to meet the local and global challenges of the future. The continued exclusion of minorities and women in the area of science has denied these underrepresented groups the opportunity for intellectual growth and has limited their contribution in many areas of our society. Given their increased numbers in our workforce and in every other sector of our society, the contributions of minorities and women in science, mathematics, and technology will have a significant effect on whether or not our country will continue to hold a position of influence on the international front and contribute to the betterment of our planet. ❖

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Families and Science

by Judith L.Greenbaum, Ph.D., Project Associate

CONCERN with preparing students for an increasingly complex world has prompted the field of education to undergo some exciting self-examination. As educators consider the redesign of the learning and teaching environment in school, they are taking a closer look at learning and teaching in the home. Much research is devoted to such questions as: can we all do a better job of teaching children about their world? can we increase children's interest and competence in science and technology? can we convince families of the importance of science to their child's future? and ultimately, can we increase the participation of women and underrepresented minority students in mathematics and science careers?

Natural Roles for Children and Parents

Young children are natural scientists. They classify and compare phenomena, test out hypotheses, discover cause and effect relationships, experiment. solve problems, and generalize solutions—long before they enter school. These are natural roles for children.

The young child learns through play. During play children learn through trial and error to manipulate objects and situations in their environment. Children's play mimics and simplifies the "real" world of their parents, making it easier to comprehend. By recognizing the value of play, parents encourage the young child's learning in the home. By providing the older child with science-related activities, toys and books, parents enrich their child's experience with science and technology.

Families teach their children in a variety of ways, depending on their culture and values: by demonstration, dialogue (discussion), story-telling, modelling, and/or by direct instruction. The Native American grandfather might use a story to illustrate a scientific principle about weather. The Anglo mother might quiz her daughter on math facts. The child living on a farm might learn a lot about biology from helping her parents take care of the animals.

Parents are natural teachers. In helping children understand their world, parents routinely teach biology, and chemistry, as well as such physical principles as gravity and inertia, and simple machines such as the lever and the wheel. They do this informally, supporting the child's natural inclination to learn.

Curiosity and Science Education

Curiosity is the lifeblood of science. All children are born curious. They stick their fingers in electric sockets, jump in mud puddles, touch hot stoves, not because they are misbehaving, but because they are curious. They are learning about the world. And they need an adult to guide them.

But something happens to the average child's natural curiosity as she/he grows older. For many children, learning stops being fun, stops being its own reward. Much of the child's natural curiosity is gone. Schools and families need to take a certain amount of responsibility for this. In their zeal to acculturate the child, to control the behavior of the child, to "teach" the child, schools and families often inadvertently stifle curiosity and creativity.

If we are to do a better job of teaching science we must foster curiosity and creativity in school and home. We need to provide children with opportunities to make choices about how and what they want to learn, take risks by trying out different solutions to problems, and learn from their mistakes by continuing to explore their world. We need to value problem-solving skills more than rote learning.

The School's Role

Schools need to recognize the driving force of curiosity and problem solving in science, and design their curriculum accordingly. They need to relate the science curriculum to the chemistry, physics, and biology their students encounter in their daily lives, thus heightening student motivation. They need to recognize that girls, poor children, and children from some ethnic/minority groups will need extra support from the schools in order to sustain an interest in science and technology.

In addition, schools can help parents become better science teachers by:

- encouraging parents to take pride in their role as teacher
- encouraging parents to use their home language when "teaching" their children
- convincing parents that science is an integral part of daily life and informing parents of the importance of science and math to the child's future
- convincing parents that studying science and math is as important for girls as for boys

• suggesting low-cost activities that families can do at home that promote and support the child's interest in science
• locating male and female role models and mentors for students from various cultures and backgrounds.
• giving parents information about careers in science to discuss with their children
• providing training programs for parents that help them foster their children's natural curiosity about the world

Parent Training

The easiest way to involve families in teaching science to children is to use the family's natural setting, the daily routine and daily activities, and the family's natural teaching and learning methods.

Here is a list of principles that can provide direction for family science activities. They include questions parents can ask to increase their children's curiosity and creativity.

• The most important thing a family can do is encourage and build upon the child's natural curiosity. "Let's find out.."
• Parents should utilize naturally occurring activities in the home, as well as their own interests to expand their child's world "Look at this..!"
• Instead of telling children what to do or giving them an answer, ask questions: "Why do you think..?"
• Children should be encouraged to predict actions or estimate quantities "Do you think it will rain...?" "About how much ...?"
• Parents should model problem-solving behavior for their children, either verbally or non-verbally. "Let's see, if I do this..."
• Parents should provide children with practice in problem-solving. "Could you figure out a way to...?"
• Parents should encourage divergent thinking: "What other ways can you..?"
• Children should be exposed to all kinds of natural phenomena and encouraged to use all their senses. "Look at those clouds..." "Doesn't the stew smell good?"
• Parents can help children to make their own toys and playthings. "Maybe we can make a desk out of this box.." Parents can reach back into their own culture for ideas. "When I was a child grandma taught me how to make..."

Some parents may need strong encouragement from sensitive educators if they are to take a more active role in their child's education. They need to be convinced that they already *are* teachers and that teaching is an important parental role. Parents may feel they don't know how to teach or they don't have enough education to teach. They may be concerned that they do not speak English well enough to "teach" their child. They may be so busy with family and work responsibilities that they feel they have no time to "teach".

By showing parents how they are already filling the role of teacher, educators may be able to encourage them to vary their teaching activities to be more effective. By helping parents understand that science is an integral part of daily life, educators may be able to encourage them to foster their children's interest in science. With good parental support, boys and girls can prepare for well-paying jobs in science and technology. ❖

Model Science Equity Programs

by Marta Larson, Field Service Specialist

A search for model science equity programs reveals a plethora of hands-on programs, perhaps more than could possibly be utilized. But few of these programs address issues of equity. They assume that all teachers are equally comfortable with science, that all students are equally motivated to learn science, and that all students adequately understand the importance of science for their future career. We know that this is not true, and other articles in this edition of *Equity Coalition* will document these concerns, along with a number of recommendations for change.

In this article, several models and approaches that go beyond hands-on activities have been selected for discussion, and listed below in alphabetical order. These programs are intended to substantially change the way schools teach science, or to significantly change the way students think about science and future careers. These programs will help to break stereotypes about science, and increase the diversity of the student population that is interested in and feels confident about science. Many are specifically oriented toward females and/or students of color. What this article does not cover is specific teaching techniques that can make a difference for these same students, a subject that is addressed elsewhere in this issue by

Tasha Lebow.

It is recommended that teachers select one or more of these equity models to use as a foundation, and add hands-on activities as needed. Choosing between these models is a daunting task, as they are all excellent. Perhaps the most effective way to select a model is to first identify as specifically as possible the needs of the population that is to be served, and then look for characteristics of the various models that match the identified needs. Key characteristics might include student age, language group, and whether the program is school or community based.

Photo by Marilyn Nolt, Souderton, PA

Cheche Konnen

Cheche Konnen (shay-shay ko-NAY) is an approach focused on bilingual education, and the need for science curriculum in bilingual classrooms. In describing the program, the authors explain that "in Haitian Creole, Cheche Konnen means search for knowledge. In undertaking this project, we sought to develop an alternative approach to science for bilingual educators, and, by extension, for all educators. From our perspective, science should be valued not solely as a means for teaching English but as a way of knowing and thinking in its own right. In this light, language is a means for scientific sense-making...A sense-making approach represents a radically different orientation to teaching and learning than that found in traditional classrooms. Students construct scientific understandings through an iterative process of theory building, criticism, and refinement based on their own questions, hypotheses, and data analysis activities" (Rosebery *et al.*, 1992).

An example of the Cheche Konnen methodology is the Water Taste Test in which a group of Haitian Creole students at the Graham and Parks Alternative Public School (K-8) in Cambridge, Massachusetts designed an investigation to determine whether water fountains on various levels of their school building had better-tasting water. After conducting blind taste tests, they discovered that water from the fountain that they all believed had better-tasting water was not preferred by those taking the test. A scientific investigation conducted by the students found water temperature differences that appeared to explain the blind taste test results, and, in the process, unacceptably high levels of bacteria in all fountains in the building. Students in this class designed the experiments using Haitian Creole (their first language) and English, but used English to conduct all the blind taste tests and to report the results.

An unexpected result of the Water Taste Test was an increase in the interaction between students in the bilingual program and students in the mainstream school community. Students in the bilingual program were seen as "doing something important and [ultimately] recognized...as experts on water quality" (Rosebery *et al.*, 1992). Language minority students using the Cheche Konnen approach have designed and implemented many such investigations, with similarly fortuitous results. Cheche Konnen is a product of the Sense-Making in Biology in Language Minority Classrooms Project, co-directed by Dr. Ann S. Rosebery and Dr. Beth Warren.

COMETS (Career Oriented Modules to Explore Topics in Science)

COMETS demonstrates an add-on approach to the science curriculum. It has two primary goals: demonstrating to early adolescents that continued study of science and math can have a career payoff, and to pique students' interest in science, especially encouraging females to consider entering a science-related career.

COMETS has 24 sets of supplemental lesson plans (grades 5-9) that can be provided to guest speakers (career role models) in science classes. The guest speaker can use the COMETS materials to conduct a hands-on science lesson related to the curriculum and their career. Students become involved in understanding the career area and its science content. Each lesson plan has three activities plus follow up activities. The lesson plans come with ideas for locating and recruiting guest speakers. Teachers select a COMETS lesson plan to correspond

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The Checklist:

How Equitable is Your Science Education Program?

by Martha A. Adler, Field Service Specialist

Directions: Answer each question with a YES or NO, even if some of the questions deal with a grade level with which you are unfamiliar. If possible, respond to the checklist as a member of a multicultural, gender representative team that includes administrators, teachers, parents, and students across grade levels. When necessary, collect information to substantiate your answers.

I. Science Education in General

Does the implementation of your district's/school's science instruction and curriculum:

____ 1. Incorporate hands-on activities on a regular basis?

____ 2. Include cooperative learning activities routinely?

____ 3. Emphasize problem solving and content equally?

____ 4. Allow students opportunities to talk about their science learning?

____ 5. Relate textbook knowledge to the science in the everyday lives of our culturally diverse society?

____ 6. Include career information on a regular basis?

____ 7. Include role models who represent both genders and people of different racial, cultural, and linguistic groups for students to interact with on a regular basis?

____ 8. Assure equal experiences for all students with avilable technology/ equipment?

____ 9. Promote the integration of the science curriculum with other core disciplines (such as, literature, language arts, mathematics, and, social studies)?

____ 10. Aim at developing and encouraging positive attitudes for teachers, administrators, parents, and students toward science?

____ 11. Develop and monitor partnerships with science and industry that include participation and representation of both genders and people of different racial, cultural, and linguistic groups?

____ 12. Assess students with performance-based criteria, which emphasize the open-ended nature of science and the importance of using language for description and questioning?

____ 13. Assure that counselors, teaching staff, and parents are aware of strategies that encourage equitable participation of female and minority students in science?

____ 14. Monitor all teaching materials (filmstrips, videos, textbooks, posters, bulletin board displays) for their equal representation of both genders and people of different racial, cultural, and linguistic groups in the science community?

II. Science in Pre-K— Upper Elementary

In supporting your science curriculum, does your district/school:

____ 15. Provide inservice training for all teachers to update and improve their science instruction skills?

____ 16. Support and train teachers who are uncomfortable teaching science?

____ 17. Emphasize accountability for teaching science on a regular basis in all classrooms?

____ 18. Encourage and facilitate out of school learning experiences at all levels and for all skill groups?

____ 19. Monitor extracurricular science activities (such as annual science fairs) for equitable representation of students of both genders and of different racial, cultural, and linguistic groups?

____ 20. Establish guidelines for science fair projects that de-emphasize the "wow" effect of experiments and encourage children to formulate their own questions and explore science in their own natural environments?

____ 21. Publicly acknowledge its strong commitment to science as an integral part of the school curriculum, rather than as enrichment?

____ 22. Provide assistance for teachers in obtaining the necessary materials and equipment for teaching science with an experiential emphasis?

____ 23. Form partnerships with parents to define their roles in supporting science education for their children.

____ 24. De-emphasize the textbook approach to science in favor of an experience-based approach?

____ 25. Do outreach efforts that include parents who are representative of the entire student population on decisions regarding science activities and explorations with children?

III. Science in Secondary School

In supporting your science program does your district/school:

____ 26. Make sure that students of both genders and of different racial, cultural, and linguistic backgrounds have equal access to all science courses?

____ 27. Require all students to take a core set of courses in biological and physical sciences that integrates both quantitative and descriptive methodologies?

____ 28. Monitor course content so that no student is left with a "watered-down" science curriculum?

____ 29. Make sure that all selections from the core set of courses be comparable (e.g., home economics is not allowed to substitute for biology)?

____ 30. Monitor enrollments for equitable representation of students of both genders and of racial, cultural, and linguistic groups in advanced placement classes?

____ 31. Monitor lab partner assignments so that students share equally in all aspects of lab work, including setting up, conducting the experiment, writing the lab report, and cleaning up?

____ 32. Assign highly qualified teachers to core science courses, making sure that they are representative of both genders and of different racial, cultural, and linguistic groups?

____ 33. Monitor career day programs for representation from a variety of science careers with career models who represent the diversity within the school community.

____ 34. Assure that counselors and teaching staff affirm and promote the participation of students of both genders and of different racial, cultural, and linguistic groups in science-related careers?

____ 35. Assure that students have equal experience with extracurricular activities (such as science clubs, science fairs, or "Science Olympiad" programs)?

____ 36. Form partnerships with parents to define their roles in supporting the science education and future careers of their children?

Scoring the Checklist

Score ONE POINT for each YES answer. If you have responded to the entire checklist, then score one point for each of the questions in part I (1-14), one point for each of the quesitons in part II (15-25), and one point for each of the questions in part III (26-36).

I. Science Education in General:

30-36 points *Congratulations!* You have equity in proper perspective.

20-29 points *Good Start, Keep Working at It!* You have the elements of a good beginning. Examine each NO answer. Can you group any of these questions into categories? Do they fall along grade level or another category? Bring these issues up with your school/district in order to improve the status of science education for all students in your system.

0-19 points *It's Never Too Late!* Examine the areas where you were able to respond positively. What has made it possible for these to be incorporated for science education in your district/school? Then examine the questions where you responded negatively. Try to identify possible barriers and solutions to bring your school/district up to a more equitable level of educating all students in science.

II. Pre-K — Upper Elementary:

If you have responded as an individual with a Pre-K — Upper Elementary perspective, then score one point for each of the questions in part I (1-14) and one point for each of the questions in part II (15-25).

20-25 points *Congratulations!* Share what you do with other schools/districts. And take a look at what's happening at the secondary level in your district.

10-19 points *Good Start, Keep Working at It!* You have the elements of a good beginning. Group the questions together by your negative and positive responses. Do you see any pattern? What is working for your district/school at this grade level? What's missing? Share this checklist with others in order to develop a plan of action and strategies for how you can improve.

0-9 points *It's Never Too Late!* Examine the areas where you were able to respond positively. What has made it possible for these to be incorporated for science education in your district/school? Then examine the questions where you responded negatively. Try to identify possible barriers and solutions to bring your school/district up to a more equitable level of educating all students in science.

III. Science in Secondary School:

If you have responded as an individual with a middle/junior — high school perspective, score one point for each of the questions in part I (1-14) and one point for each of the questions in part III (26-36). Use the same scoring as described above for part II, Pre-K — Upper Elementary.

Model Science Equity Programs

Continued from page 19

with the area of the curriculum currently being studied, thereby helping students experience how the science curriculum relates to future careers.

COMETS Profiles are biographical sketches of women in scientific professions; it serves as a companion to the career oriented modules. The COMETS Profiles also includes supplemental language arts activities for students. COMETS was developed at the Department of Curriculum and Instruction, University of Kansas at Lawrence under a National Science Foundation Grant.

Decisions About Science

This resource is part of a series for middle school students about developing self concept and decision making abilities. It provides students with information about male and female attitudes toward science, scientific knowledge about human development and the environment, and an opportunity for students to make environmental decisions based on their previous studies. The ultimate goal is to change students' stereotypical attitudes toward science, and to inform them about the relationship between science and occupational opportunity.

The activities in this unit are hands-on and interactive, at several levels of complexity, and sequenced. Students work in cooperative groups. It includes a list of print and audiovisual resources for enrichment, a teacher's guide, student text, and an implementation handbook. A part of a series entitled *Fair Play: Developing Self-Concept and Decision-Making Skills in the Middle School*, it was developed at Florida State University under a Women's Educational Equity Act (WEEA) grant, and published by the WEEA Publishing Center.

Family Science

Family Science, which is similar to its sister program, Family Math, is designed to help increase the participation of women and under-represented minorities in math, science, and technology. Parents and elementary school children attend Family Science classes together and work as a team on scientific activities using materials and items that are readily available in their own homes. Important scientific concepts are explored in an enjoyable, informal setting, where both children and adults are encouraged to learn the process of science, talk and think about science, and become aware of the many career doors that are opened by an ability to "think scientifically." Role models are an important part of the Family Science model, with adults employed in science-related careers invited into the class to talk about their career and demonstrate tools related to their work. Family Science classes are usually held in the evenings, once a week for a period of 4-6 weeks. Schools are particularly encouraged to recruit families of children of color, those with first languages other than English, families of female students, and families with low incomes as participants.

There is a Leadership Development component of the Family Science program. Teams of educators, administrators, and parents who would like to lead a Family Science class are taught the activities, learn strategies for recruiting and retaining hard-to-reach families, and increase their understanding of the equity principles involved. The teams then begin to conduct Family Science classes in their school or district.

Family Science was primarily developed by Peggy Noone and colleagues at Portland [Oregon] State University. A Family Science book is in the process of being developed. The Family Science program is being disseminated nationally by a network of participating agencies, including the Programs for Educational Opportunity.

Finding Out/Descubrimiento

This program began as a bilingual math and science curriculum for elementary school students. It is a multiple-abilities curriculum, with more recently-designed materials for the middle school grade levels. Its primary focus is on the development of higher-order thinking skills in heterogeneous classrooms, using activities that apply math and science to everyday life.

Materials are available in English, Spanish, and pictographs, and include instructions, worksheets, activity cards, and materials for manipulative activities. Children work together in learning centers on math and science-related activities that emphasize learning how to learn, asking questions, and logical thought. Children experienced at using this approach learn to think through given problems, develop strategies to solve those problems, and report their results. The model has undergone a considerable amount of evaluation, which has validated its effectiveness.

The curriculum includes a classroom implementation model, a teacher training model, and a model for organizational support. The model, which was created by Edward DeAvila with funding from the National Science Foundation and the Walter S. Johnson Foundation, is loca[illegible]d at the Program for Complex Instruction, at the Stanford University School of Education.

How High the Sky? How Far the Moon? A Program for Girls and Women

This K-12 curriculum resource is designed to encourage girls and women to pursue sciences and mathematics and to expand their interests in scientific and technical careers. It contains specific information, classroom activities, a career guide for women, role model information, and an extensive bibliography. (A word of caution about the bibliography and career information — the material was prepared in 1979, so many of the statistics are out of date, but the activities are still quite useful.)

The curriculum was developed to help educators prepare girls for scientific and technical jobs, to make science and mathematics relevant to daily life, and to increase awareness of scientific careers and women who are employed in science-related careers. It was developed by Sharon L. Menard of Lafayette, Colorado under a Women's Educational Equity Act (WEEA) grant, and published by the WEEA Publishing Center.

Operation SMART

The goal of Operation SMART is "to help girls acquire an attitude of scientific inquiry toward everything they do" (Clewell *et al.*, 1992, p. 259). Operation SMART is oriented toward girls age six through eighteen, and consists of a number of components, including structured sessions, integration of math and science into existing programs and activities, career exploration, family involvement, and use of community resources. Many of the activities focus on everyday life events and issues. SMART activities are mainly hands-on, and can be used along with field trips, speakers, mentors, and internships to stimulate a feeling of comfort and competence in scientific inquiry among the participants.

While the components were developed by Girls Incorporated (formerly Girls Clubs of America) with their centers in mind, many schools have incorporated Operation SMART materials into their curricula. Project SMART materials have been field tested, and an extensive program evaluation was completed prior to dissemination.

Materials for Operation SMART include a planning guide, activity guide, videotape of girls using the materials, training guide, program and evaluation activities, accompanied by hands-on science and math activities. Operation SMART was developed with staff support from IBM, and grant funds from the General Electric Foundation, and was piloted in Girls Incorporated centers in Massachusetts and New York.

Playtime is Science

Playtime is Science is oriented to helping parents, teachers and children aged four to seven work on scientific concepts together. Parents and teachers serve as facilitators for child-centered, discovery-oriented, highly interactive physical science activities, using materials easily found at home, or in the classroom. Key concepts include the development of higher-order thinking skills, particularly in the areas of visual-spatial, estimation, decision-making, and problem solving.

Materials include training videotapes, a manual and activity cards for implementing the program, and a home activity book for parents. Playtime is Science is funded by the National Science Foundation, and was created and piloted in the New York City schools by Educational Equity Concepts, Inc. Training and pilot projects have been conducted in both English and Spanish-speaking settings, and a national dissemination effort is underway through the Desegregation Assistance Centers, including the Programs for Educational Opportunity.

Science Activities for the Visually Impaired (SAVI) and Science Enrichment for Learners with Physical Handicaps (SELPH)

The SAVI/SELPH project is an interdisciplinary, multisensory science enrichment program which has been used effectively with students with all types of disabilities, and has also been found to be highly effective with students who do not have disabilities. Although it's major focus is on students in grades 4-7, it has actually been used with students between 1st and 10th grades. The core of the program is a science learning center, to which the students rotate. It can be set up for homebound students, and activities are quite suitable for parents to lead. Guidelines are also provided for pairing students with and without disabilities in learning teams.

Components of the program include printed activity instructions, teacher information, student equipment kits, and a philosophical background. There is a Leadership Trainer's Manual available. Teacher instructions include procedures and techniques for making the activities more accessible to students with specific disabilities, and notes that are helpful for implementing activities in a trouble-free manner.

The SAVI/SELPH materials were developed with funding from the U.S. Office of Education, and are available from the Center for Multisensory Learning at the Lawrence Hall of Science, Berkeley, California.

Science Careers Program

The program consists of twelve awareness activities, covering issues like the diversity of science and technology careers, knowing that one does not need to be a genius to succeed in a career in science or technology, believing that the ability to be a successful scientist is not restricted to any one race or sex, and learning that women need not give up marriage and motherhood to pursue scientific careers. Each activity features brief background information for teachers and detailed guidelines for use of the activity. A filmstrip/cassette entitled "Exploring Careers in Science and Engineering," and a series of posters of scientists at work help show students the diversity of scientists and science careers. Resource materials for teachers include articles on sex, race, and handicap role stereotyping and a compendium of famous women and minority scientists.

The goal of the program is to increase the career relevance of science education for all students (grades 4-9), while particularly encouraging female and minority students to consider science and engineering careers. This curriculum package was developed with support from the National Science Foundation, and can be obtained from Research Triangle Institute in Research Triangle Park, North Carolina.

Solving Problems of Access to Careers in Engineering and Science (SPACES)

Designed for students in grades 4-10, this collection of career-related activities helps students develop logical reasoning and problem solving skills. Activities include design and construction, visualization, familiarity with tools, attitudes and personal goals, job requirements, and information about women in careers.

SPACES was developed with a National Science Foundation grant by EQUALS at the Lawrence Hall of Science, University of California, Berkeley. ❖

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Twelve Answers to the Question:

"What Can I Do In My Science Program?"

by Tasha Lebow, Field Service Specialist

MAKING SUBSTANTIVE IMPROVEMENTS in school programs need not be an issue of high cost and complex new programs. Many of the most important aspects of change are more related to broadening expectation, employing new instructional strategies and articulating historically unspoken messages. The cost in dollars for making such change may be minimal, but the required investment in personal commitment and follow through is high.

The following list of strategies is presented as stimulus for all educators to look for methods of positive change in their programs, regardless of their current economic conditions.

1. Provide opportunities for elementary and high school teachers to share their content-related skills and successful instructional strategies with each other.

We know that the use of manipulatives, cooperative groupings, and hands-on learning are areas in which many elementary teachers are expert. These instructional techniques are currently being promoted as essentials to facilitate learning in high school science courses, as they greatly enhance comprehension. But few high school teachers received preservice training in these instructional techniques.

Because of limited course work in science methods and content, many elementary teachers speak openly of their limited experience or comfort with aspects of the science curriculum. The constant evolution in science theories, practices, and related technology means even highly science-literate primary teacher can benefit from ongoing inservice programs from science professionals. Current elementary science and math approaches introduce many concepts previously covered much later in the curriculum, such as physics, chemistry, geometry and early algebra. The preservice education of many primary teachers provided only minimal coverage of this content, leaving them with limited resources. All school districts contain highly trained science teachers at the high school level, many of whom have stayed current on recent advances in their fields. They can be valuable assets when utilized to supplement the limited preparation or comfort level of the elementary staff.

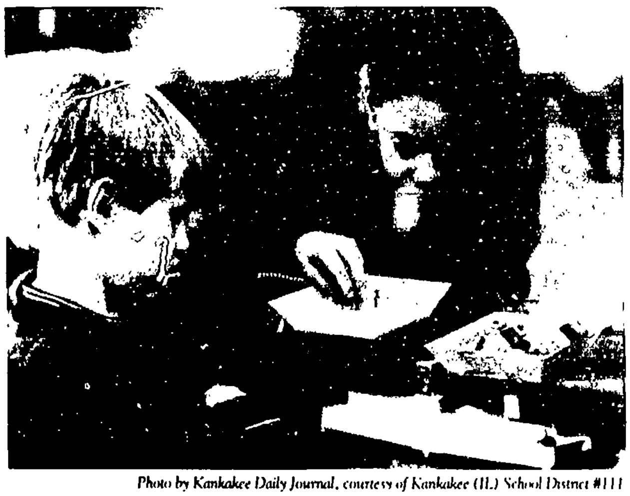

Photo by Kankakee Daily Journal, courtesy of Kankakee (IL) School District #111

There lies within these strengths and weaknesses of the two groups of teachers the balanced potential for a colleague-to-colleague skills sharing program. Structured inservice workshops that create linkages between high school teachers and elementary teachers can vastly improve the skills of both groups. Creative use of local resources can both build the effectiveness and competence of primary teachers relative to the content, and help high school teachers diversify their instructional methods. This approach compounds the benefits to students, guaranteeing that they will be better prepared when they reach the high school science program, where they are likely to find more effective, "student-friendly" instructional methods.

2. Institute student-centered instructional approaches that build concrete understanding of the content.

Real comprehension means moving from rote memorization to techniques that help students construct working knowledge. In classrooms utilizing a constructionist approach students gain experience in the integration of ideas, formulation and testing of hypotheses, and evaluation, elaboration, clarification and adjustment of ideas. It is an approach founded on the principle that students learn best what they discover for themselves, and tend not to completely comprehend what they are only told. The best science instructional approach allows students to have the personal experience of discovery when learning science concepts. Rather than passive recipients of facts to memorize and repeat on command, students formulate the direction that the science inquiry will take. When students take an active role in identifying resources, planning activities, and designing investigation techniques the learning process is accelerated, for connections between facts and applications become immediate and practical. They constantly reflect on and evaluate their skills and performance, and often find ways to remediate any deficient skills, as necessary.

3. Validate other ways of "knowing" through the recognition of qualitative as well as quantitative research and observation techniques.

Many students have the misconception that there is only one right answer to the questions of science. The idea that science is a catalogue of absolute truths that must be quantified is reinforced through some textbooks, laboratory experiments, and the manner in which the media reports on scientific theories and discoveries. Most science curricula do not accurately reflect the level of intuitive insights and creativity involved in science, but focus on isolated statements of fact and statistics. This contributes to students' misconceptions about the nature of science, and is often cited as one of the reasons that they do not "like" science.

High achieving girls and students of color are often targets of negative peer pressure

When students incorporate all of their senses and ways of understanding the world in learning, their personal experience is validated as their first hand knowledge builds. It moves science from the cerebral content of a litany of facts to a complex process of using our skills and powers to understand the world. A lesson in physics may involve building simple machines to test hypotheses, rather than reading principles from a textbook. The task requires the use and integration of numerous skills such as sensory input and evaluation, effective instruction gives an accurate picture of how science knowledge is used in practice.

4. Utilize assessment criteria that incorporate the full spectrum of skills in science applications.

Moving to portfolio evaluation techniques can allow students to demonstrate working knowledge in ways that multiple choice tests do not. Teachers who collect diverse examples of student's work related to a specific concept over a period of time can view the progression in that student's comprehension. The focus moves to what students know and can demonstrate, rather than how many problems they got wrong on an exam. Complex assessment methods can, when necessary, help identify where a student's understanding went astray, or when their grasp of the principles soar past the limits of the standard curriculum. It is also a useful tool for validating the accomplishments of historically underrepresented groups who may inaccurately perceive their abilities in math and science as limited.

5. Promote the human side of science.

Probably more that any other field of inquiry children and young adults cling to stereotypes about science. The limited stereotyped perception of scientists contributes to the lack of appeal of science careers. When pushed a little, most people will expand the definition of who uses science to include engineers and medical professionals. Role modeling programs that bring into classrooms people who use science in their professions, but who are not usually defined as "scientists" can make a real difference. When a diverse group of workers talk to students about how science helps their work students' notions of who does—and of who depends upon—science can be expanded. This can include as diverse a group as electricians, county extension agents, fire fighters, farmers, photographers, dietitians, and veterinarians. A diverse range of people who depend on science can help students understand the applications of science principles and theories. Providing living examples of women and minority scientists can counter the stereotypes of science as the domain of white men.

Career fairs are good vehicles for providing an opportunity for children to hear from science-related workers. They are most effective when the presenters include their personal stories, giving evidence that one need not sacrifice personal or family life to concentrate on a science-based career. Living examples of people who have overcome barriers to achieve their goals, and who have meaningful personal lives, help children see scientists as real people and as possible lives to emulate.

The use of role model programs are best when long term relationships are established. Many professional organizations, civic groups, and some major corporations have begun speakers bureaus, and other resources to help schools find role models for students.

6. Create an inclusive climate in which all students support one another's academic success.

Too often, high achieving students who are girls or students of color report that they were subtly or openly confronted by a hostile, unfriendly climate in advanced math and science classes. It is not enough to create positive attitudes in targeted historically under-represented groups.

All staff and all students should have expanded role and skill expectations for girls and students of color. We must strive to replace the competitive, "sink-or-swim" attitude from advanced science classrooms with a collaborative, mutually supporting climate. Students need to see the challenge as each person striving for success with the content of knowledge, rather than student against student. There is room for everyone to succeed. In classrooms that focus on students' mutual goal of understanding the content, all students report greater comfort in the class, and increased confidence about their potential for success with the content. Some strategies useful to this effort are cooperative group designs for course work and tests, formalizing study groups, and peer tutoring.

Outside the classroom, high achieving girls and students of color are often the targets of negative peer pressure related to achievement and personal goals. This pressure is especially intense for African American young men. The development of strategies to counter negative peer pressure is essential. Activities to counter the cultural attitude that math and science are only the domain of white males must be ongoing and creatively designed to defuse the power of negative peer pressure. All strata of the school population need exposure to nontraditional role models to counter the stereotypes so pervasive in the media and general culture.

7. Utilize problem-solving to connect to students' lives and student partnerships to link elementary and advanced science students in joint projects.

The best way to attract students to science is to make it relevant to their lives. Content directly related to questions and issues important to them can make strong impressions power and strength of science to help us with many of the burning questions of contemporary life. Giving direct, relevant experiences to students who are most likely to withdraw from advanced science can change their perspective on science's relevance to their futures. Using student partnership programs that link high school science students with younger students to jointly complete large projects can also create a "junior mentoring experience." When the joint project relates to some critical aspect of the community, the power of the experience is magnified.

One example of this approach can be found in the rural, northern Michigan community of Roscommon. Denis Fitzgerald, middle school science teacher, has created a linkage project between seventh grade earth science and high school chemistry students on a significant local project. The community is graced by the Au Sauble River, a wild river famous for its fishing and scenic beauty. The students have taken on a long-term monitoring project that is collecting baseline data and will later monitor the river's erosion, pollution, water quality, and wildlife. Where appropriate they will suggest strategies to local leaders of ways to improve the river's condition. The high school students help the middle school students with the technical aspects of the study. Besides helping monitor and improve the river's condition, the partnership between the two grades will hopefully lead to increases in high school chemistry enrollments in a few years. Project leaders hope that a higher percentage of girls will follow through with advanced science study, now that they have had hands-on exposure to it. "We hope that today's seventh graders will fill up the chemistry course when they are eleventh graders," Fitzgerald explains. "They already have direct experience with the equipment and techniques they'll find in the labs. And because of the love everyone in this community has for the Au Sauble, they see that chemistry has a direct benefit to them." Other school districts in the watershed are now joining the project.

8. Monitor interactions of students that arise from, and contribute to, the disparate familiarity with science equipment, techniques and computers.

Many boys tend to dominate classroom activities that involve computer or laboratory experiment dyads or teams. Because of greater resources at home, and the male-focus of most computer games, middle class boys have greater experience and direct contact with computers. Many develop a confident problem solving approach that is often more aggressive and direct than the problem solving style of girls and students with less experience with science-related equipment. When students are paired in classroom work teams, attention must be given to avoid team assignments in which experienced students might overwhelm girls or less experienced students, who will often defer to the partner with more experience. It is common to find a laboratory dyad operating with the boy undertaking the assignment or experiment, while the girl (or less comfortable student) takes notes. Teachers are wise to monitor the actual hands-on involvement of all members of a student team. Lab partner assignments pairing two potentially dominating boys, and two less assertive students together may also be useful. The dominating students will learn to cooperate, and the less assertive students will overcome their apprehension and gain valuable hands-on experience.

9. Telegraph high expectations to all students.

We know from the research of Drs. Myra and David

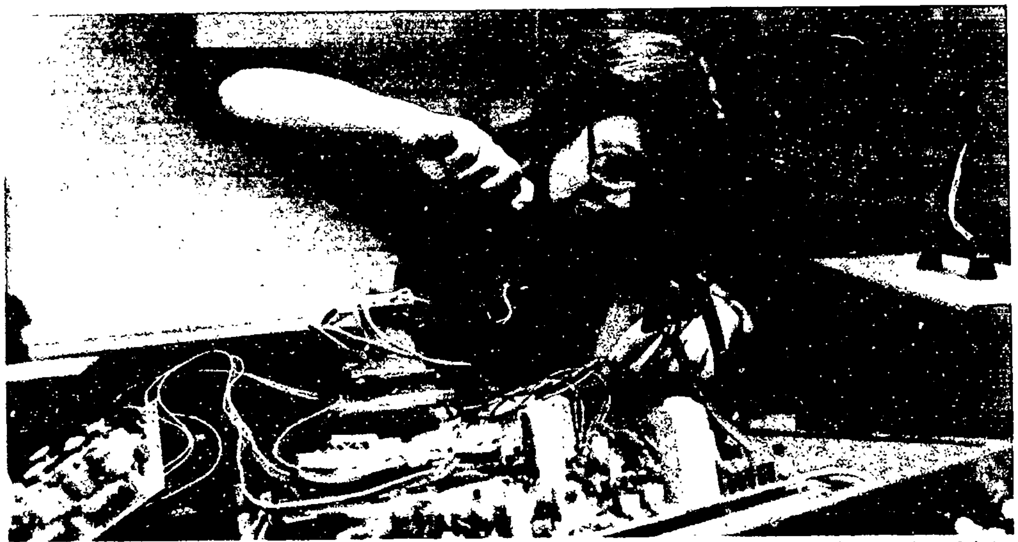

Photo by Maria R. Bastone, courtesy of Operation Smart, Girls, Inc.

Sadker, Dr. Dolores Grayson, and others that even very young children are skillful social process readers who internalize teachers' expectation about their abilities and potentials for success. Teacher biases are often unconscious and unintentionally communicated to students through subtle verbal and non-verbal cues. Teacher support—both direct and subtle—can make the difference to student perseverance and risk-taking approaches to work that is new or potentially challenging to them.

All teachers can benefit from awareness about the subtle ways in which the teacher-student relationship effects the self concept and achievement of students. Aspects of the social process such as exclusionary language, or lower order questioning and brief response times for students perceived to be low achievers help construct and reinforce students' low expectations. When teachers study the research and are coached in positive behaviors, students' self concept, and ultimately achievement improve. Workshops such as the Gender/Ethnic Expectation and Student Achievement model (GESA) provide teachers with the critical awareness of subtle aspects of instructional interactions. Such training provides specific processes, skills, and instructional techniques as well as supplemental curricula that facilitate student expectation and academic outcomes.

10. Connecting science to other courses and content areas through an interdisciplinary curriculum approach builds understanding of the importance of science.

All cultures, through all epochs of history have developed and expanded their scientific knowledge to improve the quality of life. Rather than compartmentalizing science as an isolated body of knowledge, it is best to relate science to content throughout the general curriculum. Connections between scientific advancements and discoveries and other areas of study emphasize how science contributes to concepts of reality and directly effects peoples' lives. Discoveries in science have often changed the course of history and had wide ranging impacts upon other disciplines. How, for example, the following science content relates with the specific course content can fascinate students:

- the abacus, quipu, adding machine, calculator, computer and developing theories of math;
- discoveries in physics and geology and progress related to human locomotion;
- electricity and evolution of musical instrumentation;
- physics in physical education class or on the sports field;
- chemistry and botany in art methods, cooking, or medical arts; or
- biology as described through literature.

The opportunities to infuse science concepts into other areas of the curriculum are limitless.

11. Foster links to parents and community groups for additional support for students' continued pursuit of advanced sciences.

Schools alone can not change society's awareness about the universal need for science skills. Because parents are the most powerful influence on students' course of study, informing parents about critical nature of continued study in science is critical to changing student's misconceptions. When parents are equipped with updated information on career and college "basic skills" requirements, they become advocates for their children's pursuit of advanced science education.

Community, civic, and church leaders can also add their powerful voices to promote and encourage students to persevere in the sciences. Many community service organizations have stated goals about improving the quality of life of their constituent group. Since science literacy is directly related to career and academic mobility today, these organizations can positively impact children's lives by developing programs that enhance academic skills. Many professional organizations also have the intended goal of promoting study and pursuit of technical and science careers. Many have science-outreach programs that offer mentoring or career exploration opportunities for historically underrepresented groups. The national and local chapters of such groups can be useful resources for school programs and many offer brochure, and print materials that can be useful for informing parents and students about the benefits of advanced study of science and aspects of related careers.

12. Ensure that mentoring and in-depth enrichment programs provide meaningful experiences for girls and students of color.

Well designed and delivered special science programs can make the critical difference to many non-traditional students. Many college science departments, corporations, and professional groups now offer early science-exposure programs for students who show interest or aptitude in science. Sometimes run during summers, or week-ends these extra-curricular programs for middle or high school students offer rich opportunities in job-shadowing, mentoring, etc. Some organizations sponsor programs in school, such as science or space clubs.

As with any programs that allow outside groups access to students, participation in these programs necessitates very critical analysis of the operations and impact relative to historically underserved groups. Well-meaning outside groups may not be aware of educational equity issues or of the need for vigilant monitoring and may perpetuate inequities through limited recruitment, biased materials, and faulty program design. If, for example, recruitment techniques for a special science club are not culturally-sensitive, the results could produce all male, all white membership. By assuming that a simple public announcement ensures equal access, an outside group may not see an equity problem. School personnel are more aware of equity issues, and of the need for culturally/gender affirmative strategies. Because of their expertise—and because of their legal liability to ensure gender and ethnic balance in school connected programs—school administrators must consistently evaluate outside relationships. It may be appropriate for programs with outside sponsorship to target membership to include members of historically underserved groups and directly recruit specific high potential students to ensure balanced participation. Monitoring recruitment approaches, actual enrollment, participation, materials, and outcomes will guarantee equity of service delivery. ❖

Say Yes to Science

Continued from page 1

boys and girls are virtually even in math and science achievement in the third and seventh grades. However, by the eleventh grade, boys achieve at a much higher level than girls. While we are not absolutely sure what causes this difference, it seems quite clear that there are stereotypical societal perceptions that contribute greatly to these later grade achievement differences between boys and girls. Is it somehow OK for girls to be smart and to excel in science in the early grades, but not in adolescence? Are girls led to believe that it detracts from their femininity to excel as scientists? If this is the message, then it must be silenced, for the needs of the 21st century will require everyone who is capable and desirous of becoming a scientist to be able to do so.

We must work hard to remove any and all barriers to the field of science. Evidence shows that not only gender, but race, ethnicity and socioeconomic class (SES) are acting as gate keepers to becoming a scientist. Blacks and Hispanics are still almost twice as likely as white students to be in remedial mathematics classes. Low SES students are more than twice as likely as high-SES students to be in remedial mathematics classes. Recent findings also indicate that 50 percent of high-SES students reported attending algebra or advanced classes, compared with 28 percent of middle-SES students and only 15 percent of low-SES students. Also high-SES students are more likely than low-SES students to be involved in conducting experiments in science classes on a daily basis (National Center For Education Statistics [NCES], 1992b). While we may have made modest gains in including women and minorities in the areas of mathematics and science, it is evident that we still have a long way to go before true equity is achieved.

As we move rapidly toward the 21st century, we must attract more women and minorities to the field of science. Otherwise, the numbers of scientists will diminish, and we will face a serious shortage of those most capable of helping us find our way into the future. If we are to go forward with certainty, then we must find exciting and creative opportunities for women and minorities in the scientific world. ❖

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Africans' Contributions to Science:
A Culture of Excellence

Those piles of ruins which you see in that narrow valley watered by the Nile are the remains of opulent cities, the pride of the ancient kingdom of Ethiopia [here the whole of Africa, not the present day country of Ethiopia]. There a people, now forgotten, discovered while others were yet barbarians the elements of the arts and sciences. A race of men, now rejected from society for their sable skin and fr.·zled hair, founded on the study of the laws of nature those civil and religious systems which stili govern th universe.

—Count Volney (1793, reprinted 1991, pp. 14-15)

by Salomé Gebre-Egziabher, Field Service Specialist

IN THIS ARTICLE I want to correct the prevailing misconceptions about Africans and descendants of Africans in regard to science. I wil! first outline why the contributions of Africans have not been recognized, then give a sample of the many contributions of Africans to science, and finally describe a school in Detroit that emphasizes African contributions to science and thereby seeks to boost the self esteem of young African Americans so they can more readily embrace science and math education as part of their cultural heritage.

There are at least three reasons why Africans' contributions to science have not been recognized. First, for non-Europeans, science was not separate from spirituality, religion, culture, and everyday life. Scientists were also religious leaders. In contrast, for the past 600-700 hundred years at least, Europeans have assumed that science was independent of culture, religion, and passion or emotion, that to do science all one needed was dry logic and facts. This assumption weakened the relationship of science to culture and religion and led Europeans to ignore African contributions to science.

Secondly, in acquiring scientific knowledge Third World peoples, unlike Westerners, did not rely solely on rational/experimental method. Western science assumed that knowledge in science could only be acquired by using the Western rational/laboratory experimental method (Adams,1991, p. 32). This excluded other ways of knowing, such as intuition, observation, and trial and error experimentation, especially in agriculture (Adams, 1991). Therefore the scientific achievements of non-Europeans who used different methods were characterized as unscientific.

The third reason scientific achievements of Third World peoples were minimized was the lack of technological dominance by the Third World, especially by Africans. This was compounded by racist attitudes which led to the belief that Africans, whom the Europeans of the sixteenth century enslaved, were not to be credited for their scientific ability. Africans' reputation as scientists was hurt because they did not keep written records (in the Western sense of writing), and what little they did document was taken out of the continent and misinterpreted or distorted. What records were left in the continent were ruined by lack of proper storage facilities.

However, some European authors from ancient Greece to the present time, have given credit where credit is due. Many African societies were performing scientifically and technologically sophisticated works before the coming of the Europeans. We do not have space to list all of them, but here are a few examples.

Astronomy

For about 700 years, the Dogon people of Mali in West Africa recorded the path of the star Sirius A, which they called "sigi tolo"; then they discovered Sirius B, the tiniest and densest companion of star of Sirius A, which they called "po tolo" (Adams, 1991). All that the Dogon people said about Sirius A and B has been confirmed by recent scientific revelations (Van Sertima, 1991).

This scientific knowledge of the Dogon was dismissed in a racist manner by saying that the Dogon must have had this knowledge from some Jesuit priest, or even from some extraterrestrial beings, and that the Dogon could not have discovered Sirius A and Sirius B, let alone draw their paths just with their naked eyes. All of this forgets, however, that the Dogon live in a mountainous region near the equator where the elders observe the sky all night, and that their eyes adapt to the dark extremely well (Van Sertima, 1991).

Secondly, non-European societies observed celestial bodies in order to establish calendars to determine the exact dates for the sacred holy days, so they would coincide with nature's cycles. In Kemet (ancient Egypt) scientific observation of the sky predicted the flooding of the Nile precisely enough to decide when to start planting. This led to the creation of the oldest and most accurate calendar in the world which has 365 days, with 12 months in a year, 30 days in a month, and 5 additional days at the end of the year. Present day Ethiopia uses this calendar exactly as it was created, with an additional 6th day every four years, for Leap Year.

Recent discovery of a megalithic site in northwestern Kenya called Namoratunga is the first archæo-astronomical evidence in sub-Saharan Africa. "Namoratunga has an alignment of 19 basalt pillars that are non-randomly oriented toward certain stars and constellations. The same stars and constellations are used by modern Cushitic peoples to calculate an accurate calendar. The fact that Namoratunga dates to about 300 B.C. suggests that a prehistoric calendar based on detailed astronomical knowledge was in use in eastern Africa" (Lynch & Robbins, 1978, pp. 766-768).

Metallurgy

Africans living on the western shore of Lake Victoria 1500-2000 years ago smelted iron ore and produced usable carbon steel at a temperature of about 1800°C and did it with fuel-conserving techniques. A 2nd century A.D. experimental Roman furnace reached the European record for that period, only 1600°C (Van Sertima, 1991, p. 9).

Medicine

Africans knew about diseases and their treatment, performed surgery, used plants, employed mental/spiritual therapy, and manipulated bones as required in order to heal an ailment. From 350 to 550 A.D., the Nubians may have used tetracycline from molds that grew in the stored grains, possibly dispensed by their physicians (Finch, 1991, note 15). Three widely used medicines in the United States aspirin, Kaopectate and reserpine have one thing in common. The active ingredients in all of them are found in plants in Africa: the bark of *Salix capensis* in aspirin, kaolin in Kaopectate, and rauwolfia in reserpine. Africans used all of these plants for treatment before the coming of the Europeans, and they still do (Finch, 1991).

Imhotep of Kemet was a multi-genius who was the first physician. He lived around 2980 B.C., so he should be considered to be the father of medicine instead of Hippocrates who lived about 400 B.C. and learned from the medical knowledge of the people of Kemet (Finch, 1989, pp. 325-351; Newsome, 1991, pp. 128-129).

Architecture

Africans built buildings and monuments that definitely qualify as wonders of the world. The most notable examples are the great pyramids, the buildings of Great Zimbabwe, and the eleven interconnected rock-hewn churches of Lalibela in Ethiopia. The architectural wonders of the pyramids have not been duplicated by anybody, though some European and Japanese scientists have tried, using modern technology.

African Women in Science

Women in Africa played a role in science, especially in agriculture and healing. In most African countries women were (and are) the farmers, and so they knew when and where to plant, which plants were good for food, and which were good for medicine.

African Science in the Public Schools

The Mae C. Jemison Academy was established by the Detroit Public Schools to recognize the contributions of Africans and African-Americans, past and present and especially women, to science, math and technology, and to recognize their culture for excellence in these areas. According to Principal Schylbea Hopkins, the Academy was named for the first female African-American astronaut, Mae Jemison, who flew on the space shuttle *Endeavor* in September 1992, just as the Academy opened.

The Academy offers African-centered, coeducational math, science and technology from preschool through second grade. Its staff members believe that African-centered education will enhance the self esteem of their students and help them understand that scientific achievement is a part of their cultural heritage which they should strive to preserve and continue. ❖

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Looking at Science Holistically: The North American Indian Perspective

"We know that you highly esteem the kind of learning taught in those Colleges. . . . We are convinced, that you mean to do us Good by your Proposal; and we thank you heartily. But you, who are wise must know that different Nations have different Conceptions of things and you will therefore not take it amiss, if our ideas of this kind of Education happen not to be the same as yours... . Several of our young People were formerly brought up at the Colleges of the Northern Provinces: they were instructed in all your Sciences; but when they came back to us, they were . . . ignorant of every means of living in the woods . . . neither fit for Hunters, Warriors, nor Counsellors, they were totally good for nothing.

. . .We are, however, not the less oblig'd by your kind Offer, tho' we decline accepting it; and, to show our grateful Sense of it, if the Gentlemen of Virginia will send us a Dozen of their Sons, we will take Care of their Education, instruct them in all we know, and make Men of them."

On June 17, 1744, the commissioners from Maryland and Virginia negotiated a treaty with the Indians of the Six Nations at Lancaster, Pennsylvania. As part of the negotiations the Indians were invited to send boys to William and Mary College. The next day they [the Indians] declined the offer" (Hammer, 1987, [p. 24]).

by Iva A. Smith, Field Service Specialist

THIS QUOTE responds to an attitude prevalent in the United States during the mid-18th century, vestiges of which still exist today in our educational system: the attitude or assumption that European-based or Western ways of teaching, learning, and study are the correct, appropriate, only ways, and that the cultural heritages and fundamental teachings of other groups have no validity. Because of this attitude most forms of North American Indian scientific beliefs, intellect, and technology were systematically suppressed by the early European dominance, colonization, and enslavement of the Americas.

This attitude continues to dominate discussions of mathematics and science and the methods one should use to teach and learn these subjects. It is thought that if science is not studied using the Western notion of the scientific method—hypothesis, research, experimentation, and conclusion—then neither the method nor the outcome is scientifically valid. Science as we study it in the United States has a European-culture orientation which operates on the basis of an empirical understanding of the world. Therefore, when faced with non-empirical concepts such as the ones used by Native Americans, scientists consider them to be mere superstitions.

According to Webster's Encyclopedic Unabridged Dictionary, science is:

> 1) a branch of knowledge or study dealing with a body of facts or truths systematically arranged and showing the operation of general issues; 2) a systematic knowledge of the physical or material world.

By these definitions, traditional North American Indian approaches to science and the study of science have been described as non-scientific or dismissed as irrelevant. Nonetheless, the traditional American Indian approach to science is not a series of superstitions; rather, it is as valid as is the typical European-based approach. The American Indian approach has its own systematic knowledge of the physical and material world, but the system differs greatly from the European-based model. To North American Indians science is not an entity separate from the rest of the world as these definitions would lead one to believe it is (or should be). Rather, it is an integral part of human experience. It is balanced with an outlook about life and living. North American Indian science emphasizes the spiritual aspects of all things, which is an integral part of their view of life and nature. It focuses on the relationship between human beings and nature, a relationship based on balance, harmony, and interdependence rather than instability, discord, and conquest.

For North American Indians, cultural concepts and science instruction are interwoven and reinforce the traditional holistic view of nature which is critical to their survival, both physically and spiritually. Ultimately, science helps the North American Indian understand the interaction between and the interdependence of the animate and the inanimate and the rôles they play in the Universal Cycle of Life. This is learned and taught experientially and holistically, using the experiences of other

American Indians past and present, but especially those of the elders, as a guide.

The cultures of North American Indians have changed over the years, but the values and concepts which form the basis for science teaching have remained the same. The emphasis in science teaching is on respect, love, and caring—respect for the animate and inanimate, love for all life forms, and caring for the earth and the environment.

Further, all life forms are seen as related. There is no division between higher and lower forms of life, with people seen as the highest form as is the typical European way of scientific thinking. Animals are seen as 'brothers' and 'sisters,' and plants are respected as 'friends,' as are inanimate objects. Respect is always given to the Earth and her gifts when anything is used. "We are all relatives" is a phrase most American Indians hear frequently as they attend and perform in ceremonies; it emphasizes the interrelatedness with things in the natural world. According to the noted political science professor and author, Vine Deloria, Jr. (Standing Rock Lakota), this phrase can be used "as a methodological tool for obtaining knowledge [and it] means that we observe the natural world by looking for relationships between various things in it" (Deloria, 1992, p. 37).

American Indian students must be made aware of the fact that science has been and still is an integral part of their everyday lives. Unfortunately, surviving stereotypes often make them feel that scientific study is not for them. It is important, of course, for students to know about the historical contributions of their ancestors; however, it is paramount that they understand that contemporary science also relates to them. Only then will they feel that they can succeed in the numerous occupations related to science.

To accomplish this objective, science should be taught from an interdisciplinary approach that integrates scientific content and cultural curriculum components. Science courses will become culturally relevant for American Indian students if traditional concepts of natural phenomena (seasonal changes, animal camouflages, rock formations, and the like) are infused into the curriculum. This is an effective way "to relate elements of the regular school curriculum to the students' heritage and experiences as Indian people" (*Science and Cultural Curricula*, July 1986, p. 1).

Additionally, such an integrated curriculum must include various American Indian contributions and contributors to science, past and present. It must mention cradleboards, hammocks, tipis, rubber, toboggans, anesthetics, emetics, and metallurgy. It must recall that the early European settlers and conquistadors would have quickly perished if the North American Indians had not shared their scientific wisdom of botany, zoology, astronomy, and geology so generously with them and taught their knowledge so trustingly to them.

Further, while teaching about the scientific contributions of yesterday, emphasis must be placed on the fact that we still use many of those contributions today in one form or another. The curriculum must discuss the use of willow bark to treat fevers (the bark contains salicin, a key component of aspirin), and nicotine (in the form of chewed tobacco) as an antiseptic for wounds and insect stings. It must recognize that American Indians of South and North America cultivated six out of the thirteen major food plant staples: maize (corn), peanuts, potatoes, sweet potatoes, brown beans, and cassava (tapioca root).

The curriculum must mention Medicine Wheels, large circular rock formations found throughout the North American continent which were used by North American Indians to track the stars. The Medicine Wheel, which varies from tribe to tribe and nation to nation "is a symbol of the four directions and the inter-connectedness of the world in which we live, . . . [and most importantly, it] stands for diversity, relationship and balance" (Simonelli, 1993, p. 32).

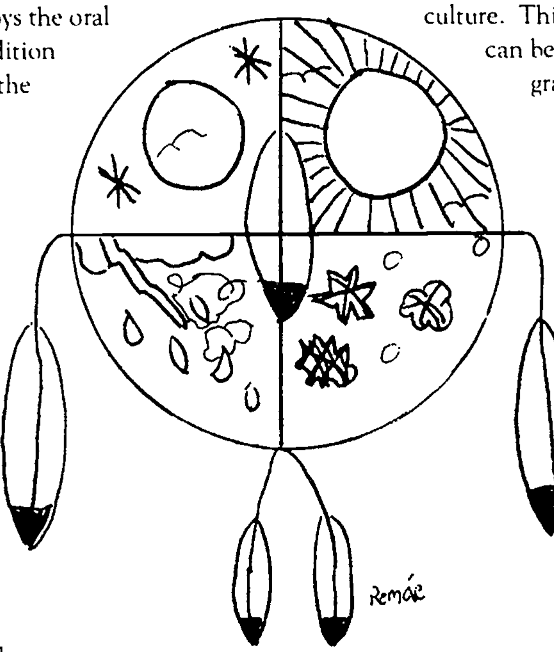
> North American Indian science . . . focuses on the relationship between human beings and nature, a relationship based on balance, harmony, and interdependence rather than instability, discord, and conquest.

The curriculum should note that American Indians have been and continue to be "exemplary users of 'multiple-use conservation,' i.e., effective management of natural resources through ensuring the use of most parts of any given resource, and minimizing waste" (*Science and Cultural Curricula*, July 1986, p. 3).

An integrated curriculum cannot forget Dr. Charles A. Eastman (Sioux), a pioneer in the medical field, Susan LaFlesche Picotte (Omaha), the first female Native American medical doctor, and Mary Ross (Cherokee), mathematician, engineer and aerospace pioneer. It must remind the students daily that ancestors of present day North American Indians were the original civil engineers, metallurgists, mineralogists, geologists, energy conservationists, ecologists, hydrologists, pharmacists, etc., in this hemisphere. It must also respect and emphasize the holistic view of nature, combat the stereotypes that sciences, especially the so-called 'hard sciences,' are too difficult for the American Indian student, and promote career options for students by making science an enjoyable endeavor.

Historically, science has been taught with textbooks, pencils, and paper, using the Western or European method. North American Indian scientific study uses hands-on activities and employs the oral tradition of story-telling. Oral tradition contains much information about the nature or way of things, and it can be a powerful technique for teaching science. This method teaches people to become good listeners and teaches listeners to use *all* their senses to discover how all things in this world are intertwined. One such ancient story or legend for teaching science from an American Indian traditional perspective goes as follows:

> [I]n the beginning days of life upon the earth, man, animals, and plants lived together in equality and mutual helpfulness. Man was one with his environment in a beautiful balance of nature. The needs of all were met in a world of beauty. Man became quite aggressive, however, in his relationship with the rest of his world and soon the harmony was disrupted.
>
> Aggressive man was multiplying so rapidly that the other creatures became alarmed and called a meeting of all insects, birds, fishes, reptiles and four-footed beasts. Their hostility having been provoked, they joined forces against man and devised many diseases to slow down his encroachment upon the earth. The bond between man and the other creatures was broken.
>
> Man found that his aggressive behavior had brought much sickness upon him and had made it hard for him to secure the food he needed . . .
>
> The plant life remained friendly to man, however, and when they heard about the many diseases inflicted upon him, they responded by offering themselves as cures and remedies for his ailments. Each tree, herb, shrub, grass, and moss devised a cure for man if only he would discover and use it.
>
> Thus man created a situation of struggle and turmoil. To have food and to keep himself healthy, he must consider the hostility of the animals and the friendship of the plant life. He must carefully and prayerfully secure and prepare his meat and plant foods within the difficulties that he himself had devised. Through the years the delicate art of securing and preparing both food and medicines developed among the Indian peoples (Sharpe and Underwood, 1973, p. 4).



Drawing by Remae Williams, Cree, age 9 Language Immersion Program, Robbinsdale (MN) School District #281

In the average science class, the previous legend probably would be viewed as a nice tale belonging in a literature course with no acknowledgment of the scientific value of themes within it. There are, however, several themes which are valid science issues embedded in the legend—all based on Native American knowledge and culture. This traditional method of teaching can be used in classrooms today to integrate Native American knowledge into science instruction.

To acknowledge both the scientific wisdom of the elders, and the cultural memory and understanding which have been handed down through generations, one can quote Standing Bear, a Sioux chief, who related the following:

> "[A]way from the woods grew the sand cherries on little low shrubs. Around and over the sand hills [where] not a blade of grass grew, these bushes flourished, yielding a luscious fruit which we were very careful in gathering. We picked this fruit only against the wind, for if we stood with our body odors going toward the fruit its flavor was destroyed." . . . But what on earth would inspire anyone to look into the direction of the wind when picking fruit? . . . The variance in rain, heat, and other climatic factors would appear to be so much more important in determining the condition of the fruit that it would seem unlikely that anyone could isolate human body odor as the critical factor in the relationship. Yet the Sioux were able to identify this element from everything else that needed to be considered (Deloria, 1992, pp. 37-38).

The extent of relatedness between plant and human in this instance is a surprising one because "the human is the less sensitive participant" Deloria continues, adding "I would be curious to learn how . . . [a] botanist trained in Western science would explain how the Sioux discovered this fact of plant life" (p. 38).

Some examples of hands-on activities which emphasize the holistic view of nature as taught by American Indians are noted in a description of activities which took place at the Shannon County Science Camp for

American Indian students on the Pine Ridge Reservation. Camp activities focused on making science culturally relevant to its students.

In a computer class, students learned how to make designs which could be used for Lakota beadwork. Lessons in geology, hydrology, and botany related to the geographic areas where the students lived. Students incorporated photography with astronomy by building an observatory and studying the Lakota year through the use of constellations. Then they took photos of space.

Students also explored buttes while fossil hunting and then made edible buttes out of peanut butter, jelly and bread. Additionally, they learned about rock formations and soil erosion while making their buttes. "Build a butte, bite a butte" seemed to be one of the unwritten mottos of the Camp's participants (Zukav, 1992, p. 75).

The students found out that hands-on activities were much more interesting than merely listening or reading. They also found out that they could do science. Their self-esteem was raised because they found out that it was not too hard for them, and most of all science did, indeed, relate to their everyday lives and was not at odds with their native culture.

Students as well as teachers can discover that although the traditional Native American ways and the European ways of knowing, learning, and teaching are different, using both methods will not impede students in learning about the issues involved in science. Rather, integrating traditional Native American methods with European methods can encourage all students to use their imaginations and draw their own inferences and conclusions.

Children are natural scientists in that they are always curious and asking questions. It is the obligation of teachers and other educators to encourage their students' scientific curiosity, creativity, and discovery. For Native American students, who often see their traditional teachings, values or cultural factors denigrated or totally non-existent in the curriculum, using their traditional culture in the classroom serves as a means for helping them to gain more interest in science education.

Finally, a statement from Vine Deloria:

> It is my hope that the present generation of Indian students will adopt some version of this [traditional] methodology as they are studying Western science, . . . and leapfrog into prominence in their fields by writing and teaching from an Indian perspective. In this way science will move very quickly into a more intelligent understanding of the natural world" (1992, p. 37). ❖

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Special thanks to Robbinsdale (MN) S.D. students Paul Woelfle and Kaylene Strong who also submitted art work and to Robbinsdale's director of Indian education and coordinator of multicultural education, Jackie Fraedrich, for recommending all these student-artists.

Funding for Equity in Science Education

by Ted Wilson, Editor and Research Associate

UNDERREPRESENTATION of women and minority group members in science and engineering is receiving more attention from policy makers as concerns about national security have faded with the end of the cold war. As a result, more funding for science education programs geared to the needs of students from underrepresented groups is becoming available. Three programs, two federal and one private, illustrate this trend.

Eisenhower Math and Science Program

The Eisenhower Act (P.L. 100-297 of 1988) authorizes the expenditure of funds for "improving the skills of teachers and the quality of instruction in mathematics and science in the Nation's public and private elementary and secondary schools." Funding for Eisenhower state formula grants for this purpose has increased an average of 25 percent a year since 1988 to $246 million in FY 1993 (Crudup, 1993, p. 1).

More than two-thirds of Title II/Eisenhower Program funding flows through state educational agencies to local school districts on the basis of their student population and local poverty levels (Knapp, p. 9). However, the funding is spread quite thinly and provides only short-term inservice training experiences averaging about 6 hours per year per teacher (U.S. Senate Committee on Appropriations, 1992, pp. 69-70).

Strengthening economic competitiveness and national security was the purpose of the original 1984 legislation which was the forerunner of the Eisenhower Program, but subsequent amendments require recipients of funds to take into account the need for greater access to mathematics, science, and computer learning programs by students from historically underrepresented groups, including females, minority students, students with limited-English proficiency, migrants, and handicapped students (Knapp, 1991, p. 25).

However, Michael S. Knapp evaluated the Eisenhower Program and found that most states did not emphasize this goal. Furthermore, only 13 percent of local school districts supported activities which placed an explicit focus on underrepresented groups (Knapp, p. 27).

Rather than extensive regulation, he recommended additional leadership at the federal, state, and local levels to remedy this problem (Knapp, p. 37). For example, local science coordinators and equity advocates could work more closely together. Also, local districts may use Eisenhower funds for science equity related programs such as recruiting or retraining minority science and mathematics teachers (Crudup, 1993, p. 3).

For more information contact your state department of education's Eisenhower Mathematics and Science Program coordinator. For more general information about the State Formula Grants Program, contact the Office of Elementary and Secondary Education, School Effectiveness Division, 400 Maryland Ave., S.W., Rm. 2040, Washington, DC 20202 (mail stop 6140); Ph. (202) 401-1336.

National Science Foundation (NSF)

The primary mission of the National Science Foundation is to support basic scientific research, but Congress has also assigned to NSF responsibility for improving science, mathematics, and engineering education at all levels. As a result, NSF's budget for supporting precollege education in mathematics and science has been jumping by better than 20 percent a year (Trattner, 1992), and NSF received an estimated $309 million for precollege mathematics and science education in FY 1993 (Abel, 1993).

Congress also asked NSF to help improve the number of minority group members and women who enter the fields of science and engineering. "The statistics on this over the last 20 years are not terribly impressive," admits NSF deputy director Frederick M. Bernthal. "We have to do something different." (Trattner, 1992, p. 412).

NSF now makes its equity and economic competitiveness goals very explicit in its solicitations for grant proposals: "The Foundation has a particular interest in improving the quality of and access to science, engineering, and mathematics education for women, minorities, persons with disabilities, and other populations traditionally underrepresented in scientific and technical fields of study. For in the years ahead, these groups will comprise a growing proportion of the pool of U.S. students from which a highly skilled work force will be drawn" (NSF, 1992, p. 1).

NSF is also beginning to work more directly with states and schools in many of its K-12 activities (Carnegie Commission, 1991, p. 48). NSF's Division of Human Resource Development has primary responsibility for managing the effort to expand the participation of women, minorities, and persons with disabilities, and its equity goals are realized through such specifically targeted funding programs such as Summer Science Camps, Partnerships for Minority Student Achievement, and Comprehensive Regional Centers for Minorities (NSF, 1993, p. 10).

Of NSF's $309 million for precollege math and science education in FY 1993, some $12-15 million or about 5 percent was designated for activities to encourage underrepresented populations to participate in science and math. Between $2 and $5 million of these funds were specifically designated for activities for women and girls.

In addition to these specifically targeted programs, NSF strongly encourages minority students and girls to apply to such competitive programs as the Young Scholars Program. Furthermore, many of NSF's efforts on behalf of underrepresented groups are folded into its research grants through various kinds of participation.

For example, the University of Michigan just received a $1.35 million NSF grant to expand its watershed studies program that links secondary school students and teachers throughout the world. The Rouge River project, for instance, electronically links schools from inner-city Detroit with schools in suburban and rural areas in the same watershed, making it possible for diverse student populations to learn more about one another and to work together to resolve issues that affect them all (Kellogg, 1993, pp. 1, 8).

For more information contact Human Resources Development, Directorate for Education and Human Resources, National Science Foundation, Washington, DC 20550; Ph. (202) 357-7350.

Annenberg/CPB Math & Science Project

The Annenberg/Corporation for Public Broadcasting Math and Science Project is a 12-year effort to help all children excel in math and science. Annenberg/CPB provides about $10 million in funding each year to regional math and science improvement efforts, particularly those which use telecommunication and information technologies.

Like the federal programs already described, Annenberg/CPB emphasizes underrepresented populations—African Americans, American Indians, Mexican Americans and Puerto Ricans. However, it has been less active in supporting math and science education programs targeted to girls.

In one Annenberg/CPB grant, the Quality Education for Minorities Mathematics, Science, and Engineering Network (Q.E.M. Network), a Washington, DC-based nonprofit advocacy group for minority education received a $1.5 million to develop a cadre of minority teachers in math and science. The grant will fund Q.E.M. Network's Teacher Leadership Corps Project, which aims to create a group of 100 African-American, Native-American, and Hispanic teachers. The project is headed by Mary Hatwood Futrell, former president of the National Education Association.

In another Annenberg/CPB grant, the Indianapolis Public Schools will develop the *Math/Science/Technology Teacher Academy* of minority teachers to bring innovative changes to the teaching of mathematics, science and technology education in elementary classrooms throughout Indiana. Ms. Billie Moore directs the Academy which is housed at William A. Bell Elementary School (IPS #60).

For more information contact the Annenberg/CPB Math and Science Project, 901 E Street, NW, Washington, DC; Ph. (202) 879-9654. ❖

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Recommended Resources on

Science Education and Equity

by Eleanor Linn and Ted Wilson

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Recommendations regarding programs for women and minorities, and students with physical disabilities. 14 pp.

Rutherford, F. J. & Ahlgren, A. 1990. *Science for All Americans: Scientific Literacy, What is it? Why America Needs It, and How We Can Achieve It*. New York: Oxford University Press.

Includes reforms needed to reach women and minorities.

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Theory Development

Aronowitz, Stanley. 1988. *Science as Power: Discourse and Ideology in Modern Society*. Minneapolis: University of Minnesota Press.

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Gendering of science, stereotypes of science as a man's world, and language of science as masculine metaphors and values.

Lewontin, Richard C.; Rose, Stephen; and Kamin, Leon J. 1984. *Not in Our Genes: Biology, Ideology, and Human Nature* New York: Pantheon.

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Longino, Helen E. 1990. *Science as Social Knowledge: Values and Objectivity in Scientific Inquiry*. Princeton, NJ: Princeton University Press.

A feminist and philosopher looks at scientific method.

Research on Effective Strategies

Clewell, Beatriz Chu; Anderson, Bernice Taylor; and Thorpe, Margaret E. 1992. *Breaking the Barriers: Helping Female and Minority Students Succeed in Mathematics and Science*. San Francisco: Jossey-Bass Publishers.

Intervention strategies and guidelines for promoting participation in science and mathematics.

Davis, Barbara Gross & Humphreys, Sheila. 1985. *Evaluating Intervention Programs: Applications from Women's Programs in Math and Science*. New York: Teachers College Press.

Easily understandable guidelines for evaluating intervention programs using science intervention programs as a framework.

McNeal, Ann. Fall 1992. "My Favorite Books on the Relation of Women and Minorities to Science." *Feminists in Science and Technology (FIST)*, Vol. 6, No. 1. Write School of Natural Science, Hampshire College, Amhearst, MA 01002 or send e-mail messages to: mmurrain@hamp.hampshire.edu.

FIST welcomes contributions on disk or via e-mail and costs $5 (individual) or $15 (institutional) for 2 issues/year.

Kahle, Jane Butler. 1985. *Women in Science: A Report from the Field*. Philadelphia, PA: The Falmer Press.

Classrooms fostering equality in the U.S. and elsewhere.

Lockheed, Marlaine E., et al. 1985. *Sex and Ethnic Differences in Middle School Mathematics, Science, and Computer Science: What Do We Know?* Princeton, NJ: Educational Testing Service.

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Sutman, Francis X., Guzman, Ana Cha, & Schwartz, Wendy. March 1993. Teaching Science Effectively to Limited English Proficient Students. *Clearinghouse on Urban Education Digest*, No. 87.

Includes extensive bibliography of instructional materials.

Tobin, Kenneth; Kahle, Jane Butler; & Fraser, Barry J. 1990. *Windows into Science Classrooms: Problems Associated with Higher-Level Cognitive Learning*. London: The Falmer Press.

Why do teachers around the world ask higher-order questions of some students, neglecting minority youngsters and girls?

Model Programs & Classroom Activities

Caduto, Michael J. & Bruchac, Joseph. 1989, 1988. *Keepers of the Earth*. Golden, CO: Fulcrum, Inc.

Center for Multisensory Learning, Lawrence Hall of Science. 1981. *Science Activities for the Visually Impaired (SAVI) and Science Enrichment for Learners with Physical Handicaps (SELPH)*. Berkeley, CA: LHS-University of California.

Meaningful science experiences for all youngsters. Write Lawrence Hall of Science, University of California, Berkeley, CA 94720; (415) 642-8941.

Conwell, Catherine R. 1990. *Science EQUALS Success*. Charlotte, NC: Charlotte EQUALS/Charlotte-Mecklenburg School System.

Hands-on science activities from EQUALS for helping women and minorities succeed in mathematics.

What Will Happen If . . . Young Children and the Scientific Method. 1985. New York: Educational Equity Concepts, Inc., Dept. S, 114 E. 32nd St., New York, NY 10016; (212) 725-1803.

Age-appropriate introduction to physical science methods, using familiar materials. Accompanying staff development guide argues that science is as vital as language and reading.

Girls Incorporated. 1992. *Seeds for Growth: Operation SMART™ Training Guide*. New York: Girls Inc., 30 E. 33rd Street, New York, NY 10016.

Encourages girls in science, math, and relevant technology.

Indian Education Program, Anoka-Hennepin Independent District 11. 1991. *Grandmother Spider's Web: Incorporating American Indian Themes into the Secondary Curriculum*. Coon Rapids, MN.

Fourteen model lessons on American Indian history and culture appropriate for science classes. Other materials available cover topics such as useful plants and time keeping.

Lawrence Hall of Science. 1987. *Great Explorations in Math & Science (GEMS)*. Berkeley, CA: Lawrence Hall of Science-Univ. of California, Berkeley, CA 94720; (415) 642-7771.

"Guided discovery" for elementary science/mathematics.

Massialas, Byron G. 1983. *Decisions About Science*. Newton, MA: WEEA Publishing Center.

Part of a series entitled "Fair Play: Developing Self-Concept and Decision-Making Skills in the Middle School."

Mayberry, Claude (Ed.), *Science Weekly*, 2144 Industrial Pkwy, Suite 202, Silver Springs, MD 20904; (301) 680-8804.

Hands-on science activiities for K-8 students; 16 issues/year for $8.95; class subscriptions for 20+ students, $3.95 each.

Menard, Sharon L. 1979. *How High the Sky? How Far the Moon? An Educational Program for Girls and Women in Math and Scinece*. Newton, MA: WEEA Publishing Center.

Pickard, Dawn, *et al*. 1991. *SEMS plus 1991, Module 5: Issues of Equity and Quality in Science Curriculum Development*. Marquette, MI: Science Education in Michigan Schools, Northern Michigan University, c/o Dr. Phil Larsen.

Identifies major geocultural groups of Michigan and suggests science activities for students of diverse backgrounds.

Rosebery, Ann S.; Warren, Beth; Conant, Faith R.; & Hudicourt-Barnes, Josiane. Spring 1992. "Cheche Konnen: Scientific Sense-Making in Bilingual Educaiton," *Hands On!* #15. Published by TERC, Cambridge, MA.

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Smith, Walter S., Molitor, Loretta L.; Nelson, Bess J.; & Matthews, Catherine E. 1981. *COMETS: Science-Career Oriented Modules to Explore Topics in Science*. Lawrence, KS: School of Education, University of Kansas.

100 physical science, life science, math, and computer activities designed for early adolescent girls.

Sprung, Barbara; Colón, Linda; and Jenoure, Sandra. 1990. *Playtime is Science: Implementing a Parent-Child Activity Program*. New York: Educational Equity Concepts.

Parents and children discover the science in ordinary materials found in most homes.

Biographies of Scientists

Keller, Evelyn Fox. 1983. *A Feeling for the Organism: The Life and Work of Barbara Mcclintock*. San Francisco: W. H. Freeman.

"Not only a gripping biography but also a meditation on styles of doing science." —Ann McNeal, FIST

Manning, Kenneth R. 1983. *Black Apollo of Science: The Life of Earnest Everett Just*. New York: Oxford University Press.

"Powerful delinieation of the effect of discrimination on the career of a distinguished biologist." —Ann McNeal, FIST

Triana, Estrella; Abbrazzese, Anne; & Matyas, Marsha Lakes. 1992. *Stepping into the Future: Hispanics in Science and Engineering*. Washington, DC: AAAS/Proyecto Futuro. Call AAAS Books, (301) 645-5643.

Profiles Hispanic scientists in both English and Spanish.

Verheyden-Hilliard, Mary Ellen (Ed.). American Women in Science Biographies for the Elementary Grades. Bethesda, MD: The Equity Institute.

Books for elementary students to read or have read to them. with such titles as *Engineer from the Comanche Nation, Mancy Wallace* and *Scientist and Governor, Dixie Lee Ray*.

Help in Reviewing Science Books

Nilsen, Alleen Pace. Sept. 1987. "Three Decades of Sexism in School Science Materials." *School Library Journ.*, pp. 117-122.

Describes male bias in educational materials For materials send $2.50 in stamps to Alleen Nilsen, Graduate College, Wilson Hall, Arizona State University, Tempe, AZ 85287.

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