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ABSTRACT

Two of the sessions at the technological literacy conference were panel discussions on the promises, practices, and priorities of Science, Technology and Society (STS) Education and urban minorities for elementary school and secondary school students. Papers presented and discussed during these sessions are presented. "STS and Urban Minority K-8 Students: Empowering through Education" by Dana R. Flint recommends strategies that can be used with elementary school students, as does "Empowerment of Urban Minorities through STS: Practice at the Elementary School Level" by Frederick A. Staley. Paul Jablon presented "An Effective STS Instructional Model for Academic Success with Urban At-Risk Students: Projects, Peers, Personalization, Politics, and Potpourri," which examines the BONGO program, an interdisciplinary, team-taught, and project-oriented program for high school students. "Science/Technology/Society and Urban Minorities: Promising Approaches" by Saligrama C. SubbaRao outlines several promising strategies to teach STS courses to urban minorities. (Contains 43 references.) (SLD)

STS AND URBAN MINORITY STUDENTS

A COMPILATION OF PAPERS PRESENTED DURING PANEL DISCUSSIONS HELD AT THE EIGHTH TECHNOLOGICAL LITERACY CONFERENCE IN CRYSTAL CITY, VIRGINIA, ON JANUARY 16, 1993

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INTRODUCTION

Two of the many sessions held at the Eighth Technological Literacy Conference were panel discussions entitled:

- STS and Urban Minorities: Promises, Practices and Priorities (K-8); and
- STS and Urban Minorities: Promises, Practices and Priorities (9-12).

The papers which were presented and discussed during the two sessions are reproduced in this document.

Members of both the panels responded to many questions which were raised by participants of these sessions. The following are some of the questions which were asked of the panelists:

- Are there any essential elements necessary to reach & encourage minority student populations that are "not as important" to typical majority (white) school populations?
- Is there an effort to involve role models? Is their involvement being sought to assist teachers?
- Given the serious problems & concerns & failings of both urban schools & urban areas (cities) how do we make STS topics relevant & important & interesting to students?
- For a teacher who is not familiar with the culture, traditions, and even language of students in a multicultural classroom, what are some ways of meeting these students' needs.

The answers to these and other questions can be found in this document.

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STS AND URBAN MINORITY K-8 STUDENTS: EMPOWERING THROUGH EDUCATION

By Dana R. Flint*

In order to understand the significance of STS approaches to urban minority students at the K-8 level, we should start with an account of the complex of problems faced by urban minority communities. Most central among these problems are those which themselves have a technological and scientific component. Robert Johnson, for example, has observed that the Black population is both very much affected by and has a heightened vulnerability to scientific and technological changes.[1] Included among the historically significant technological changes are the following:

1. Automobile. The infrastructure of American society has been built around the automobile. While urban expressways enable rapid and flexible mobility, they also have adverse effects on inner city minorities. They contribute to the decline of the urban tax base, the isolation of urban minorities, and cause significant problems of air and noise pollution.
2. Television. Most homes now have televisions, which are widely believed to shape the behavior and attitudes of viewers. But television tends to reinforce negative stereotypes of Blacks, thus contributing to racism.
3. Agricultural mechanization. One major factor in the exodus of Blacks from the rural South was the mechanization of agriculture. This had dramatic effects on employment and unemployment of Blacks. The

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[1]Robert C. Johnson, "Science, Technology, and Black Community Development," Albert Teich, (Ed.), Technology and the Future, 6th edition, (New York: St. Martin's Press, 1993).

lack of sufficient new employment opportunities in the cities to which Blacks migrated adversely affected the cohesiveness of Black life.

4. Automation. As automation has increased, very often Blacks have been employed in job categories which have been eliminated. As a result, Blacks have suffered more of the adverse effects of automation than most other groups.[2]

Further, Johnson suggests that microelectronics and bioengineering technologies will continue to have further substantial impacts on minority communities. He concludes from this that Blacks must take a much more active role in shaping the directions of change in science and technology in order to ensure that science and technology serve the needs of Black communities more than adversely affecting such communities. For this effort there must be "Black scientists, technologists, engineers, policy analysts, social scientists, community workers, and activists."[3] It should be added that for the same reason there needs to be a scientifically and technologically literate minority citizenry.

Since, as is widely known, Blacks and other minorities are significantly underrepresented in many of these occupational categories, empowering Black communities to have a greater control and influence on their collective destiny is not likely to happen unless there is a reversal of that underrepresentation. To reverse this pattern, Johnson points out, it is necessary to make science and technology as much a part of the lifestyle of Blacks as music, dancing, sports, and religion.[4] Doing this is essential for the uplifting of Black communities.

Clearly, the need is for a dramatically altered pattern of preparation for careers and leadership roles among minority students than that which is the present pattern. It is reasonable to assume that students in the K-8 years begin to fix attitudes towards schooling which carry through to later school years. Since decisions and attitudes towards such preparation are likely to become settled during the K-8 years of a student's education, intervention to alter this underrepresentation in the areas of science and technology must first occur in these years. Waiting until later years in a student's educational path is likely to be to wait too long. For many students at the

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[2]Theodore Cross, The Black Power Imperative, (New York: Faulkner, 1984), pp. 446-451.

[3]Ibid., p. 281

[4]Ibid., p. 281

eighth grade level it may have already become too late to reverse patterns of science, math, and technological phobia or apathy.

Further, recent studies have suggested that black students decline in the number of advanced courses in science they take when compared to the other students. The study suggests that:

> Several factors have been identified as reasons for the ethnic gap in enrollment: lower teacher expectations; shortage of role models; stereotyping science as a white, male domain; differential exposure of science instruction and inappropriate instructional techniques; unequal tracking by teachers and counselors; lack of support from parents and counselors; low self-confidence; the belief that science will not be needed in a future career or the inability to see the relevance of science; and a lack of success in previous science and mathematics courses.[5]

This list of factors points to an issue that confronts educators, students, and communities. The attitudes of teachers and students represented in this research could very well function to reproduce the same future of insufficient leadership in science and technology as is the case today. More minority students need to be especially encouraged to take leadership roles in science and technology, either through careers in these areas or as concerned citizens. Otherwise, our system of schooling will reproduce the same patterns of underrepresentation as exists today. The following are guidelines concerning effort:[6]

1. Paths to Success. Since the factors identified above suggest that teachers, students, counselors, and parents may not expect success from the student in careers in science and technology, it is particularly important that pathways towards success in such areas be made clear and expected for the minority student. The student should be able to grasp how a present phase of his or her preparation will enable him to move on to the next phase, and eventually to achieve a career. Exposure to successful minority scientists, engineers, policy analysts,

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[5] Willie Pearson, Jr., & H. Kenneth Bechtel, (Eds.), Blacks, Science and American Education, (New Brunswick: Rutgers University Press, 1989), p. 51. Also, conversation with Dr. Saligrama SubbaRao.

[6] Leonard Waks, "Science Through STS for Urban Minority Youth," and "Guidelines for STS Education for Urban Youth," Project Funded by U.S. Department of Education, Leonard Waks, Project Director.

activist citizens, and entrepreneurs is important for addressing this issue. STS approaches are important because it is often through tracing the patterns of scientific and technological change that new career paths are revealed. Students can experience this through having opportunities to meet individuals in these careers or to see films and videos which reveal such careers.

2. Facilitate identification with the task of schools. Since many minority students perceive the task of schools and science as alien practices of a white society, they do not easily identify with these domains. Schools must make it easier for minority students to identify with their task of educating by including minority themes and issues. A history of science of minority scientists may counter this tendency to see science as a white person's domain.

3. Encourage students to learn to like school. Students need opportunities to exercise their curiosity and urges to make discoveries. A child's natural curiosity needs to be cultivated for when students do not like what they do in school they are less likely to be successful. Discovery centered and experiential learning activities are important in this context, as well as cultivating science-related hobbies. Further, students can be encouraged to discover STS type factors, including ways in which technology and science enrich their lives.

4. Assist students in understanding their community and making connections between what they learn and what is going on in their communities. What they learn should assist them in solving problems in their community and learning the plus side of their community. Also, involve parents and significant others in the student's learning. A specific STS learning activity might be for students to visit agencies, such as a gas company or a hospital, to learn about the technologies they use. Students should be acquainted with the many ways in which science and technology are part of the community in which they live.

5. Assist students in using scientific process skills as applied to STS issues. For example they might be asked to classify the kinds of noises they hear in their neighborhood. Students may be encouraged to be

more attentive observers of the world around and to make more careful observations.

6. Students may be encouraged to solve STS problems, such as recycling, through participating in cooperative problem solving efforts. They may be encouraged to identify such a problem in their communities, devise a solution, and to experience themselves as being part of the solution. Further, parents and schools may become involved in cooperative efforts to solve community problems resulting from the impact of science and technology. Students can experience empowerment through being part of that effort.

While this is not an exhaustive list of recommendations for promising strategies, it does seem that these strategies can be utilized with K-8 students. My point is these STS approaches are especially important in order to address the tendency of urban minority students to identify science and technology as alien, irrelevant, and a white person's domain. If that perception is not combated at this early level, then schools will reproduce the same patterns of insufficient minority involvement in science and technology leadership. The welfare of our whole society may depend on not allowing the reproduction of that pattern to occur.

EMPOWERMENT OF URBAN MINORITIES THROUGH STS: PRACTICE AT THE ELEMENTARY SCHOOL LEVEL

By Frederick A. Staley*

INTRODUCTION

Empowerment has served as a watchword and goal for the education of urban minorities for many years (Cross, 1984, Cummins, 1986, and Flint, 1992). Continued widespread urban unrest, however, suggests we have a long way to go before our nation's urban minorities have the equality that empowerment as citizens ought to provide.

Many are beginning to realize the future of American society is dependent upon the quality of education provided to those living in urban America. Speaking about the future of urban schools, Cuban (1989) suggested, "If the system is left as it is, the social and individual cost of inadequate schooling will severely erode the social fabric of the nation" (p. 29). Changes are needed in what is taught, how it is taught and how schools are organized in the urban regions of this country if we going to survive as a nation.

HOW CAN THE EDUCATIONAL SYSTEM EMPOWER ITS STUDENTS SO THAT THEY CAN BECOME THE CITIZENS WHO WILL REFORM AND RESTRUCTURE URBAN CITIES?

First, we must start at the elementary school level because empowerment requires not only the learning of skills and the acquisition of knowledge, but the development of attitudes as well. Belief in oneself as capable and the belief that one can make a difference in one's own life and the lives of others takes time to develop. These need to begin to germinate early in one's life. Second, we must focus reform

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and restructuring efforts toward the whole school-community, not just within individual classrooms. Third, we must make dramatic changes in the way we go about educating urban minorities.

For the past three years, a project entitled the "Urban, Minority, Middle School STS Teacher/Community Enhancement Project," has attempted the difficult task of curriculum reform and school-community restructuring. We have made changes in what is taught (***Curriculum***) , how it is taught (***Instruction***), and how the school is organized (***Organization***). These three components of change are best thought of as a triangle (See figure 1) with all three sides in support of and necessary to the goal of empowerment.

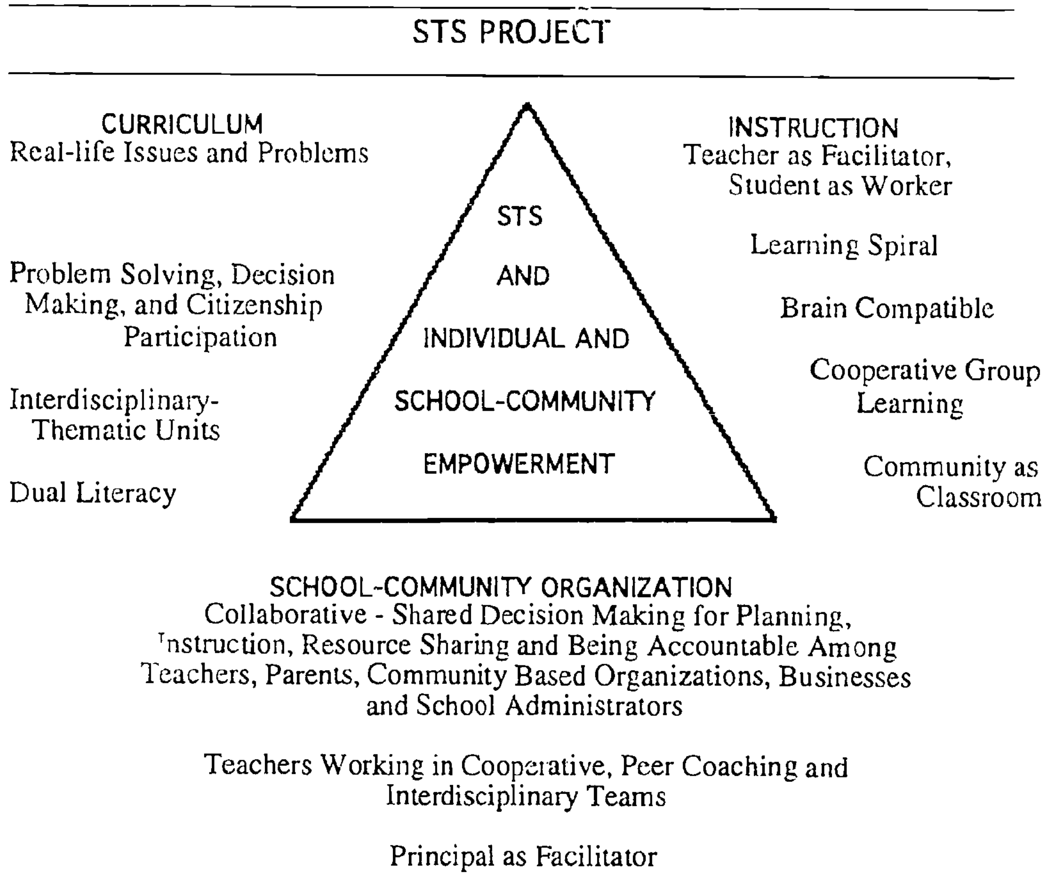

FIGURE 1. STS Project Model for the Urban, Minority, Middle School STS Teacher/Community Enhancement Project.

The *Curriculum* side of the triangle represents those changes in what is taught. True to an STS approach, the curriculum emphasizes science-oriented real life issues and problems of society that are of interest to urban middle school students in Phoenix. One important step toward students' empowerment was their selection of the themes they wanted to investigate. Such themes as Toxic Wastes in our Neighborhood, The Brown Cloud over Phoenix, Human Health Decisions of Drugs and AIDS, Energy Conservation in Our School and Homes, Neighborhood Beautification, The Destruction of the Tropical Rain Forest, and Space Explorations of the Solar System are typical of the themes these students have investigated.

Consonant with the investigation of real-life issues and problems is the emphasis on the development of students' problem solving, decision making, and citizenship participation skills. Interdisciplinary-thematic units that teachers develop or transpose from other commercial sources are organized to follow a problem identification, problem exploration, solution proposition, decision making, and action taking sequence (Bybee, 1989, Lewis, 1991, Staley, 1992) which are designed to develop empowering skills.

To combat the entrenchment of the basic skills movement and the unfounded belief by many that minority students need a great deal of remediation due to low standardized test scores, we are pushing the idea of "dual literacy." We say, "Yes, all students, need to be proficient in reading, writing, speaking and listening, but they also need to be proficient in higher level thinking skills." To spend most of the time on one kind of literacy, at the expense of the other, or to suggest that students must learn the basic skills before they can proceed to develop the higher thinking skills disables rather than empowers minority students. With an emphasis on dual literacy, students are engaged in meaningful STS topics which not only help develop high level thinking skills, but provide a valuable context for learning the basic skills as well.

On the *Instruction* side, the triangle in Figure 1 suggests changes in how we teach. Encouraged are those types of interactions between students and teachers that empower rather than make students dependent. Instead of serving as the fountains of knowledge, teachers become the facilitators and the students convert from passive to active roles as the workers and constructors of meaning. The use of a Learning Spiral and a Brain Compatible Model of Instruction (see Cohen, Horak, and Staley, 1990), by teachers during STS instruction encourages a great deal of student engagement and expression as students grapple with issues and problems. Another instructional change necessary for empowerment is the practice of using cooperative learning. Cooperation, like empowerment, requires the ability to work together for a common goal, to compare others' points of view with one's own view, and to negotiate for the common good. Small groups, working cooperatively on a portion of an STS issue or problem, have many opportunities to develop essential empowerment skills. Finally, because students are studying relevant issues and problems, they are drawn to the community which they can use as a resource for their investigations. Community agencies, governmental offices, and businesses are tapped through phone calling, letter writing and personal interviewing. If necessary, students may also provide petitions, solicit political support, or conduct media events to carry out the citizenship participation phases of their units of study. These are the same skills all empowered citizens need to function effectively in a democratic society. STS instruction is, thus, not the preparation for life, but life itself through the development of the attitudes and skills of empowerment.

We did not begin our project with the intent of restructuring schools. It didn't take us long to realize, however, that it is not just curriculum and instruction at the individual teacher or classroom level that should be the focus for change. We realized our focus had to be with the whole school-community. Thus, we placed the *school-community organization* at the foundation of the triangle in Figure 1, implying that the organization ought to be the foundation for everything that happens in the school-community. Parents, students, teachers, business representatives and members of community based organizations were all brought together with the school principal serving as facilitator to operate as a collaborative, decision making group. Their roles have been to determine mission, vision, and goals for the school-community, and to work to carry out the school-community's plan for curriculum reform and school-community restructuring. The result of all this has not only been the empowerment of students, parents, and community members through the recognition of their talents, interests, and resources, but the empowerment of teachers and administrators as well, as they became more skilled in shared decision making.

MORE THAN PROCEDURAL CHANGES ARE REQUIRED

The changes suggested above are mainly procedural. They are reforms that have been supported for several years as approaches that would benefit all students, not just urban minorities (see Cuban, 1989, Cummins, 1986, and Knapp, Turnbull & Shields, 1990). What is not represented, however, are those more personal and attitudinal factors needed to make these procedures actually work in empowering minority students. First and foremost are the beliefs and attitudes of educators that their students, parents, and community members are capable of being in control of their education and destinies. Instructional strategies and ways of working with parents and the community that put students and parents in dependent roles do not promote empowerment. Attitudes of collaboration and sharing in classroom and school-community interactions shift everyone's roles and expectations from those of being dependent to interdependent.

Related to the idea of dependency is the attitude of dominance. Before students, parents and minority community people can become empowered they must feel that their culture or minority group is not being manipulated and viewed as the dominated group by the dominant group. Instead, all groups in a collaborative, shared, decision making arrangement must work towards rejecting the idea of a dominating group (whether it be the educators or the white members), manipulating things for the dominated group. As Cummins (1986) suggests, this has not been easy because it gets at the very heart of the problem minorities face in the larger society, not just within schooling. Teachers' and the schools' respect for students' cultural/linguistic background also helps to insure that curricular and instructional reforms, and school-community organizational restructuring actually have the intended effects of empowering students, parents and minority community members.

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AN EFFECTIVE STS INSTRUCTIONAL MODEL FOR ACADEMIC SUCCESS WITH URBAN AT-RISK STUDENTS: PROJECTS, PEERS, PERSONALIZATION, POLITICS, AND POTPOURRI

By Paul Jablon*

A review of the literature about current science classroom practices in secondary schools across our country, or a set of visits to urban science classrooms, demonstrates a general lack of structural change over the past 25 years. This is true despite a concurrent change in make-up of student population in our urban schools, and their highly publicized lack of success in academics, especially science. There are a few well intentioned science educators who have emphasized some change concerning the outcomes expected of secondary science — a change towards conceptual understanding and process skill acquisition.

The conceptual approach advocated stands in stark contrast to typical approaches to secondary science, which emphasize discrete topics, uncoordinated facts, and disembodied vocabulary. These had only reinforced the complexity of the natural world, rather than giving adolescents powerful conceptual tools that can help them make sense of nature's complexity. They were accompanied by vocabulary-driven curriculum guides and textbooks that often resulted in science classes that resembled trivia games. In contrast, a constructivist approach realized that adolescents invent concepts on their own. Good science programs simply help them to do so more effectively by creating rich environments that encourage exploration and concept development. Daily hands-on, minds-on investigations, designed, and redesigned by the students based on collaborative group feedback, allow the concrete operational adolescents to enter the realm of complex conceptual thinking.

Some science courses might even cross the disciplinary boundaries of Biology, Chemistry, Physics, and Earth Science by introducing unifying scientific

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concepts such as diversity, variation, order, structure, function, model, scale, system, subsystem, and change that teachers could use in integrating topics as diverse as seeds, dinosaurs, batteries and the solar system. By focusing on concepts, and the process skills needed to utilize them for critical thinking, rather than the collection of factual information, teachers enable lifelong learning. Concepts are powerful learning tools. With experience, adolescents elaborate on and increase the sophistication of their concepts until they become understandings required to deal effectively with issues of adult life.

As with suburban adolescents, within the science classroom this constructivist, daily, activity approach engaged some urban students in real "sciencing." Concerned about the majority who were not, some science teachers have brought the world of STS into their classrooms, utilizing simulations, future wheels and other mechanisms to uncover the interrelationships between society, technology and science. Another subset of the urban school population became engaged as some teachers employed this approach in their classrooms, but the majority of students were not only not attending to much of what was happening in their science class, but were not even attending their science classes.

A survey by the author of eight New York city high schools (with varying ethnic and socioeconomic student populations) showed that less than 55% of students on register were present in their science classes. Less than 10% of New York City high school students take any science courses beyond those few required for graduation. More than 23% of the city's high school students do not attend school on any given day (School Profiles, N.Y.C. Bd. of Ed.). "Nobody is knocking at the doors of the 200,000 kids who are not in class on any given day, in some schools more than half of those enrolled . . . . Of this number, 50,000 slip away after homeroom" (Economic Development Council, 1977).

The published dropout rate in New York City high schools is 40%. Many investigators suggest, however, that the real dropout rate is much higher than reported (Perlez, 1987). "Reports exist about published dropout and retention rates. The New York City dropout rate is estimated at 50% by the Public Education Association and at 65% by Aspira" (Lieberman, 1986, p. 7). The situation in other urban areas is even bleaker (Hahn, 1987). Midgley and Wilce (1980) reported higher dropout figures for Chicago and Los Angeles.

These are a set of symptoms or results that arise from the mismatch between the students affected by these societal changes and the present school environment that are so startling that both the public and educators, at the school district level and at universities, address each as if they were the problems themselves. If there are lower reading scores, then reading is the problem. Truancy increases, then attendance is the problem. Students don't attend or achieve in science courses, then better science courses must be the solution to the problem. "Declining scores on tests of scholastic aptitude have called attention to the apparently declining levels of critical thinking among high school students" (Sternberg, 1985, p. 194). But "the traditional methods of schooling have always been, and continue to be, seriously deficient in promoting critical, independent, productive thought" (McPeck, 1981, p. 154).

Attempting to teach a particular subject such as science within the present context of today's high schools has become a frustrating and unsuccessful task, as demonstrated by both achievement and attitudinal statistics (National Science Board, 1985; Linn, 1986; Rutherford, 1987). A majority of students in the nation dislike science by the ninth grade and elect no additional science courses beyond those required (NAEP, 1988).

It is easy to understand how the emphasis placed on such disturbing statistics can mislead the public, school administrators and even university researchers into labeling these as "problems" our schools must combat (and implicitly labeling certain groups of students as problems) rather than identifying and accommodating the underlying needs of today's students (Ralph, 1989). The following is a typical quotation from an educational study: "Numerous studies were also undertaken to determine why students did not complete high school. The consensus revealed a multiplicity of factors. Most often cited were inability to read on grade level and frequent absenteeism" (Sullivan, 1981). As is usually the case, the study then went on to describe a particular uni-dimensional treatment given to counteract one of these symptoms rather than addressing the underlying problem of matching the overall school environment to the characteristics of its student population.

After traveling throughout the country reviewing secondary schools, the President of the Carnegie Foundation for the Study of Teaching, Ernest Boyer (1984), called for an approach to education that encompasses a number of facets:

> I believe it is possible to build a bridge between 1984 and the year 2000. Through language study, students should learn to communicate effectively

and responsibly and learn to evaluate the messages of others. Through science and math, students should confront complicated environmental problems. Though the study of government, history and western and non-western cultures, students should learn about our own heritage, come to respect other cultures, and consider ways to live together on this planet.

Above all, students should learn to move across the disciplines, to think creatively and to deal thoughtfully with consequential issues, understanding that learning must be measured by the wisdom of its application. For this reason we recommend in our report that each student complete a senior independent project" (p. 350). (Underlinings by the author for emphasis)

There are some science educators who see this ". . . need of new orientation. It is time to institute a science curriculum that balances process and content that includes room for societal issues" (Sigda, 1983, p. 625). There needs to be "a focus on current issues that deals with morals, values, ethics and aesthetics" (Penick and Yager, 1983, p. 623). Science educators are discovering that science as it is practiced by scientists is not interesting to all students (LaPointe, 1984; Anderson, 1972). Some science educators are recently calling for an interdisciplinary approach (Hodson, 1988; Yager, 1988).

> Like most complex human enterprises, science is multidimensional: it includes not only the factual but also the historical, sociological, technological and humanistic dimensions. Some of these dimensions are far more appropriate for many learners than the process and content dimensions. Some educators have argued that these other dimensions are far more important for achieving general scientific literacy than are process and content. Some even suggest that process and content are least important of all (Yager and Penick, 1983).

Six interest dimensions of science that could serve as portals of entry to the study of significant science were identified. These are illustrated in Figure 1. The overlaps represent the core of science, the science that an individual needs to be an effective citizen in our technological world (Anderson, 1978). What is especially significant in Anderson's model is his use of the phrase "portals of entry."

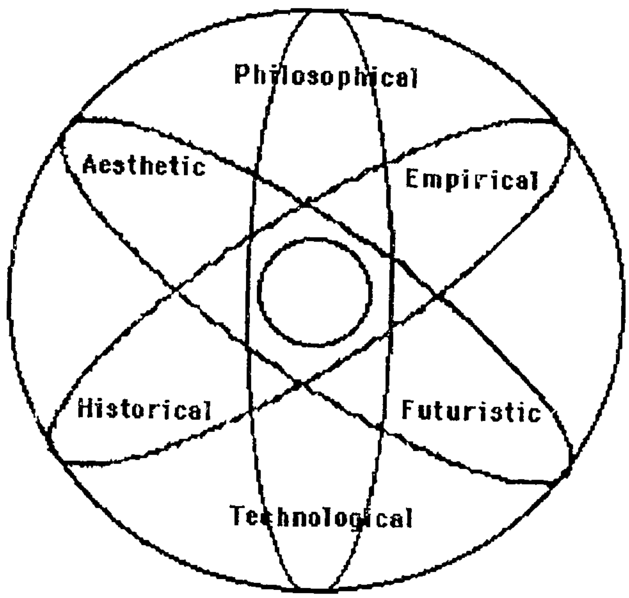

FIGURE 1. Portals of Entry for Science Learning (from Anderson, 1978).

The one point of reluctance shared by all these science educators, despite their insight into the problem, is their **unwillingness to look outside the science classroom for the solution to our science education problems.** On the other hand, there is a program that demonstrates a level of effectiveness in engaging urban students in science, and their subsequent acquisition of science concepts and process skills. It moves beyond the boundaries of the science classroom, and enlists a multidimensional approach to the problem of the whole urban secondary school environment. It restructures the school, and the place of science within it, through the restructuring of the overall secondary school curriculum itself.

A closer inspection of this program raises issues of major significance to the structure of urban secondary science programs, and the structure of instruction in urban schools in general. Therefore, an examination of the effectiveness of this program, and the underlying structure that accounts for the success of its students and teachers, will precede a section that enumerates suggested alterations in science programs based on an assumed acceptance of the model.

Amidst the staggering statistics of high drop-out rates, low reading and math scores, teen pregnancy, and drug abuse among urban at-risk students, a program in New York city demonstrates an exceptionally high rate of success (Jablon, 1989). A close look at this BONGO Program demonstrates the parameters of the multidimensional structure that integrates the interdisciplinary core with a network that accommodates the needs of these students. However, the program begun in 1977 by two teachers at a single high school evolved over time from a more traditional parallel discipline format into the structure that has since inspired similar programs in other schools throughout the city as well as in urban areas as diverse as Cleveland, Ohio and Charlottesville, Virginia.

Essentially, the program grew out of the teachers' experiences with the students. They realized that the urban student population had changed. The rise in the number of one parent families (Bronfenbrenner, 1986), the predominance of negative peer groups (Pulkkinen, 1982), and the effects of intensive immersion in the medium of television (Leibert, 1973) were among the numerous societal factors interfering with academic success. Low reading and writing scores, aversion to science and math, the cutting of classes, truancy, drug abuse, and various antisocial behaviors were all merely symptomatic of a school structure that did not accommodate the characteristics of new students (Hahn, 1987). Although band-aid solutions had been tried throughout the school system, the overall educational structure had been fairly stagnant. On the other hand, the BONGO Program began an organic process of modifying its structure in order to accommodate the enrolled students. It has therefore become a multidimensional matrix, where each aspect of the program works not in isolation from other parts, but rather interdependently, in order to accommodate the multivariate needs of the student population. Each student requires a prescription of varying amounts of each part. Each part also depends on another part as a prerequisite for its success. This interdependent structure, where one aspect supports the other, is likened to the hubs of a geodesic dome where each part can be defined as a separate component of the structure, yet the overall integrity of the structure is dependent on the interplay of each part.

Even though the effects of the program on students who were enrolled over a ten year span were measured using traditional experimental design, with control groups, pre- and post-testing, and statistical analyses with a .001 to .01 significance level, the strength of the study lies in its ethnographic component that attempted to uncover the structure that accounted for any level of success that the program demonstrated.

Five major components of the program that accounted for its success were identified:

1. It was **interdisciplinary**, including during one term or another, most every subject area: science, social studies, language arts, technology, physical education, art, philosophy, music, and career education. Therefore, it was **team taught,** much of the time with two teachers from different disciplines in the same room, teaching at the same time.
2. It was necessary to **personalize the subject matter** through the role playing of analogous interrelationships in the classroom on a daily basis.
3. It was **project oriented**, where a major part of the term was devoted to completing a major project presented to the public that was dependent upon the subject matter studied and upon each student for completion. The projects included writing and producing original full length plays, publishing community newspapers, and writing and publishing oral history books.
4. **Issues of social conscience** were imbedded in the interdisciplinary themes which led the students to act upon their beliefs and create projects that had an impact on their communities.
5. It was the school's responsibility to create **positive alternative peer groups.**

This structure accounted for some fairly compelling results with a population of urban Black, Hispanic, and white students who almost all had a history of at-risk behavior. Ninety-two percent had no cuts during the time they were in the BONGO Program. **Seventy-seven percent of those students had a history of cutting before they were in the program, which dropped to 0 cuts while in BONGO.**

Attendance also increased. Sixty-five percent of the students experienced increased attendance, 31% showing a massive increase. The number of students who showed either perfect or 95% attendance doubled (perfect attendance went from 3 to 5%, 95% attendance went from 21 to 45%). **While students were in BONGO, 50% had 95% attendance or better.**

Eighty-nine percent of the BONGO students either increased or remained constant in their academic performance with 51% showing a major increase. **Most startling is that 32% went from passing no courses, or one or two courses, to passing *all* their subjects.**

Peer groups, which are known to have a tremendous, often detrimental, effect on the behavior of adolescents, have been demonstrated to change while students are part of the BONGO Program. In a study of peer attitudes and behaviors, 60% of the students entering BONGO felt their friends were not encouraging them to do well in school. By the end of the term, 35% of the BONGO group reported they had new friends in school, and that these friends encouraged them to do well in school. The number of BONGO students who spent most of their time doing creative things doubled by the end of the term.

Critical thinking tests which were administered to BONGO students showed that **60% of the BONGO students significantly raised their critical thinking abilities**, which was four times greater than their peers in control classes. Tests of process skills in science and abilities in understanding Science, Technology and Society (STS) revealed that 41% of the BONGO group increased their science reasoning skills and STS awareness over the course of one term as compared to 9% within the control group.

What accounted for these changes in behavior? What was the unique interplay of the five components, for most of these components are not unique in American education? What role did the interdisciplinary core play in this process?

The BONGO Program has some inherent operating characteristics which will assist in an understanding of the daily structure within which the five components interact.

1. Students meet everyday for three consecutive class periods at the end of the school day, usually for a total of about two hours.
2. There are no separations between subjects, or between periods.
3. Students receive three school credits, one for each of the subjects being studied in BONGO during a given term. Students could be taking science, social studies, and English for Biology I, American History I, and American Literature credits.
4. Usually there are two teachers from different disciplines who team teach some, or all, of the three periods.

5. Each term there is new theme, and usually different course credits are offered from the term before so that some of the students from the term before, or previous terms, can be enrolled in the program again.

The rest of the day, students in the program take additional classes they need for graduation. Enrollment in the program is by choice, the only entrance criteria being that students are clear about the program requirements. There were no additional funds or materials allocated, space requirements allotted, or school regulations or structures altered.

The program is truly interdisciplinary, similar in nature to what Heidi Hayes Jacobs (1989) describes as *Interdisciplinary Units*. During the three periods the class meets, there is no one period for any one particular subject. Rather, the subjects are integrated around themes so that although certain subject areas are emphasized during certain moments, or certain ideas are discussed from the perspective of a particular subject, at any given time there is a great amount of cross referencing between disciplines. This allows students with an interest in literature a "portal of entry" into lesser liked subjects such as science or math, because they are being studied simultaneously. Similarly, students who have strengths in traditionally "non-academic" areas, such as dance, music, or athletics have a chance to demonstrate their strengths as part of their academic studies and therefore usually have a greater tolerance dealing with what they view as the "boredom" of the more formal subjects.

It has always been the founders' contention, in support of Jacobs or Karel Rose (1982) in her whole language work, that there are some universal themes that appear again and again that both cross over and unify all the various disciplines. They include such themes as change, growth, metamorphosis, journeys, or the right of the individual versus the right of society. Many of these themes have issues of social conscience embedded in them. This interdisciplinary approach allows a uniquely rich analysis of the interplay of values and pragmatics that govern much of our actions related to social consciousness. Long before science educators coined the term STS for this interplay between science, technology and society, BONGO students were embroiled within its issues (Jablon and Born, 1988).

The first half, or two thirds, of the term students are mostly engaged in cooperative learning situations, intermixed with a small amount of whole class activities including traditional lecture-discussions and trips. What distinguishes this interdisciplinary learning from other models is the idea of personalization of subject matter. Most adolescents, but especially these urban, at-risk students, do not have their security, love, or self-esteem needs met — as defined by Maslow's hierarchy of needs (1968). Yet most of what we do in schools is to ask students to work within the realm of self-actualization, saying that these things they are asked to study they will need "some day" or for the "betterment of society." Rarely are they engaged in any activities in the academic classroom that will fill their immediate needs for the lower level foundational elements. Needs that if not addressed, disallow the student from engaging in the self-actualized activity we present. Many students not finding any of these more emotional needs being addressed in their academic classes, seek them in their anti-school, negative peer groups.

Over the years, the teachers found that most big ideas and concepts that we wish students to acquire, whether in social studies, science, or in the relationships of characters in novels, are universal relationships between individuals and groups, individuals and other individuals, or between groups and groups. They are in many ways based on the same psychological and sociological foundations as the relationships these students are having with their peers and their parents, the two primary areas of concern to adolescents. If we allow students to role play selected real life situations between these individuals or groups that are analogous to interrelationships in social studies, science or literature situations, then students not only "experience" this larger, complex relationship we wish them to understand, but simultaneously meet these emotional needs. In addition, they acquire conflict resolution skills that they can utilize in their everyday interpersonal relationships.

For example, having three students role play a situation between a 15-year-old high school student who must work long hours to add to her family's income because a parent has recently died, her teacher who is upset by the drop in quality of the student's work in her class, and the parent who is caught in between wanting the best for the student and the rest of her family's welfare, has allowed classes of students studying about the cutting of the rainforests to understand the complex relationship between the poor natives cutting the rainforests (the student), the government of the third world country which is encumbered with a large international debt (the parent), and the environmentalists trying to help both the native and the future world ecological situation (the teacher). Students not only had a unique insight into world economics, but into their own personal relationships and therefore identify positively with their academic classes.

The program is team taught which allows for a truly interdisciplinary perspective. In addition, teachers can model how open supportive communication between those in disagreement can lead to interesting and fertile ground for increased and richer understanding of the issue under discussion. In a similar fashion, team teaching gives the teachers concerned an opportunity to learn from each other's strengths. Styles and methods that work with students that do not respond to yours become apparent when both teachers are working in the same room, with the same group of students. In addition, trying a new and foreign method can be less frightening knowing you have an ally who can assist you and act as "the safety net." Also a team is more likely to try out new strategies untested by anyone, than is an individual teacher. The BONGO teachers throughout the country note these as a positive side effect of team teaching — a part of that interdependent matrix that supports the whole structure of the BONGO Program.

Although the first two-thirds of the term contains some cooperative learning projects and lots of role playing, it is truly an academic study of whatever topics fall under the particular term's theme. At a certain time during the term, the class shifts gears. If the students were writing a play, then they spent a number of days arguing amongst themselves about what was the most important idea they had learned this term so they could use this as the underlying message of their play. Not only did this discussion allow the students to do an incredible amount of synthesis of the material they had just encountered, but the same synthesis continued to occur as they turned these formal ideas into characters and conflicts as they wrote and rehearsed their play.

Adolescents, inherently altruistic and wanting to make an impact on their world, take the issue of social conscience, create a public project and fulfill their need to make a difference. In addition to fulfilling this desire, being part of a large final project where every student's part is required for completion, creates a situation for many students where for the first time they are needed at school. Not the typical situation where a teacher or counselor calls home and asks why they are absent, or says they are "missed," but rather a classmate who calls and tells them "to get your rear end in here, because we can't do this without you." This creates a positive alternative peer group where it becomes "cool" to be part of a school class — a class that is truly supporting you. This group is formed very quickly due to the students who have returned to class from previous terms who already have "bought into" the whole process and help set up the class rules early on in the term. These rules, such as no cutting, calling in early in the day if you are sick and going to be absent, etc., are enforced by the class. The teachers are facilitators and partners in the whole endeavor.

The BONGO teachers learned much of this by "listening to the students." Likewise, before the published results about learning styles by Rita Dunn (1978) and others, the BONGO room had a lack of formal school furniture, a rug where most of class was held, places for students to work at formal tables alone or in groups, at varying light levels, with and without background music, and generally a class with a variety of learning modalities. All of this was created because students were listened to.

In trying to create a totally interdisciplinary learning environment it became clear that most educators needed to redefine the objectives and the structures of their own subject area specialties before they were able to engage in dialogue with other subject area teachers about real interdisciplinary teaching. This allowed them to see broad concepts, process skills, and synthesis abilities as objectives, rather than discrete areas of information. For example, once science teachers abandoned their traditional Biology, Chemistry, Physics, and Earth Science courses that were long on facts, for more integrated courses that used areas of each science discipline to address a Science, Technology, and Society (STS) issue (genetic engineering, world hunger, water pollution, etc.) they then found it obvious how to integrate with global studies or medieval literature (Jablon and Born, 1990). Likewise teachers from other subject areas needed to undergo the same transformation before a fluid dialogue ensued.

Years of staff development by the founders demonstrated that BONGO is not a model to be replicated, but rather a process that allows teachers and administrators a personal growth so they can create a structure that promotes an environment that accommodates at-risk students. This led to the creation of the *BONGO Workbook*, an interactive manual that attempts to lead teams of educators through the primary steps of this process, and a set of six introductory videotapes to accompany it.

If our school systems, colleges and universities, nationwide, are going to accommodate the societal changes that affect our youth, the positive evaluation of the BONGO program lead to certain propositions that we need to consider.

1. Subject-specific departments in the school should be de-emphasized, and the framework, within which concepts and skills are acquired, should be restructured. "Science teachers" should also be well versed

in the other subject areas as well as the mechanisms to embed science within interdisciplinary formats.

2. Team-taught classes should be part of every student's and teacher's day.
3. Class content should be personalized on a regular basis through the use of in-class drama and simulation based on students' social interaction. These techniques should become part of the repertoire of the science educator.
4. Positive alternative peer groups should be created by having each student in a school elect a program that entails a group-dependent project. These programs need to have new themes and new mixture. of required courses each term so some number of former students can re-enroll and provide a role model for commitment and collaboration and allow for tradition. The ability to create a new interdisciplinary curriculum each term by a team of teachers should be a goal of schools rather than static, rarely modified syllabi as suggested by present norms.
5. Schools should integrate controversial social conscience issues into the curriculum with methods for students to impact upon their community, based on their chosen values, so as to develop a participatory citizenry.
6. These same projects should be an integral part of classrooms such that students' strengths can be utilized and built on so that students experience the need to regularly attend school. These projects will allow for immediate rather than delayed gratification for learning academic material.
7. Schools should combine the matrix of components listed in the first six recommendations so that they would have the greatest impact on the drop-out problem and would also install a self-correcting system for the future.
8. School systems should rethink the idea of "intervention" type remedial programs and instead restructure the regular school environment.
9. Those science and social science educators who are fostering STS studies should change their posture from the present method of infusing STS in subject area classes and instead, insist on

interdisciplinary, team taught classes which integrate the traditional science, social studies, art and English content.

10. Both school systems and educational researchers should stop trying to employ singular treatments for an educational system impacted by multidimensional societal changes.
11. More educational research is needed that includes both an experimental component which identifies the impact of treatment, and an ethnographic component which identifies the components of the treatment that are involved in actually impacting on student behaviors.
12. Science education leaders should suggest that school systems adopt this type of model as part of existing structures, as with the original BONGO Program, or it should become the underlying structure and philosophy of whole schools as they are created, as with The Murray Educational Center, a high school in Charlottesville, Virginia, based on the BONGO model. Each of them accommodates a particular system at a given time. However, a nation with the present number of "at-risk" students can no longer ignore the results of this (and similar) studies asking for a restructuring of "the traditional" school environment.
13. If the science education community wishes to address the at-risk, urban student, then it should look beyond the science classroom and to the restructuring of the educational environment in which science is taught. The integration of science with other subjects will open the "portals of entry" which are presently closed to most students. "Social conscience" projects will foster positive peer groups and create an active, participatory, scientifically literate citizenry. Most importantly, students will attend and participate in science activities, for if students are not present in class the most well intentioned efforts of educators are useless.

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SCIENCE/TECHNOLOGY/SOCIETY AND URBAN MINORITIES: PROMISING APPROACHES TO SCIENCE EDUCATION (9-12)

By Saligrama C. SubbaRao*

INTRODUCTION

A major report titled "Minorities in Science — The Pipeline Problem" published in a recent issue of *Science*[1] has reminded us of the fact that minorities continue to be severely underrepresented in science and engineering. Although minorities constitute 18% of the workforce, they make up only 5% of the employed scientists and engineers. Today, only 8% of the total number of bachelor's degrees awarded go to minorities. The statistics are even worse at the M.S. and Ph.D. levels. Efforts of over two decades to bring minorities into science have not been very successful. The message is clear: there is no quick fix. It has been reported[2] that a majority of girls, disadvantaged students and ethnic minorities had no interest in science and mathematics by the time they left elementary school. Minority students drop out of the Science Education pipeline faster than others, and also are less likely to get into the pipeline where it begins. Several factors contribute to the low enrollment of minorities in science: lower teacher expectation; shortage of role models; stereotyping of science as a white, male domain; differential exposure of science instruction and inappropriate instructional techniques; unequal tracking by teachers and counselors; lack of support from parents and counselors; low self-confidence; the belief that science will not be needed in a future career or the inability to see the relevance of science; and a lack of success in previous science and mathematics courses[3]. It is estimated that by the year 2000, almost 50% of all urban

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[1] Science, 258, 1176-1237 (1992).

[2] Hamm, M. (1992) *School Science and Mathematics*, *92*(1), 6-91.

[3] Willie Pearson Jr. and H. Kenneth Bechtel, (Eds.), *Blacks, Science and American Education*, Rutgers, The State University, (1989), p. 51.

school children will be minorities. Therefore, it is imperative that more effort is needed to improve the retention of urban minorities in science.

The Historically Black Colleges and Universities (HBCU's) have made significant contributions in educating African-Americans in science and engineering for over a century mainly because they have strong support programs to help the students overcome the barriers identified above. Lincoln University, the oldest HBCU, has a long-established tradition of excellence in meeting the educational needs of socio-economically disadvantaged students. Its success in preparing minority students to become scientists, engineers and medical professionals is impressive. This is attributable to a cluster of programs that includes the Lincoln Advanced Science and Engineering Reinforcement Program (LASER), the Minority Access to Research Careers Program (MARC), the Minority Biomedical Research Support Program (MBRS), Lincoln's Initiative in Biological Sciences (LIBS), and the Pre-college Lincoln University Science Program (PLUS).

The chemistry department at Lincoln has taught General Chemistry to pre-college students based on the STS framework. The Science/Technology/Society (STS) approach to teaching science is based on a general framework that encompasses the following elements:[4]

1. Student identification of problems with local interest and impact.
2. The use of local resources (human and material) to locate information that can be used in problem resolution.
3. The active involvement of students in seeking information that can be applied to solve real-life problems.
4. The extension of learning going beyond the class period, the classroom, the school.
5. A focus upon the impact of science and technology on individual students.
6. A view that science content is more than concepts which exist for students to master on tests.
7. An emphasis upon process skills which students can use in their own problem resolution.

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[4]NSTA Position Paper, July 1990.

8. Opportunities for students to experience citizenship roles as they attempt to resolve issues they have identified.
9. Identification of ways that science and technology are likely to impact the future.
10. Some autonomy in the learning process (as individual issues are identified).

This General Chemistry course was not a full-fledged STS course but had several major STS elements. The experience has been challenging and rewarding. The STS approach appears to have the ingredients to foster and sustain minority participation in science. In this paper, several promising strategies to teach STS courses to urban minorities are outlined. Some of these strategies have been tried by us; however, most of them did not originate with us.

STRATEGIES

A. Make the topics relevant

Many of the urban minority students live in poor neighborhoods. This provides an abundance of social issues which touch the lives of the urban minority and at the same time have global significance. For instance minority students in our pre-college program have repeatedly identified topics such as drugs, disease health, food, trash, etc. Any one of these topics can be integrated with relevant technological and societal issues to develop an STS Science course.

B. Make science interesting and exciting

All children are naturally born scientists. They all have an innate curiosity to unravel the mysteries of nature. But somehow a large number of children lose this curiosity. Conventional science has failed to nurture and develop the love of discovery in children. Most conventional science courses are arcane rituals of data transmission and acquisition. The vocabulary employed in this process is often beyond the comprehension of minority students, and soon leads them to boredom and failure. Furthermore students see little connection between the science they learn in class and their daily lives. Many minority students view science as irrelevant and unimportant. Minority students typically have little early childhood exposure to science. Therefore, they enter high school without a strong science knowledge base. Science teachers must strengthen their knowledge base while at the same time making science relevant to their minority students. They must show them that science is fun, interesting and exciting and do this by teaching science the way scientists practice science. We can recommend several ways to make science exciting.

- Teach the process of science, not just the product

Scientific investigation is challenging, full of suspense and results are uncertain. Students must see that science is a process and not a group of facts. The processes of science — observing, classifying, using numbers, using space time relationships, measuring, communication, inferring, predicting, interpreting data, controlling variables, formulating hypotheses, building models, experimenting — are as important as the product of science. Facts are forgotten easily if they are not used frequently, but the processes will always remain because they can be used in daily life.

- Emphasize discovery-based learning

Science learning is more than absorption of information. Students must be actively engaged in the process of learning. They must be involved in exploring and defining important concepts. For students to relate to science in a meaningful way, it is important for concepts and relationships to be derived by students rather than presented to them. Facts and formulas are worthless if they are only committed to memory. Minority students appear to learn well with teachers who have developed an interactive teaching style. They seem to get lost in the traditional chalk-talk class where they are passive receivers of knowledge.

- Provide challenging hands-on laboratory experience

Students' interest in science can be stimulated and enhanced by providing proper laboratory experiences. Activities can be designed to help students to understand the concepts, conduct experiments, promote inquiry and problem solving skills. Laboratory provides an ideal atmosphere for peer interactions. Laboratory exercises should not be turned into cookbook exercises. It will deprive the students of the excitement of discovery that is present in all scientific research.

C. Incorporate alternative teaching and learning strategies

- Promote cooperative learning

Cooperative learning has been recognized as the preferred learning style of many minority groups. Cooperative learning strategies appear[5] to promote students'

[5] *Circles of Learning: Cooperation in the Classroom* by Johnson, D.W., Johnson, R.T. and E.J. Holubec, (1990) 3rd ed. Edina, Minnesota: Interaction Book.

motivation, self esteem, positive attitude towards a given subject and use of higher-level critical thinking skills. Cooperative learning strategies enable students to learn that there are many ways to approach and solve problems. Students learn how to disagree and how to arrive at a consensus. Teachers must actively promote cooperative learning. Classrooms should be organized into several mixed ability groups. The teachers must move around and maintain learning activities in each group.

- Use upperclass students as tutors

High ability upperclass minority students work well as tutors for lower level students. Peer involvement can positively influence the students because of the similarities in background, experience and age. The teaching role also helps the upperclass students to improve their content and communication skills and also enhances their sense of pride.

- Incorporate multimedia, computers, videos, films, scientific journals, magazines, and newspapers

"Multimedia" has received considerable attention. It is a powerful tool that provides opportunities to teach students with varying learning styles and levels of preparation. Multimedia provides the capacity to integrate video, still images, audio, text and graphics into a lecture to produce a dynamic and interactive presentation. Early indications are that multimedia use in the classroom enhances student interest and enthusiasm.

Computers can be used in several ways to enhance classroom teaching and learning. Software is available to simulate complex experiments, to interpret and analyze data and to teach critical thinking and problem solving techniques.

Excellent videos and films on various science and technology topics are available and should be used. Students must be encouraged to borrow these videos and watch them with their parents. Scientific journals, magazines and newspapers often publish science-related articles of current interest. Students must be encouraged to read and discuss them in class.

- Provide meaningful field trips

Many urban minority students have very little opportunity for informal science learning at museums, zoos and other science centers. The importance of such informal experiences cannot be overestimated. At some of these centers, exhibits are interactive. Students should be taken on field trips to some of these places.

- Assist the students to learn information search

It is very essential for students to develop skills in obtaining information from various sources. Students must be trained in the effective use of the library and must be encouraged to visit the public libraries frequently. Modern libraries are equipped with computer search facilities, which with guidance, are not difficult to operate. Students must also be encouraged to write letters or make phone calls to obtain information from other sources such as government agencies, private corporations, foundations, etc.

D. Emphasize problem solving skills

Students often do not see the value of science outside of the classroom. Teachers who help students to transfer scientific processes learned in the classroom to real life situations increase the chances of their students improving their attitudes about science and the understanding of the scientific processes. The students should be trained to solve problems similar to those found in real life situations.

Students must be encouraged to identify a project in which they are interested and which also has local and community relevance. They must be guided step by step to solve the problem. The students must be required to use local resources such as family members, neighbors, community leaders, public library and other sources. After completion of the project, the students must write a report and "publish" it by circulating it to family, school and the community. A small write-up in the newspaper would give even more recognition and support.

E. Help students experience relationships among disciplines

Some students can readily see connections among the various disciplines of science, mathematics, and technology but others do not. Teachers must be aware of this and encourage students to make connections. Good teaching always reveals connections both within science and other areas of knowledge. Both scientists and non-scientists with interdisciplinary backgrounds should be invited as guest speakers to lecture to the class and stimulate the students to see science and technology as a social phenomenon that influences their own thought and actions.

F. Help minority students discover their science heritage

Minority students think that science is the domain of white males. They do not learn in school that many of their forefathers have made important contributions to science. Students rarely learn the names of George Washington Carver, Percy Lavon Julian, or Charles Richard Drew. Teachers should find ways to stress the contributions of minority scientists. Teachers must impress upon minority students that one becomes a scientist not because one is born with special talents but mainly because of hard work and self-discipline.

G. Reinforce a positive self-image

Many urban minority students are surrounded by failure both in and out of school. They see few examples of success and develop a sense of hopelessness and low self-esteem. They may enter school with poor expectations and perform poorly. Building students' self-confidence should be a priority. Students' self-confidence is bolstered as they experience success. Teachers must help the students to develop the belief that with reasonable efforts they can be successful. Minority students need to be challenged and supported to succeed. Teachers must set and communicate high expectations to all their students. The low expectations teachers have about what students can and cannot do often become self-fulfilling prophesies. Minority students need to be given honest evaluations frequently. When students fail in a test, encourage them to work hard rather than brooding over the failure. Students can put up with initial set backs if they enjoy science and feel hopeful about the future. The teachers must let the students know they care. Patronizing should always be a taboo.

H. Help minority students to explore career opportunities in science

Minority high school students rarely receive adequate counseling and sufficient information regarding technical careers. A first step to increase the flow of minorities into science and technology is to provide them with proper information, guidance and encouragement. Outstanding minority scientists may be invited to present seminars on career opportunities in science. They will also serve as role models and enhance motivation and interest in science. HBCU's and minority professional organizations can provide role models. Visiting scientists programs are available in several universities and industries. Students could also be taken on field trips to industries, universities, hospitals etc., where they will have an opportunity to speak with scientists and learn more about a variety of employment and educational opportunities in science. Students must be especially encouraged to participate in career fairs that are organized frequently.

I. Get the parents involved

Parents must be involved actively in the education of their children. Parents must be informed about the potential lucrative employment opportunities that would be available for minorities with a science background. They should be invited to the career awareness seminar where they can meet and interact with minority students. This may inspire them to encourage their children to study science courses. Many parents want to be involved. Proper strategies have to be developed to involve parents in meaningful ways.

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