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ABSTRACT

There is evidence that more boys than girls have experience in activities related to science and mathematics outside of school and that there are a number of kinds of interventions that can sustain girls' interest and participation in science and mathematics. What is missing is a theoretical explanation for the phenomenon that more boys than girls persist in science and mathematics in high school and beyond. This address discusses girls' opportunities to participate in nonformal science and mathematics activities outside of the home. The characteristics of excellent intervention programs are listed and a number of specific programs are cited. This discussion focuses on museums, media, youth organizations, and informal programs. Three major concepts are also discussed including equity, inquiry, and linkages. There are 14 references listed for this topic. (CW)

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EQUITY ON PURPOSE: IN PURSUIT OF EXCELLENCE IN INFORMAL, OUT-OF-SCHOOL INTERVENTIONS IN MATH, SCIENCE AND TECHNOLOGY

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At one time the theme for this presentation was that out-of-school experience in math and science is critical to understanding the small gender differences in achievement and the substantial gender difference in preparation for scientific and technical careers. There is recent evidence (Linn and Petersen, 1986; Lockheed, et al, 1985; Fox, Brody and Tobin, 1985) that experience is an important variable. But at the international meetings on Girls and Science and Technology immediately preceding this meeting both Alison Kelly of Britain (1987) and Leonie Rennie of Australia (1987) presented evidence that experience is not independently related to performance or persistence in math and science. That is, though all these analysts and others (Miura and Hess, 1984; Sanders, 1986) report that more boys than girls have experience in activities related to science and math outside of school, there is some doubt that lack of this experience is a "cause" of girls' dropping out of math and science courses or careers.

Far be it from me to fly in the face of the evidence. Therefore, the theme of this presentation is now that the factors accounting for girls' lack of persistence in math and physical science through the end of high school and into postsecondary work are complex and incompletely understood. Let me hasten to add that there is a near-consensus on an empririical basis about the kinds of interventions that can sustain girls' interest and participation and I will present a list of these characteristics shortly. What is missing as yet is a theoretical or causal explanation for the phenomenon that more boys than girls persist in math and science through high school and beyond. I maintain that there are still good reasons for examining girls' opportunities to engage in math and science in the realm I have been charged to discuss--outside the home, outside school and outside the "formal" programs in the out-of-school setting.

I understand that others on the panel are charged with reviewing most of the programs that appear in the excellent compendia of intervention programs prepared by the American Association for the Advancement of Science (AAAS) (Malcom,1984) and Educational Testing Service (Lockheed, et al,1985; Clewell, Thrope and Anderson, 1987). These programs are most often sponsored by universities and operated in, or in cooperation with, elementary and secondary schools. (I will nevertheless mention many of these programs as vital sources of materials or linkages.) Interestingly, the authors of two of the compendia conclude that programs specifically targeted for girls, as distinct from

minorities of both sexes, do not emphasize experience in math and science. Rather, the majority of programs for girls are one-day or short-term efforts and they focus on changing attitudes. and linking math and science with careers. (Malcom, 1984; Clewell, Thorpe and Anderson, 1987). I am not at all recommending we abandon efforts that address careers or attitudes but noting that there may be a need for additional attention to out-of-school experiences in math and science for girls.

I believe there is near consensus on the characteristics of excellent interventions for young people of school age and the criteria for excellence vary little by whether the program is conducted in school or out, on Monday or Saturday. As you have already heard from others, excellent intervention programs are characterized by:

hands-on activities
practical examples and applications
cooperative learning styles
team approach to teaching and learning
beginning where people are, rather then where they are expected to be
role models of people plausibly "like me"
sensitivity to the groups being served
connecting activities to careers in math and science
parental support and involvement
clear goals and objectives
evaluation of the program's effectiveness

The best programs both espouse and incorporate many or most of these characteristics (Malcom, 1984; Lockheed, et al., 1985; Kreinberg, 1982; Smith, 1987; Chipman, Brush and Wilson, eds., 1985; Humphreys, ed., 1982). My charge is to discuss programs that are both "informal" and "out-of-school" and I would like to do that by touching briefly on such programs in museums and media and then move on to programs offered by youth organizations, using Girls Clubs of America's Operation SMART as the example I know most about. My authority, if I need one, for designating informal programs as museums, media, and "other activities" is that these are the designations the National Science Foundation uses.

MUSEUMS AND INFORMAL ACTIVITIES

Adventures in recreational learning greet the children and young adults who enter many of the children's museums, museums of science and technology, and science centers across the United States. Exhibits tagged with questions instead of answers, "junior explainers" (volunteer staff who are only a few years older than the young visitors) and signs everywhere of "please touch" and "try me" make the environment kid-friendly. Some 170 organizations are members of the Association of Science-Technology Centers (ASTC) and they develop exhibits which then often travel to other ASTC centers or can be readily replicated by others. My Daughter the Scientist, developed in Chicago, profiles women who have been successful in science. It combines role models with some hands-on activities designed to interest girls in particular in math and science. Projects sponsored by ASTC as an organization include development of three traveling exhibits: MILLIONS on large and small numbers, STRUCTURES on mechanics and architectural form, and DINOSAURS on science and imagination in the study of ancient life forms. Several of the museums have exhibits accessible to children and adults with disabilities and other exhibits to allow currently abled people to experience having a disability.

Many of the museums offer Camp-Ins in which groups of girls and their adult leaders stay overnight. Scheduled activities include supper, breakfast and an introductory session, with much of the remaining time for wandering the museum and trying things out. Most campers apparently get at least some sleep in their group's chosen campsite--under the dinosaurs or near the spaceship. The Camp-Ins were developed by the Center for Science and Industry in Columbus

Ohio. In an unconfirmed history, local Girl Scouts asked for the program; the museum planned for 100 participants and 1000 signed up. Camp-Ins are now a significant part of the program of many science centers and most of them continue to serve more girls than boys in this overnight format.

MEDIA AND INFORMAL PROGRAMS

The most widely known informal program in the media is Children's Television Workshop's 3-2-1 Contact. Principles of science are explained and then demonstrated in practical applications designed to appeal to children aged eight to twelve. The programs are carefully designed to be accessible visually and intellectually to children with a wide range of abilities. Girls and boys from diverse ethnic backgrounds are shown as interested in and competent at science. And the adult role models are similarly diverse and are "real" and approachable. Children's Television Workshop provides a leader's guide (over 1 million distributed), a magazine for youth (about 700,000 readers), training for leaders, and help in forming 3-2-1 Contact Clubs, so that the program moves from television to hands-on involvement.

Many other programs and projects have recognized the value in producing audiovisual aids as part of formal or school-based programs, especially in showing role models in scientific and technical careers. If you do not know about Walter Smith's COMETS materials, or the FUTURES UNLIMITED posters from the Sex Equity Consortium at Rutgers, or Iris Weiss' posters and audiotape produced while she was at Research Triangle Institute, or about the videotapes available through Chris Black at the very dental school building in which we are meeting at the University of Michigan, then by all means visit the resource room at this conference or seek out these people. In addition, films, videotapes and television programs with science content abound, many of them with excellent information and exciting images. Most of these have not been designed to become interventions, though many could effectively be made part of interventions designed by others.

YOUTH ORGANIZATIONS AND INFORMAL PROGRAMS

The mathematics and science that go on in voluntary youth organizations frequently are overlooked in compendia of interventions for females and ethnic minorities. In some ways this is good news, in the same sense that it is good news when targeted programs become so thoroughly institutionalized as to become invisible (Malcom, 1984).

It would be difficult to comprehend the major secular youth organizations totally devoid of math and science content: 4-H without animal science, Girl Scouts without star gazing, and Future Homemakers of America without the chemistry of food preservation are hard to imagine, even speaking only of some of the youth organizations that serve girls. Together such organizations serve millions of school age girls and provide countless hours of fun and enlightenment with math and science content each year. Yet the gender discrepancy in persistence in math and science courses through high school remains.

One reason the science in youth organizations is invisible is that much of it is incidental. In youth organizations as in other informal learning environments math and science are often treated as one of several appropriate topics. Certainly this was the case in a study of math and science offerings for middle school ages in Girls Clubs. Though some 55 percent of Girls Clubs offered at least some math, science or technology programs, the programs dif

fered markedly depending on the intent--the goals and objectives--of the program (Nicholson and Crenshaw, 1986). Several Clubs offered nature study, gardening, homework help and other activities that seem to be consistent with even a very traditional definition of preparing girls for womanhood.

A larger proportion of Clubs had recently added math or science to the program schedule as a specific response to girls' need to prepare for economic self-sufficiency and the critical need for math and science in preparing for lucrative careers (Nicholson and Crenshaw, 1986). Thus in Girls Clubs, as probably in other youth organizations and informal learning environments, there are both incidental and intentional programs when it comes to promoting girls' interest, participation and performance in math and science. It would seem that intentional programs are increasingly needed. Indeed the notion of intent may need to be added to the list of characteristics of excellent programs.

Equity, Inquiry and Linkages in Youth Organizations

In many ways the voluntary youth organization is the ideal setting in which to provide experience that goes beyond one-time exposure or incidental activity in math and science. Time schedules are often more flexible, groups are smaller and so transporting girls for field trips is not a logistical nightmare, and no authority insists that six more topics be covered this term. Especially, voluntary youth organizations are free to do excellent informal science because they do not need to certify students to move to the next level by virtue of having mastered a body of information. Despite these advantages, the youth organization often is overlooked as a setting for intentional programs in math, science and technology. And too few programs in any setting achieve the critical characteristics that Girls Clubs of America espouses as key elements of informal programs: equity, inquiry and linkages.

Equity. The concept of equity is at least implicit in the list of characteristics of excellent programs. Though "sensitivity to the groups being served" and "clear goals and objectives" imply that programs should be equitable, it is not clear that these programs may need to be driven by equity as a primary concern. I am suggesting that incidental programs in math and science may provide valuable enrichment for those already predisposed to benefit from it; but for many youngsters, including many girls and minority boys, informal programs need to be intentional and equity-driven.

Even in the early grades many girls have already been left out or left behind in math and science, as observed by staff of the seven Girls Clubs in the Operation SMART collaboration. Opportunities to catch up--to play with large blocks as an eight-year-old or to use physical objects for counting at this age--can be made a normal part of the program in the voluntary setting, where they might seem conspicuously remedial in school. The girls-only situation of some Girls Clubs can also be an asset in demonstrating that girls can do anything. Bicycle repair and similar skills that many boys have learned at earlier ages can be approached at a pace that is comfortable for the girls who participate. Practical applications that may be only a series of examples in the classroom can be as numerous and deep as needed to achieve real under-

standing in the flexibility of a youth organization. For example, one Operation SMART group at a Girls Club examined the principles of air flow and then visited a meteorologist to learn about the measurement and prediction of air flow; they returned to the Club where they made similar instruments and tested the principles. They then went back to the meteorologist with their questions and observations and learned still more about why they might need to know about air flow.

There is a real risk in designing programs for equity that one will perpetuate stereotypes and perpetuate a cycle of underexpectation. But the risk may be worth taking as some of the subtler forms of past discrimination are addressed and overcome. For example, there may not be a demonstrable gender difference in fascination with science but it is worth getting beyond the amazing science demonstration when working primarily with girls. More girls than boys may need to know about real world applications of science before they become interested, and so practical applications should be offered. Similarly, it is stereotyping to predict that a boy using a computer for the first time will charge ahead and find out what it will do, even at the risk of damage, while a girl in the same situation will await permission and instructions. Some girls are confident "hackers" and some boys are careful with equipment. Yet thinking about the stereotypes can help to insure equity through program design by providing ample instruction and comfortable opportunities to ask questions, at the same time encouraging reasonable risk-taking. This kind of search for equity led the Operation SMART collaborative to the path of inquiry to insure that girls who had already been left behind in math and science could catch up; and to encourage the interest, participation and achievement of all girls in math, science and technology.

Inquiry. Again the characteristics of excellent programs go part way toward describing the best that informal, out-of-school programs can be. Education in math and science that is based on hands-on activities, practical examples and applications, cooperative learning styles, and a team approach to teaching and learning, unfortunately is still the exception in the United States through the middle school level (Lockheed, et al., 1985). And education based on these characteristics is likely to be engaging for children. Still, the Girls Clubs in the Operation SMART collaborative found that they had to go well beyond hands-on activities to challenge fundamental assumptions about teaching and learning, teacher and learner. They came to grips with their own apparent hypocrisy as they found themselves exhorting girls to get dirty, take things apart, get involved, and challenge the question as well as the answer when they were involved in SMART activities; but exhorting girls to take turns, pay attention, maintain order and stop when the time was up in other activities at the same Club. They decided that the inquiry approach was far better and was indeed what many girls had missed in prior socialization. But it meant undertaking significant change in staff attitudes, Club rules and understanding of goals and objectives. Undertaking this level of transformation is probably easier and therefore more likely in a youth organization than in a school or school system; it seems important but difficult in any institution.

The Clubs asked themselves: Whose question are we working on--questions the staff poses or questions girls have? What in my own life makes math and science different from other subjects and are these factors also preventing the girls we are serving from doing math or science or technology, or what is the block? Staff answered girls' questions with questions and found it was easier for some of them than for others to appear not to know the answers. They found that there are techniques to be learned in being a co-learner with girls--it takes practice and confidence to answer questions with questions and to guide self-discovery. So the Operation SMART collaborative, already work-

ing with many organizations to enhance the math and science experience of girls in the model Clubs, redoubled the attention to linkages that could help them go beyond hands-on activities and cooperative learning to an inquiry approach. They sought allies and materials that went to the most fundamental assumptions about who should be in charge of learning and what should be learned, as a critical aspect of sustaining girls' interest and participation in math and science.

Linkages. Since few youth organizations begin with trained scientists or science educators on their staff, linking with other organizations is vital to their offering math and science programs of high quality. In the survey of 55 Girls Clubs few claimed to be working directly with schools in developing their math or science programs and yet teachers were everywhere in Girls Clubs--on the staff and board, as volunteer program staff, as interested parents and as advisors. Most of the Clubs with well developed, especially intentional, programs had connections with universities and colleges, science museums and nature centers, businesses and labor unions, or other sources of expertise (Nicholson and Crenshaw, 1986).

By the time Operation SMART was officially launched, the Girls Clubs of America National Resource Center library had gathered many of the excellent materials including program activity books developed by other organizations. The collection was expanded rapidly as national Operation SMART staff and staff in model Clubs sought assistance in what the appropriate content for math and science activities might be in Girls Clubs. AAAS Science Resources for Schools, materials from the American Chemical Society and from the Young Astronauts program, and anything on bubbles were immediately useful. The EQUALS materials including Math for Girls and Other Problem Solvers were an instant hit in Clubs. Perhaps even more significant is that the first meeting of the Operation SMART collaborative included training by EQUALS personnel. Indeed the combination of excellent materials and training by the developers of the materials has been a boon to rapid implementation of high quality programs through EQUALS, Children's Television Workshop on 3-2-1 Contact, The Math/Science Network on Expanding Your Horizons Conferences, and the Boston Museum of Science through the ASTC connection, to name only a few.

Linkages have been important to the expansion and quality of Operation SMART in a third way, in addition to local connections and as a source of content for activities and training in how to work with girls in math and science. The national linkages begun with National Resource Center Associates and an Advisory Committee to Operation SMART have been multiplied through our position as one of the AAAS community-based organizations in their Linkages project. Funders such as the Ford Foundation, Carnegie Corporation of New York, the National Science Foundation, General Electric and IBM have all made additional linkages both attractive and possible.

It is impossible to estimate the value of being an "insider" organization when setting about the development of innovative programs to meet girls' needs. The benefits include knowing about research before it is published, bringing the wisdom and enthusiasm of experts of all types to bear on practial problems of program design and implementation, and meeting with the directors of other projects to advance one's own thinking by light-years. At GCA we have worked hard to be worthy insiders and to extend the linkages outward to others who can benefit. Mostly we have been the beneficiaries of linkages with the finite but cordial, committed and increasing numbers of people and organizations dedicated to a more equitable world of math, science and technology in the future.

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