DOCUMENT RESUME

ED 410 106 SE 060 478

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TITLE Connecting Adolescent Girls of Color and Math/Science Interventions.
PUB DATE Mar 97
NOTE 13p.; Paper presented at the Annual Meeting of the Association for Supervision and Curriculum Development (Baltimore, MD, March 22-25, 1997).
PUB TYPE Reports - Research (143)
EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Black Students; Career Exploration; *Females; Hispanic Americans; Intervention; *Mentors; *Minority Groups; *Partnerships in Education; *Science Programs; *Scientists; Secondary Education
IDENTIFIERS African Americans; Hispanic American Students; People of Color

ABSTRACT

This paper describes a study of Project SPLASH!, a program for minority adolescent girls with high potential in mathematics and science. This paper aims to contribute to the knowledge base on characteristics of program interventions which may increase the representation of women and minorities in the fields of mathematics and science. Findings on student and parent perceptions regarding the goals of the program, gender issues, causal attribution, self-esteem, and motivation are shared. Goals shift as girls are mentored by practicing scientists. Students reveal preferences for co-educational programs, active learning, outdoor education, and no formal grading in comparison to more relational components of this program. Ethnic self-esteem data suggests higher self-esteem among African American than Hispanic participants. Issues of socialization such as matched gender and ethnic role models are minimized by the participants. Contains 25 references. (DDR)

Connecting Adolescent Girls of Color and Math/Science Interventions

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abstract

This paper describes a study of Project SPLASH!, a program for minority adolescent girls with high potential in mathematics and science. Findings on student and parent perceptions regarding the goals of the program, gender issues, causal attribution, self-esteem, and motivation are shared. Goals shift as girls are mentored by practicing scientists. Students reveal preferences for co-educational programs, active learning, outdoor education, and no formal grading in comparison to more relational components of the program. Causal attribution reflects an emphasis on effort. Ethnic self-esteem data suggests higher self-esteem among African-American than Hispanic participants. Issues of socialization such as matched gender and ethnic role models are minimized by the participants. The intent of this paper is to add to the knowledge base on characteristics of program interventions which may increase the representation of women and minorities in the fields of mathematics and science.

Connecting Adolescent Girls of Color and Math/Science Interventions

Wondering "why?" is a universal human characteristic which undergirds all inquiry. We see an effect and we ponder the cause. The particular effect that motivated the National Science Foundation (NSF) to fund two programs that will be described here is the significant underrepresentation of women and specific minorities in science. Currently, 45% of the workforce within the United States is female, yet only 16% of employed scientists are women (Appler & Gibbons, 1993). In 1984, non-Asian minorities (African Americans, Latinos and Native Americans) represented 20% of the total population within the United States yet less than 7% were employed in science-, mathematics-, and technology-related careers (Weis, 1988). According to a NSF 1992 status update only 3% of all scientists and engineers in the United States are black and only 2% are Hispanic. There is a lack of reliable data on Native American participation in these professions, but it appears that they too are underrepresented.

Studies to explain the underrepresentation are varied and complex. Some have focused on biologically-based differences, others on issues related more to learning environment and socialization. Currently however, neither the biological nor the environmental rationale has unequivocal evidence to support the achievement disparities (Oakes, 1990). A recent synthesis of research on gender differences conducted since the 1970s reveals that differences in abilities in science and mathematics have dwindled over the past 20 years as to be almost non-existent (Linn & Hyde, 1989). This is a very significant and hope-filled finding because it suggests that even if cognitive ability differences may exist between boys and girls, these abilities may be alterable. In other words, interventions can be constructed to overcome differences because cognitive abilities can be learned (Sternberg, 1983) and both girls and minority groups can acquire skills to offset differences (Ginsburg and Russell, 1981).

This paper describes a study of Project SPLASH!, an early intervention program for adolescent minority girls with high potential in mathematics and science. Findings include student and parent perceptions regarding the goals of the program, gender issues, causal attribution, self-esteem, and motivation. The project description and findings are shared in an effort to add to the knowledge base on math/science program interventions for minority adolescent girls.

PROJECT DESCRIPTION

Project SPLASH! was collaboratively developed under the leadership of Sr. Kathleen Sullivan, a Professor of Mathematics at Seattle University and Peter Alexander, the Mathematics Department Chair at Heritage College on the Yakima Indian Reservation in Central Washington. The summer component of the program serves minority girls with high potential for scientific careers who are about to enter eighth grade. Students spend 3 weeks carrying out a variety of mathematics and science activities related to the theme of water and wave activity at the respective campuses followed by a week-long joint camp experience. They learn to gather data and to interpret and communicate the results of their experiments using wordprocessing, spreadsheets, graphing, calculators and e-mail. The girls work on active learning team projects with

practicing scientists. For example, Boeing engineers developed a 7-foot model wind tunnel and a balance to illustrate the principles involved in testing air foils at the Boeing facility. Students carried out experiments on styrofoam air foils with different camber and varying the angles of attack. A field trip to Boeing contextualized the learning.

The Science for Young Leaders Project, funded by NSF's Model Projects for Women and Girls Program, serves the Seattle University SPLASH participants by strengthening the academic year component of SPLASH! Each girl works in a team on an in-depth, hands-on science project mentored by a professional scientist and a Seattle University mentor. One group constructed a model sailboat and figured out the best angle to sail the boat "up-wind" in a channel in a university water lab with a fan for wind! A geophysicist took another group into the mountains to collect data on snow avalanches. They later fed this information into a U.S. Forestry computer program. These projects were shared with fellow campers, parents and teachers at a science celebration in the spring.

METHODS

The participants in Project Splash included 27 adolescent girls who live in or near Seattle and attended the Seattle University program and 19 adolescent girls who live in Central Washington and attended the program at Heritage College. Fourteen of the participants are Hispanic, 13 are African American, 9 are Multi-ethnic, 4 are Native American, and 5 are Pacific Islander. The girls are selected from a pool of applicants based on their interest and ability in mathematics and science.

Student surveys were conducted at the beginning and at the end of the 4 week summer component for all SPLASH participants (n=46). An additional student survey was administered at the spring science celebration for the Seattle University SPLASH participants (n=27). In addition, the girls were asked to respond to 4 open-ended journal questions. Parent surveys for the Seattle University participants were conducted at the end of the summer program (n=19) and following the spring science celebration (n=22). The study is limited by the size of the sample.

Questions addressed by the study include:

- Which goals of the project are most valued by the participants?
- What perceptions exist related to gender and racial factors?
- To what do the girls attribute their success?
- What level of self-confidence and self-esteem exists?
- What program characteristics are motivational?

PROJECT FINDINGS AND DISCUSSION

As the girls increased their academic learning by participation in the projects, the project leaders and evaluators gained insights on how to assist adolescent girls of color more effectively. Findings related to the goals of the program, gender issues, causal attribution, self-esteem and motivation are identified here and discussed in relation to some of the relevant literature on these topics.

Goals of the Program

At the beginning and end of the SPLASH program, students (n=46) were asked to identify their top 3 goals from the list of 10 project goals presented in Table 1.

Table 1. The Common Goals of SPLASH! and The Science for Young Leaders Project

- To increase the participants' knowledge of science and mathematics;
- To build the participants' self-confidence in a way that will allow them to consider future careers in science;
- To provide them with accurate information about the required academic preparation;
- To introduce the participants to the culture and methods of science;
- To encourage participants to interact formally and informally with scientists;
- To build a peer group interested in science;
- To develop skills in teamwork, group leadership, and project management;
- To introduce participants' families to the possibilities and benefits that scientific careers offer; and
- To test and disseminate a participatory, team-driven project-focused education model.
- To strengthen eighth-grade girls' ability to describe scientific findings in writing and in formal presentations to peers and adults.

A majority of participants initially selected two goals: 1) to increase knowledge of science and mathematics (80%); and 2) to gain skills in teamwork, group leadership, and project management (62%). The third highest student priority at the beginning of the project was developing self-confidence to consider a career in science (28%). By the end of the program, increasing knowledge (75%) and gaining skills In teamwork, group leadership, and project management (44%) remained in the top 3 priorities. However, an interesting shift occurred. The goal of being exposed to the culture and methods of science that had ranked in the lower quartile (24%) shared a 2nd. place priority (44%); and the ability to describe scientific findings (32%) ranked above the goal of developing self-confidence (28%). One explanation for the shift may be that students need to be exposed to the culture and methods of science and the opportunity to describe scientific findings before a true appreciation for these goals can be developed. Based upon experiences with earlier intervention projects, the directors placed a good deal of emphasis on having the students communicate the results of their scientific discoveries. The young women made presentations, produced video and artwork, and put together a newsletter for their parents, as well as a yearbook that described all the projects of the academic year teams.

Another interesting finding surfaced when student (n=27) and parent (N=19) perspectives were compared at the end of the summer program. Similar to the students, a majority of parents identified the goals of increasing knowledge (63%) and gaining skills in teamwork, group leadership, and project management (53%) within their 3 highest priorities. However, 58% of the parents selected the goal of developing self-confidence to consider a career in science, in contrast to 28% of the girls. In addition, only 21% of

parents selected exposure to the culture and methods of science, which was ranked in the top 3 by 44% of the girls. It may be that parents are more sensitive to how much confidence it takes to achieve career goals in science. It may also be that parents underestimate the impact of exposure to the culture and methods of science as a motivational factor. The staff of SPLASH feels that much of this appreciation for the culture of science owes a great deal to the bonds that the young women formed with professional mentors who became their friends and models. The designers of the program consider time spent working on projects with practicing scientists to be the most effective form of career education for students this age.

At the end of the summer program, parents were asked to evaluate whether student goals had been achieved. Their responses are reported in Table 2.

Table 2: Parent Evaluation of SPLASH Goals Achievement (n=19)

	Yes	No	Undecided
Knowledge in math/science increased	100%		
Self-confidence to consider a career increased	68%	26%	5%
Information given about m/s academic preparation	79%		21%
Exposure to culture/methods of science	79%		21%
Interaction with scientists occurred	79%		21%
Skills in teamwork, leadership,and projects gained	84%	5%	11%
Families introduced to scientific careers	52%	32%	16%
Participation in NSF model program occurred	84%		16%
Ability to describe findings increased	68%	11%	21
SPLASH was a satisfying experience	89%		11%

Although the goal achievement of introducing families to scientific careers was affirmed by only 52% of the parents at the end of the summer, a parent survey (n=22) following the Science Celebration Fair in the spring revealed that 100% of the parents agreed that families had been introduced to the benefits and opportunities that scientific careers have to offer. Ninety-one percent affirmed that their daughter's confidence and interest in math/science as a career option had increased over the year.

Gender Issues

Specific gender differential abilities in math and science have drawn considerable research attention. According to Sadker, Sadker, & Klein (1991), no significant differences between males and females exist before the age of ten. Early differences emerging in upper elementary favor females. Mixed results exist in the middle school years with differences favoring males emerging by secondary school. However, meta-analytical research has also demonstrated that sex-differences in quantitative abilities and science achievement have declined relatively quickly. In math they are reduced to insignificant levels. The most specific study finds that females are more able in mathematical computation at all ages, however; differences favoring males in problem solving are present in high school. Gender differences in favor of males are greater in science knowledge than in scientific processes and these differences appear related to differences in learning opportunities (Linn & Hide, 1989).

Math/science interventions for girls often propose a "girls only" program. Assumptions supporting this proposal relate to the fear that boys tend to dominate the interaction or girls may self-censor (Sadker & Sadker, 1994). However, The Young Leaders Project participants (n=27) communicated a preference for having a co-educational program. When asked if they prefer to work with boys and girls in academic settings, 56% said yes, 8% said they prefer to work with girls only, and 36% said it doesn't matter. It would seem that their preference for co-educational academic learning relates to factors beyond male interest in math/science since 64% reported that the boys in their classes in middle school are less interested in math/science than they are. Sixty-seven percent said other girls in their classes have the same interest as they do in math/science.

Causal Attribution

Since biological differences are insufficient in determining the cause of underrepresentation of women in mathematics and science, attention is drawn to studies that link women's attitudes toward achievement. Theorists suggest that women and minorities may limit their participation in these fields because they do not have high expectations for success (Oakes, 1990).

Research first established a difference in the way males and females approached problems in the 1970's. Females have been reported as exhibiting a greater propensity for learned helplessness than males. Concurrent studies investigated gender differences in causal attributions of success and failure. Boys were found more likely to attribute success to ability and failure to lack of effort, while girls more frequently attribute success to luck or effort and failure to lack of ability. Girls demonstrate a greater frequency of learned helplessness attribution pattern for mathematics than boys (Ryckman & Peckham, 1987).

In the SPLASH Project girls (and parents) were asked to identify the most significant reason why they (or their daughter) were selected as a participant in the program. Consistent with other studies (Oakes, 1990), these girls and their parents chose options related to effort rather than intelligence. See Table 3.

Table 3: Perceptions as to Why Girls Were Chosen for the Projects

Girls Perceptions (n=46)			Parent Perceptions (n=19)	
12	27%	Hardworking	6	32%
14	30%	Intelligent in M/S	5	26%
2	4%	Fortunate	0	0%
20	43%	Able to Handle Tasks	9	47%

note: 2 girls and 1 parent selected more than one response

When the Young Leadership Project participants were given an opportunity to describe themselves in a journal format, only 7 (n=24) made a reference to being intelligent or smart; whereas 17 (71%) made a relational reference (e.g., caring, friendly, kind, nice). Yet 80% of the girls and 79% of their parents selected 'smart' among other characteristics when provided with a checklist of 10 descriptive traits. Further study is needed to discern reasons

for this contrast in responses. Researchers are only beginning to hypothesize that differential attributions may be individually and/or situationally specific.

Confidence and Self-esteem

Central to the psychosocial development that occurs during the middle school years is the establishment of a sense of identity (Erikson, 1968). During preadolescence and adolescence, students are increasingly involved in asking: "Who am I?". To answer, they engage in an ongoing evaluation and analysis of self based on an assessment of individual ability and achievement.

The AAUW report,*Shortchanging Girls, Shortchanging America* (Greenberg-Lake,1990), clearly established the significant loss of self-esteem that both boys and girls experience during the middle school years. According to the AAUW national study of 3000 children between the ages 9 and 15, boys' self-esteem dropped 21% while girls' self-esteem dropped 31%. The interaction between race and self-esteem were documented as well. According to the study, African-American girls expressed high self esteem in elementary school and retained it through high school, although positive feelings about school work and teachers declined. The personal self-esteem of Hispanic girls plummeted with a record drop of 38 points.

The decline in self-esteem for females and the differences in experience for females are clearly present in the study of math and science. According to Greenberg-Lake (1990), females' enthusiasm for math as well as their self-perceptions of math capabilities decline precipitously over time, from 31% who believe they are "good at math" in elementary school to 15% who view themselves this way by high school. In addition, males and females interpret their difficulties with math and science differently in ways that are consistent with causal attribution theory. Boys who dislike math in later years do so because they see the subject as unuseful. Girls view their problems in the subject as a personal failure. In other words, boys preserve self-esteem despite lack of achievement and participation; whereas, girls decline in self-esteem. In science, a similar pattern emerges as girls grow into adolescence.

The majority of SPLASH program participants (n=46) rate their level of self-confidence as average (33%) or high (35%) in most settings. Thirty-three percent say their confidence varies depending on the setting. Analysis by race reflects a pattern consistent with the AAUW findings. Forty-six percent of the African-American girls (n=13) indicated high self-esteem in most settings, in contrast with 29 % of the Hispanic girls (n=14). Only 15% of the African Americans say their self-esteem varies depending on the setting in contrast to 64% of the Hispanic participants. When asked to identify words that described them, 50% of the African Americans compared to 36% of the Hispanics chose "proud". Seventy-five percent of the African Americans compared to 50% of the Hispanics indicated that they are leaders.

Motivation

Motivational factors are critical determinants of whether or not girls and/or minorities pursue the study of math and science and consider career opportunities in those fields. Social learning theory suggests that motivation requires both a high expectation for being able to accomplish the goal and a high value for what is being learned. If either of these factors is missing, motivation will be minimal. Consequently, interest levels, perceptions of the utility of the subject matter, and the influence of significant adults have received much attention by researchers in an effort to find the locus of girls'

and minorities' desire to explore math and science and their success in doing so.

Interest Levels

Noddings (1988) analyzed instructional arrangements, such as small group work and extended interactions between students and teacher, to enhance relational learning styles. Other theorists have focused on the conflicts between typically masculine images of scientists and girls' conceptions of a feminine identity, the concern that academic success undermines popularity with males, and the effect of declining self-esteem on classroom behaviors.

The SPLASH participants were selected based on evidence of their interest and ability in mathematics and science and the program was designed to be "girl-friendly". At the end of the summer, the girls and their parents were asked to evaluate areas of the program that were motivational. See Table 4.

Table 4: Perceptions of areas of the program that were motivational

Girls Perceptions (N=45)		Parent Perceptions (N=19)
40%	Cooperative vs. Competitive	58%
12%	Girls vs. Mixed Gender Grouping	21%
48%	Racially Diverse Peer Group	37%
68%	Active Learning Projects	89%
60%	Outdoor Activities	58%
64%	No Formal Grading	11%
48%	Small Group Learning with Friends	47%

It is interesting to note that program areas which are often considered to be most relational were selected as motivational by less than half of the girls. Small group learning with friends was selected by 48%. Cooperative vs. competitive was selected by 40%. Only 12% indicated that the girls vs. mixed gender program component was a motivational factor. In contrast, program areas that are stereotypically associated with boys (active learning at 68% and outdoor activities at 60%) were highly valued. Another interesting finding occurs as the girls' and parents' ratings of "no formal grading" are compared. The girls identified this area as the 2nd highest motivational factor (64%) in contrast to parental perception (11%). One of the most enthusiastic and hardworking students may have spoken for many of the others when she expressed her appreciation for "not needing to worry about messing up." This data suggests that parents clearly underestimate the value of ungraded learning as a motivational factor for their daughters.

Utility of the Subject Matter

Pervasive sex and race stereotyping of math and science contribute to negative perceptions of the utility of math and science for girls and minorities (Clewell, Anderson, Thorpe, 1992; MacCorquodale, 1984). Media and textbook representations employed in the math and science fields perpetuate stereotypes of math and science as "white male activities" (Clewell, et al., 1992). Occupational sex stereotyping has been recognized by researchers as a

significant factor in girls' perceptions of their career opportunities (Farmer, 1985).

The Young Leaders Project students (n=27) were asked to respond to the open-ended question: "In my opinion, there are fewer females in the career areas of math and science because...". Their responses highlighted limitations of opportunity (52%), interest (22%), encouragement (15%), education (7%) and ability (4%). The perception that opportunities are limited may affect the expectation factor in the [expectation x value = motivation] equation.

Although SPLASH participants acknowledge that math and science careers are dominated by males, 67% indicate that girls in their classes at school are as interested in math and science as they are. Only 15% of the participants believe that the boys in their classrooms are as interested as they are in math and science. Boys are rated as less interested in math and science by 64% of the participants.

Role Models

The use of role models to motivate students and increase identification with subject matter and/or career opportunities is an established practice in programs designed to promote achievement in the fields of math and science for female and minority students (Clewell, Anderson & Thorpe, 1992). Given girls' and minority students' negative perceptions of the utility of math and science, the encouragement and support of significant adults is a particularly important motivational factor (Oakes, 1990).

Johnson & Prom-Jackson's study (1986) of a group of predominantly low-income, minority students selected to receive scholarships to college preparatory high schools revealed that one significant predictor of enrollment in advanced math and science courses was an influential math and science teacher. In their study of the role model effect on middle school age boys and girls, Smith and Erb (1986) found that the use of women science career role models could have positive effects on both boys and girls attitudes towards women in science.

While research demonstrates that role models can change motivational attitudes, particularly with girls and minorities, there is not conclusive evidence to suggest that they are more effective when matched to the gender and ethnicity of those they encounter. In Clewell, Anderson and Thorpe's extensive review of successful math and science programs for girls and minorities, they found that many of the staff did share the same ethnic backgrounds of the participants, but no compelling evidence exists to support a conclusion that this significantly contributed to the program's success.

Similar to other findings, the Young Leaders Project participants (n=27) seem to indicate that they regard gender and race as relatively unimportant in teachers and peers. When responding to the statement "It is important to me to have teachers of the same ethnic background as myself, 20% agreed, 20% disagreed, and 60% said it doesn't matter at all. When responding to "It is important to me to have teachers who are women", 32% agreed, 12% disagreed, and 56% said it doesn't matter at all. One student may have revealed a common interpretation of questions regarding the gender and ethnicity of teachers. When asked if the ethnic and racial diversity of the SPLASH staff was acceptable or unacceptable, she checked acceptable and then added the comment: "I liked you all". Checking unacceptable may have seemed like an act of disloyalty toward a valued teacher. When SPLASH participants were asked if they prefer to work with all girls in academic settings, only 8% said yes in contrast to 56% who prefer to work with both boys and girls, and 36% who say it doesn't matter. No student indicated that they prefer to work in academic settings or spend time in social settings exclusively with members of their same sex or same ethnic group. The majority said it doesn't matter in each area. These responses indicate that the degree to which the formation of gender, ethnic identity, and future career identity inform each other is a question for further research.

Conclusion

Goal 4 of the National Education Goals established at the National Governors Association in 1990 says that "By the year 2000, U.S. students will be first in the world in science and mathematics achievement". The achievement of all U.S. children is of considerable importance to those who are concerned with competing in a global marketplace. For others, equity of opportunity to develop excellence is a compelling issue of justice rather than successful competition. Clearly, equal representation of gender and racial groups within mathematic and science careers will be difficult to achieve within this decade.

However, projects like SPLASH and Science for Young Leaders are opening important doors for very talented young women.

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SE060478

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Date: 6/23/97

Annual Conference and Exhibit of the Association for Supervision and Curriculum Development "LEADING THE VISION: CONNECTING WORLD COMMUNITIES OF LEARNERS" (Mar 22-25, 1997

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