DOCUMENT RESUME

ED 472 915 SE 067 307

AUTHOR Ferreira, Maria M.
TITLE The Effects of an After-School Science Program on Middle School Female Students' Attitudes towards Science, Mathematics and Engineering.
PUB DATE 2001-06-00
NOTE 20p.; In: Proceedings of the Annual Meeting of the Association for the Education of Teachers in Science (Costa Mesa, CA, January 18-21, 2001). For full proceedings, see ED 453 083.
PUB TYPE Reports - Research (143)
EDRS PRICE EDRS Price MF01/PC Plus Postage.
DESCRIPTORS *Student Attitudes; *Curriculum Development; Engineering Education; *Equal Education; Group Activities; Hands on Science; Mathematics Education; Mentors; Middle Schools; *Minority Groups; Role Playing; Science Instruction; Sex Differences

ABSTRACT

This study examined the impact of an after-school science program that incorporated cooperative learning, hands-on activities, mentoring, and role models on a group of minority female students' attitudes toward science, engineering, and mathematics. Eighteen African American middle school students participated in the study. Seven female engineers implemented the program and served as role models and mentors. The curriculum focused on topics related to the automotive industry and consisted of electricity, magnetism, gears, motors, freezing and antifreezing, friction, speed and acceleration, and center of mass and gravity. Each of these topics was explored through a variety of hands-on group activities with one mentor. Results indicate the program had a positive influence on students' attitudes toward science, mathematics, and engineering. (KHR)

The Effects of an After-School-Science Program on Middle School Female Students' Attitudes toward Science, Mathematics and Engineering

[Maria M. Ferreira]

THE EFFECTS OF AN AFTER-SCHOOL SCIENCE PROGRAM ON MIDDLE SCHOOL FEMALE STUDENTS' ATTITUDES TOWAR SCIENCE, MATHEMATICS AND ENGINEERING

Maria M. Ferreira, Wayne State University

Despite the gains of the last twenty years in the representation of women in scientific fields, their numbers still lag behind their male counterparts. In 1998 women received 13.0% of the Ph.Ds. in engineering, 23.7% in the physical sciences, and 45.5% in the life sciences (National Research Council, 1999). However, this difference increased when the data were desegregated by citizenship. In 1998 Women of American Citizenship earned only 6.2% of the Ph.Ds. in engineering, 12.6% in the physical sciences, and 30.6% in the life sciences.

Although the NRC report did not provide data on the number of Ph.Ds. in science and engineering awarded to minority females, African Americans, Hispanics, and Native Americans combined (female and male) received only 3.2% of the Ph.Ds. in engineering, 3.0% in the physical sciences, and 4.7% in the life sciences. In view of these figures, much talent is being lost which could contribute to the advancement of science and engineering in the U.S. (AAUW, 1992; National Commission on Excellence in Education, 1983).

Theoretical Framework

Researchers have found that until third grade an equal number of boys and girls show interest and feel confident in learning science. By fourth grade, 74% of the girls and 81% of the boys say they like science. These numbers continue to decrease throughout middle school and by eighth grade 64% of the girls compared to 72% of the boys say they like science. By their senior year in high school, only 57% of the girls compared to 74% of the boys show interest in science

(Jones, Mullis, Raizen, Weiss, & Weston, 1992).

Investigators have developed various explanations for the significant decrease in girls' interest in science through their school years. Feminist scholars (Harding, 1986; Keller, 1992; Kelly, 1985; Kleinman, 1998; Salner 1985) postulate that the "male" characteristics of science as currently practiced make its pursuit by girls unattractive. According to Kelly (1985), the portrayal of science as masculine affects a child's gender identification. She contends that science as an intellectual domain is perceived as masculine and that this perception discourages girls from expressing interest in science, from doing well in science, and from continuing to study science.

Others have investigated the role that the family (Huston, 1983; Matyas, 1985; Oakes, 1990; Tracy, 1987) and school (Kahle, Andersen, & Damnjanovic, 1991; Oakes, 1990; Roth, 1996; Shepardson & Pizzini, 1992) play in the socialization of children into gender specific roles. Parents tend to buy more scientific games for boys than for girls, and boys are more likely to play with toys that encourage manipulation, or construction (Oaks, 1990; Tracy, 1987). According to Matyas (1985), boys' toys and games "tend to emphasize relationships between objects, manipulation of objects in space, grouping, and taking apart and rebuilding of objects" (p. 37). These different opportunities for manipulating objects through childhood play appear to be directly related to spatial ability of boys and girls (Matyas, 1985).

Teachers and the classroom environment also contribute to gender socialization (Kahle, Andersen, & Damnjanovic, 1991; Oakes, 1990; Roth, 1996; Shakeshaft, 1995). Although surveys of teacher responses suggest that they hold similar expectations for the success of both boys and girls in science, actual classroom observations uncover differential teacher expectations for boys and girls in science classes starting in elementary school (Kahle, Andersen, &

Damnjanovic, 1991). Boys tend to be encouraged to try again when they fail at something while girls are allowed to give up (Oakes, 1990). In addition, teachers in science classes tend to call on boys more often than on girls, and the questions they ask boys are usually more challenging than those asked of girls (Roth, 1996; Sadker & Sadker, 1986). Teacher questioning is a very important aspect of student learning and is a good indication of the quality of teaching. Good questions focus students' attention and help develop their critical thinking skills by making them express their own ideas, face their own misconceptions, and question evidence (Roth, 1996).

In studies investigating student science experiences, boys report a greater number of actual classroom science experiences and participate in more extracurricular science activities (Kahle, Matyas, & Cho, 1985). Girls have fewer opportunities to experiment, handle less science equipment, and participate less in science-related experiences (Kahle, 1990). These researchers found that boys' greater familiarity with science was related to their greater interest in science-related careers.

Research indicates a strong correlation between attitude towards science and achievement in science (Cannon & Simpson, 1983; Schibeci & Riley, 1986; Weinburgh, 1995). A meta-analysis of the research conducted between 1970 and 1991 indicates that "in all cases a positive attitude results in higher achievement" (Weinburgh, 1995, p.387), and is greatest for low-performance female students. In addition, attitudes toward science predict student selection of future science courses (Farenga & Joyce, 1998) and affect students' aspirations to science careers (Catsambis, 1995). As a result, educators are pressed to find educational strategies that help improve students' attitudes towards science. Some approaches have been successful in developing students' interest in science (particularly females'). Some of these pedagogic approaches include cooperative groups, hands-on activities, role models, and mentors.

Purpose

The purpose of this study was to examine the impact of an after-school science program, which incorporated cooperative learning, hands-on activities, mentoring, and role models on a group of minority female students' attitudes toward science, engineering and mathematics.

Method

Funding

The program was founded by a small grant from the ExxonMobil Education Foundation in collaboration with the Society of Women Engineers. The grant covered the cost of the curriculum development and a part-time program coordinator. One of the local automotive companies covered additional expenses related to supplies, food, and transportation associated with field trips.

Setting and Participants

The program was implemented in a small, urban middle school. The participants were 18 African American, middle school (7^{th} and 8^{th} grades), female students and a group of 7 volunteer, female engineers (5 of them African American) who implemented the program and served as role models and mentors. Each of the mentors worked with a group of 3 students. The mentors were recruited through the local chapter of the Society of Women Engineers.

The biweekly sessions took place from 4:30 to 6:00 P.M. from September 1999 through April 2000 in the classroom of the mathematics teacher. In addition to facilitating the implementation of the program, the mathematics teacher recruited the students and served as the liaison between the implementers of the program and the school's administrators, and students' parents.

Curriculum

The curriculum focused on topics related to the automotive industry and consisted of the following units: Electricity, Magnetism, Gears, Motors, Freezing and Antifreezing, Friction, Speed and Acceleration, and Center of Mass and Gravity. Each of these topics was explored through a variety of hands-on/minds-on activities.

During the activities in these topics, the students made observations, inferences, and predictions, tested their predictions through experimentation, collected data, and built and tested models of car parts. For example, in the "gears" unit, the students started by brainstorming about the concept of "gears" - what they were, examples of items that used gears, and so on. Then the students tested two gears of the same size (a driver and a follower) to determine the direction of the follower in relation to the driver. In the following activities the students added other same size gears and tried to deduct a rule for the direction of the follower gear. Next the students tested combinations of different size gears, while trying to predict the outcome of the different combinations. At the end of this unit, the students were asked to design a toy that used gears.

The students worked in groups of three with one of the mentors as the facilitator. The role of the mentor was to foster discussion among the students, to ensure that all the students in the group participated, and guide them when they had difficulties with some aspect of the activities. In addition, each of the mentors did a demonstration related to their area of expertise. For example, one of the mentors did a demonstration on airbags. This approach helped students observe how a particular concept was applied in the automotive industry, and allowed them to see a female role model in the position of "expert" in her field.

In addition to the after-school sessions, the program included field trips to some of the local automotive engineering plants and museums connected to the automotive industry. During these trips the students had the opportunity to see how some of the concepts that they had explored through the activities were applied in the design and manufacturing of automobiles.

Evaluation of the Program

According to the director of the program, the main purpose of the program was to foster the girls' interest in science and engineering. Consequently, it was agreed that the evaluation of the program should address only attitudinal change, and not content retention.

To this end, a pre and post-test instrument (4-point Likert-type survey) was developed to measure changes in: (1) students' attitudes towards math, science, and engineering; (2) their misconceptions concerning gender specific careers in science and engineering; and (3) their intentions to pursue a career in science or engineering. The participants were asked to rate each survey item from "strongly agree" (value of 4) to "strongly disagree" (value of 1).

Descriptive statistics were used to identify changes in students' attitudes in the aforementioned areas. Statistical significance was not computed due to the low (N), which made such analysis inadequate. (Of the 18 students who initially joined the program, only 14 completed it). Data were also collected through open-ended interviews with the students and mentors regarding various aspects of the program. These data were analyzed using qualitative methodologies (LeCompte and Preissle, 1993).

Results and Discussion

For each survey item the means and the percentage of students who agreed with each statement were computed for the pre- and post-test. As results in Table 1 indicate, the program had a positive influence on students' attitudes toward science, mathematics and engineering. Although analyses of variance were not conducted because of the small number of participants (N), the scores on the post-test were higher than those in the pre-test for a number of selected items.

Table 1

Mean and Percentage of Students Agreeing with Selected Items on the Pre- and Post-test

Survey Statement	Average Pre	Average Post	% Agree (Pre)	% Agree (Post)
I like science	2.82	3.00	76.5	85.7
Science is easy for me	2.65	2.86	58.8	78.5
I think science is fun	3.12	3.21	76.5	85.7
Most scientists are men	1.71	1.54	16.8	11.4
Anyone can be a scientist	2.88	3.00	75.7	85.7
I would like to be an engineer some day	2.41	2.86	52.9	78.6
I would like to design the car of the future	2.90	3.00	76.5	85.6
I might study engineering in college	2.82	3.00	76.5	85.7
I like math	3.12	3.89	82.4	92.9
Math is very important for most jobs	3.89	3.93	96.7	100.0

Without good math skills one can not become a scientist or engineer.	2.94	3.29	76.5	78.6
Items on the Post-test Only				
I enjoyed the after school science program		3.50		100.0
I would recommend the program to other girls		3.57		100.0
I liked to work with a mentor		2.93		71.4
Some day I would like to mentor young women		3.43		92.9

All the students also agreed that they enjoyed the program, that they would participate again in a similar program, and that they would recommend the program to other girls. In addition, when asked "What did you enjoy most in the after school program?" all the girls answered the hands-on activities and field trips. One of them responded, "I enjoyed building models, car parts, and paper works." Another one added "Doing activities because they were very educational and fun." Still another answered, "when we went on field trips we had a lot of fun and we got to meet new people." These responses were common among the students' comments. The response of one of the girls, however, reflected a greater awareness about some of the gender issues that the program was trying to address. She pointed out that she had "liked when we made things, because it just goes to show you girls can do the same as boys."

These results confirm previous ones in which increased experiences with science such as performing experiments lead to positive attitudes toward science classes and science related careers (Bartsch, Snow, & Bell, 1998; Lee-Pearce, Plowman, & Touchstone, 1998; Travis, 1993). Hands-on activities have shown to significantly increase student learning in science, mathematics, and writing (Sutman, Bruce, May, McConaghy, & Nolt, 1997). Hands-on activities have also shown to increase student problem-solving skills, self-confidence, and improve their attitudes toward science and science related careers (Bartsch, Snow, & Bell, 1998; Lee-Pearce, Plowman, & Touchstone, 1998; Tyler-Wood, Cass, & Potter, 1997).

Feedback from the students' mathematics teacher also indicated that the program positively influenced the students in other ways. According to the teacher the attitude of some students had improved since the onset of the program. She mentioned particular students whose participation in mathematics class has increased. According to her, these students "participate in class and encourage others to participate. They talk to me openly and freely about their problems with math, other students, and 'life'." She made reference to specific students whose past behavior in class had been disrupting. According to her, "they have stopped their rude outbursts in class."

The positive impact of the program on students' attitudes toward mathematics might have been due, in part, to the teacher's involvement in the program. The after-school sessions took place in the mathematics teacher's classroom. She played an active role in the implementation of the program and was present at every session. Thus, the students had the opportunity to view their mathematics teacher and develop a relationship with her outside the constraints of the regular mathematics class. Furthermore, because most of the science activities involved mathematics, students had the opportunity of experiencing mathematics in the context of its applications in science and engineering (Lee-Pearce, Plowman, & Touchstone, 1998; Rohrer & Welsch, 1998). For example, when studying the concepts of velocity and acceleration, the students had to compute the velocity and acceleration using a model vehicle.

Impact of the Program on the Mentors

Research on mentoring indicates that both mentor and protégé benefit from the relationship (Fagenson, 1989; Hall & Sandler, 1983; Healy & Welchert, 1990). The mentor serves as a role model and provides knowledge, advice, acceptance, and confirmation to the protégé (Fagenson, 1989). On the other hand, the mentor benefits from the satisfaction of making a positive impact on another person and often receives admiration, respect, and gratitude from the protégé (Hall & Sandler, 1983; Healy & Welchert, 1990).

The results of this study indicate that the mentors perceived themselves as role models and viewed their involvement in the program as an opportunity to make a positive impact on the girls' attitudes toward engineering. According to one of them the girls in her group looked up to her "as their big sister, as they often called [her]." When asked about the strengths of the program one of the mentors answered that, ". . . we really can make an impact on these girls' lives and possibly interest many of them in the sciences and engineering." Another one commented that the program "helped the girls learn the importance of team work to complete a task, especially on the final project. They seemed to stay interested in the various topics and experiments, asking a lot of good questions in our post-discussions." These comments indicate that the mentors played an important role in the socialization of the girls into the field of engineering (Fagenson, 1989; Turner & Thompson, 1993).

Some researchers contend that the lack of role models and mentors in science and engineering is a contributing factor to females' lack of interest in science and science-related careers (Matyas, 1985; Marlow & Marlow, 1996). Although research indicates that a mentor or role model does not necessarily need to be of the same race or sex as the protégé, seeing others of the same sex and/or race in positions of power and expertise helps affirm one's career aspirations (Astin & Astin, 1993; Janes, 1997; Kegel-Flom, 1995).

Conclusions and Limitations of the Program

The results of this study add to the existing body of knowledge on the impact that enrichment science programs, that employ a variety of pedagogical strategies such as cooperative learning, inquiry and mentoring, can have in narrowing the gender gap in science, mathematics, and engineering.

For instance, cooperative learning groups have shown to be particularly successful with females who tend to dislike the competitive aspects of science (Peltz, 1990). Cooperative learning has been found to facilitate student learning in science and improve their attitudes toward science (Bianchini, Holthuis, & Nielsen, 1995; Cannon & Scharmann, 1996; Chang & Mao, 1999; Kahle and Rennie, 1993).

However, even though this program's goals were commendable and it exhibited important characteristics recommend by research (hands-on activities, cooperative learning, role models, and mentors), its impact was limited by a number of shortcomings related to its implementation: Scheduling and the mentors' lack of pedagogical knowledge.

Scheduling

In order to meet the mentors' working schedule, it was decided that the sessions would take place every other week, after school, and be 1.5 hrs. long. However, after being in school for a full day, some students had difficulty committing themselves to spend an additional hour and a half in school. Although incentives such as pizza and attendance awards were used, enrollment in the program was low (18) and attendance to the program by some students was sporadic. In addition, the two-week interval between sessions limited knowledge transfer from one session to the next, particularly when students needed to apply concepts learned in previous sessions.

The amount of time allocated to each session (1.5 hrs.) was also not adequate to properly cover some of the day's science activities, which usually involved making observations, inferences, predictions, testing predictions (i.e. collecting data), and often included a presentation by one of the mentors.

Thus, programs such as this one are best implemented weekly, on Saturday's mornings, in 2.5-3.0 hrs. blocks of time. This type of scheduling facilitates content coverage and transfer, and has the potential to increase student attendance and retention.

Mentors' Pedagogical Knowledge

As previously pointed out, the program focused on science activities related to automotive engineering and was implemented by a group of women engineers. It was hoped that the combination of engineering related activities and engineer role models would have a positive impact on students' attitudes toward engineering-related careers. However, it was somewhat surprising to find that only 71.4% of the students agreed with the statement "I liked to work with the mentor" (see Table 1).

Although the mentors were practicing engineers with expertise in various areas of engineering (mechanical, chemical, electrical), some of them were not familiar with the pedagogical approaches used in the program. Their comments indicated that they had limited understanding of cooperative learning and/or inquiry and used a traditional approach of "telling" instead of guiding the students through the activities as facilitators. The traditional educational experiences that some of the mentors had experienced themselves as students might have contributed to the way in which they perceived their role in the implementation of the program. Some of them were visibly uncomfortable with the "exploratory" nature of some of the activities and had difficulty involving all the students in their group as the following comment indicates:

> The experiments in which the students were building something (circuits, the plane model, etc.) were difficult because only one person could work on the activity at a time. If I'm working with 3 students, it is hard to keep the other 2 occupied, interested and involved in the activity.

In addition, although all the mentors were given a handbook with all the activities, objectives for each, and advice on how to involve students through questioning, some of the mentors did not examine the day's activities until the beginning of the session. As a result, they were often unprepared to answer student questions and appropriately guide them through the activities.

These issues were reflected in some of the students' answers to the question "What did you enjoy least in the program?" According to one of the students, "The thing I least enjoyed about the program was that our mentor was not always there, attentive and sure of what she was doing." Another student responded, "My mentor had an attitude problem and some of the other mentors did too." Furthermore, when asked, "What things (if any) should be changed in the program?" one of the students responded, "Make sure all the mentors know what they are doing, so if we have questions they can help us."

These results indicate that to maximize the success of programs such as this one, mentors and others involved in the implementation of the program must become familiar with the pedagogical approaches used in the delivery of the program. This might require training sessions for mentors and other facilitators as well as follow-up sessions.

Lastly, the lack of data on increased student participation and achievement in science was one of the limitations of the program's evaluation. As previously pointed out, the program director was mainly interested in measuring the impact of the program on students' attitudes toward science and engineering. She felt that if achievement were part of the evaluation, the mentors might place too much emphasis on content coverage, thus discouraging some students from participating in the program.

Some researchers (Cannon & Simpson, 1983; Schibeci & Riley, 1986; Weinburgh, 1995) have found a positive relationship between student attitudes toward science and their achievement in science. Others have found that attitudes toward science predict student selection of future science courses (Farenga & Joyce, 1998), and affect students' aspirations to science careers (Catsambis, 1995). However, since data on achievement and participation were not collected, conclusions regarding the program's impact in these areas cannot be made.

References

American Association of University Women. (1992). *How schools shortchange girls.* Washington, D.C.: Author.

Astin, A. W., & Astin, H. S. (1993). *Undergraduate science education: The impact of different college environments in the educational pipeline in the sciences.* Los Angeles, CA: Higher Education Research Institute, UCLA.

Bartsch, I., Snow, E., & Bell, S. (1998). FLEDGE-ling: A science program for girls. *Journal of Women and Minorities in Science and Engineering,4*(4), 321-31.

Bianchini, J., Holthuis, N., & Nielsen, K. (1995). Cooperative learning in the untracked middle school science classroom: A study of student achievement. (ERIC Document Reproduction Service No. ED 389 515).

Cannon, J. R., & Scharmann, L. C. (1996). Influence of a cooperative early field experience on preservice elementary teachers' science self-efficacy. *Science Education, 80*(4), 419-36.

Cannon, R. K., & Simpson, R. D. (1983). Relationships among attitude, motivation, and achievement of ability-grouped, seventh-grade life science students. *Science Education, 69*(2), 121-138.

Catsambis, S. (1995). Gender, race, ethnicity, and science education in the middle grades. *Journal of Research in Science Teaching, 32*(3), 243-257.

Chang, C., & Mao, S. (1999). The effects on students' cognitive achievement when using the cooperative learning method in earth science classrooms. *School Science and Mathematics, 99*(7), 374-79.

Fagenson, E. A. (1989). The mentor advantage: Perceived career/job experiences of proteges versus non-proteges. *Journal of Organizational Behavior, 10*, 309-320.

Farenga, S. J., & Joyce, B. A. (1998). Science-related attitudes and science course selection: A study of high-ability boys and girls. *Roeper Review, 20*(4), 247-251.

Hall, R. M., & Sandler, B. R. (1983). *Academic mentoring for women students and faculty: A new look at an old way to get ahead.* Washington, D.C.: Association of American Colleges.

Harding, J. (1986). The making of a scientist. In J. Harding (Ed.), *Perspectives on gender and science* (pp. 159-167). New York: The Falner Press.

Healy, C. C., & Welchert, A. J. (1990). Mentoring relations: A definition to advance research and practice. *Educational Researcher, 19*(9), 17-21.

Huston, A. C. (1983). Sex-typing. In E. M. Hetherington (Ed.), *Handbook of child psychology, vol. 4: Socialization, personality, and social development* (pp. 387-468). New York: Wiley.

Janes, S. (1997). Experiences of African-American baccalaureate nursing students examined through the lenses of Tinto's Student Retention Theory and Astin's Student Involvemnt Theory. (ERIC Document Reproduction Service No. ED 415 817).

Jones, L. R., Mullis, I. V. S., Raizen, S. A., Weiss, I. R., & Weston, E. A. (1992). *The 1990 Science Report Card: NAEP's Assessment of Fourth, Eighth, & Twelfth Graders,* National Center for Educational Statistics, Washington, D.C.

Kahle, J. B. (1990). Real students take chemistry and physics: Gender issues. In K. Tobin. J. B. Kahle, & B.J. Fraser (Eds.), *Windows into science classrooms: Problems associated with higher-level cognitive learning* (pp.92-134). New York: Falmer.

Kahle, J. B., Anderson, A., & Damnjanovic, A. (1991). A comparison of elementary teachers attitudes and skills in teaching science in Australia and the United States. *Research in Science Education, 21,* 208-216.

Kahle, J. B., Matyas, M. L., & Cho, H. (1985). An assessment of the impact of science experiences on the career choices of male and female biology students. *Journal of Research in Science Teaching, 22*(5), 385-394.

Kahle, J. B., & Rennie, L. J. (1993). Ameliorating gender differences in attitudes about science: A cross-national study. *Journal of Science Education and Technology, 2*(1), 321-334.

Kegel-Flom, P. (1995). For girls and women only...? *AWIS Magazine, 24*(5), 2.

Keller, E. F. (1992). How gender matters, or, why it's hard for us to count past two. In G. Kirkup & L. S. Keller (Eds.). *Inventing Women: Science, Technology and Gender.* Milton Keynes, UK: Polity Press.

Kelly, A. (1985). The construction of masculine science. *British Journal of Sociology of Education, 6*(2), 133-153.

Kleinman, S. S. (1998). Overview of feminist perspectives on the ideology of science. *Journal of Research in Science Teaching, 35*(8), 837-844.

LeCompte, M. D., & Preissle, J. (1993). *Ethnography and qualitative design in educational research.* (2nd Ed.). New york, N.Y.: Academic Press, Inc.

Lee-Pearce, M. L., Plowman, T. S., & Touchstone, D. (1998). Starbase-Atlantis, a School without Walls: A Comparative Study of an Innovative Science Program for At-Risk Urban Elementary Students. *Journal of Education for Students Placed at Risk (JESPAR), 3*(3), 223-235.

Marlow, S. E., & Marlow, M. P. (1996). Sharing voices of experience in mathematics and science: Beginning a mentorship program for middle school girls. *Focus on Learning Problems in Mathematics, 18*(1-3),146-54.

Matyas, M. L. (1985). In M. L. Kahle (Ed.). *Women in science: A report from the field.* Philadelphia, PA: The Falmer Press.

National Commission on Excellence in Education. (1983). *A nation at risk.* Washington, D.C.: Author.

National Research Council. (1999). *Doctorate recipients from United States universities. Summary report 1996*. Washington D.C.: National Academy Press.

Oakes, J. (1990). *Multiplying Inequalities: The Effects of race, social class, and tracking on opportunities to learn mathematics and science,* pp.13-45. Santa Monica, CA: Rand Corporation. Rand publication number R-3928-NSF.

Peltz, W. H. (1990). Can girls + science - stereotypes = success. *The Science Teacher. 57*(9), 44-49.

Rohrer, J., & Welsch, S. (1998). The Lake Tahoe Watershed Project: A summer program for female middle school students in math and science. *Roeper Review, 20*(4), 288-90.

Roth, W. M. (1996). Teacher questioning in an open-inquiry learning environment: Interactions of context, content, and student responses. *Journal of Research in Science Teaching, 33*(7), 709-736.

Sadker, M., & Sadker, D. (1986). Sexism in the classroom: From grade school to graduate school. *Phi Delta Kappan,* 67, 512-515.

Salner, M. (1985). Women, graduate education, and feminist knowledge. *Journal of Education, 167*(3), 46-58.

Schibeci, R. A., & Riley, J. P., II (1986). Influence of students' background and perceptions on science attitudes and achievement. *Journal of Research in Science Teaching, 23*(3), 177-187.

Shakeshaft, C. (1995). Reforming science education to include girls. *Theory Into Practice, 34*(1), 74-79.

Shepardson, D. P. & Pizzini, E. L. (1992). Gender bias in female elementary teachers' perceptions of the scientific ability of students. *Science Education, 76*(2), 147-53.

Sutman, F. X., Bruce, M. H., May, P. N., McConaghy, R., & Nolt, S. K. (1997). Hands-on science and basic skills learning by culturally and academically diverse students: A test of the IALS. *Journal of Curriculum and Supervision, 12*(4), 367-382.

Tracy, D. (1987). Toys, spatial ability, and science and mathematics achievement: Are they related? *Sex Roles: A Journal of Research, 17,* 115-138.

Travis, J. (1993). Making room for women in science. *Science, 260*, 412-415.

Turner, C. V., & Thompson, J. R. (1993). Socializing women doctoral students: Minority and Majority Experiences. *The Review of Higher Education, 16*(3), 355-370.

Tyler-Wood, T. L., Cass, M. A., & Potter, L. (1997). Effects of an outdoor science laboratory program on middle school students. *ERS Spectrum, 15*(3), 30-33.

Weinburgh, M. (1995). Gender differences in student attitudes toward science: A meta-analysis of the literature from 1970 to 1991. *Journal of Research in Science Teaching, 32*(4), 387-398.

NOTICE

Reproduction Basis

- [X] This document is covered by a signed "Reproduction Release (Blanket)" form (on file within the ERIC system), encompassing all or classes of documents from its source organization and, therefore, does not require a "Specific Document" Release form.

- [ ] This document is Federally-funded, or carries its own permission to reproduce, or is otherwise in the public domain and, therefore, may be reproduced by ERIC without a signed Reproduction Release form (either "Specific Document" or "Blanket").