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ABSTRACT

Research studies have shown that students in rural high schools have fewer science role models, participate less frequently in extracurricular science activities, and have less science career information than do their peers in more cosmopolitan settings. Furthermore, girls in rural schools may be particularly disadvantaged. For example, analyses of the results from the 1981 National Assessment of Education Progress indicated that girls continue to score below the national mean on all cognitive science items and to express negative attitudes toward science. The goal of Project SCORES was to develop a sustained intervention model utilizing the strategies of teachers who successfully encouraged students to continue in science, and to remediate the lack of participation in science by rural students. Therefore, Project SCORES established a cooperative relationship among a university science department, local science-related industries, and rural secondary schools. This paper describes the project, intervention strategies, project evaluation, and demographic characteristics of samples. (Author/CW)

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SCORES

Science Career Options for Rural Environment Students

FINAL REPORT

Women's Educational Equity Act Program Grant #GXX8402219

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EXECUTIVE SUMMARY

Research studies have shown that students in rural high schools have fewer science role models, participate less frequently in extracurricular science activities, and have less science career information than do their peers in more cosmopolitan settings. Furthermore, girls in rural schools may be particularly disadvantaged. For example, analyses of the results from the 1981 National Assessment of Education Progress indicated that girls continue to score below the national mean on all cognitive science items and to express negative attitudes toward science. However, Kahle's (1983) study of teachers, who successfully motivated high school girls to continue in science, has revealed several commonalities. For example, the teachers, three of whom were in rural settings, maintain perceptually stimulating classrooms, use gender-free language and examples, presented career information, and provide guest speakers and field trips.

The goal of Project SCORES was to develop a sustained intervention model utilizing the strategies of teachers who successfully encouraged students to continue in science, to remediate the lack of participation in science by rural students. Therefore, Project SCORES established a cooperative relationship among a university science department, local science-related industries, and rural secondary schools. Two intervention models were developed, a "limited" intervention program and a "full" intervention one. One rural secondary school was selected for each intervention program, and a comparable school was selected as a control school. Students in all three schools completed surveys which described their science career interests, perceptions of science and scientists, attitudes toward science, and extracurricular science experiences. Achievement data were collected at the end of the study from all students. In addition, teachers and students were interviewed, and classroom observations were made.

The intervention strategies were discussed with participating teachers at a summer workshop. Resource materials were provided for both teachers throughout the program. Community volunteers and college science majors aided the teacher in the full intervention school through special presentations, by assisting with laboratory activities, and by field trips to a local industrial and educational laboratories.

Evaluation of the intervention programs, full and limited, revealed the following changes.

* Students perceived science careers as appropriate for women.
* The gap between males' and females' science career interests was reduced.
* Teachers developed and used gender-free teaching strategies.
* Science resource materials were tested and evaluated by students, teachers, and project staff members.
* Cooperative liaisons among schools, universities, and local communities fostered more equitable science education for rural youth.

In addition, future programs concerning educational equity in science may benefit from the following recommendations, based on Project SCORES' results.

* Utilize the "limited" intervention model as the most cost-effective program.

* Implement an intervention program of longer duration.

* Collect and/or develop resource materials which describe technical careers.

* Collect and/or develop resource materials which describe non-career-related aspects of science which are relevant to students' lives.

* Involve school personnel (administrators, parent leaders, resource personnel) in more phases of the program.

* Use teacher participants as change agents to foster quality and equitable education.

INTRODUCTION

Project SCORES developed a sustained intervention model to remediate the lack of formal and informal participation in science by rural students, a population largely uninvolved in the past according to science education research. The goals of the project were to establish a cooperative relationship among a university science department, community volunteer agencies, local science-related industries, and rural secondary schools; to evaluate the model's effectiveness in removing obstacles to rural students' participation in volunteer, nonprofessional and professional activities related to science; and to establish a model that could be replicated and/or adapted by others. Although Project SCORES was directed at all rural students and was implemented with intact classes of students, the underrepresentation of girls in science was a particular concern of the project.

Past research has shown that girls in rural high schools have fewer role models, extracurricular experiences, and career information in science than boys do (Kahle & Lakes, 1983; Kahle, 1983). Therefore, part of the projects' activities were specifically geared to changing girls' attitudes towards science. Although the primary focus of the intervention effort was to encourage girls to pursue advanced science studies, there was every reason to believe that boys and parents would be substantially affected by the intervention program as well. The project activities were designed to sensitize teachers, parents, and community leaders about the need for increased career counseling, extracurricular science activities, and unbiased classroom and community environments which promote students' participation in science.

The project was conducted in rural, high school biology classes. Nationally, biology is taken by 74% of all high school students, and it is the only science taken by the vast majority of students. In Indiana, 82% of high school students take biology, which is usually offered in the 9th grade. Both because of the high percentage of students enrolled and because of its early place in the science curriculum, biology is an optimum course for intervention strategies. In addition, only 10.1% of Indiana students have made career decisions before grade 9 (Kahle, 1985). Since the science talent pool is essentially decided in the high school years (Berryman, 1983), introductory biology classes present an ideal opportunity for science career education.

The project included two types of intervention programs, "limited" intervention and "full" intervention, in addition to a non-intervention, "control," group. Both programs involved rural students in increased science activities and provided them with information about careers in science. The full intervention program also gave rural girls ongoing exposure to female role models in science and furnished field trips for all students to a science-related industry or to university science/engineering laboratories.

GOALS & OBJECTIVES

A major goal of Project SCORES was to increase the numbers of girls from extreme rural areas enrolling in secondary school science and mathematics courses and using science in future professional, non-professional, and volunteer work. The program addressed socio-cultural/personal and educational barriers to rural girls' pursuit of science both as a vocation and as an avocation.

Specific objectives were developed to meet identified needs of each group involved. The objectives are delineated in the project's proposal. In addition, major goals, identified during the project preparation and planning period in consultation with external consultants and participating teachers and administrators, are outlined below. Goals are listed according to the targeted group.

Student Goals:

* To increase an awareness of the diversity and availability of career and personal options in science, emphasizing the roles of women;
* To increase participation in extracurricular and curricular science activities;
* To extend educational and career guidance.

Teacher Goals:

* To practice gender-free teaching behaviors, instructional methods, and reinforcement techniques;
* To evaluate the importance of career-oriented guidance materials in science classrooms.

Parent Goals:

* To develop an awareness of the importance of science in daily as well as in work activities;
* To provide positive encouragement for girls' educational and career choices.

University, Community & Industrial Volunteer Goals:

* To increase the number of extracurricular science experiences for extremely rural youth;
* To expand young women's perceptions of career opportunities;
* To provide role models who use science in their daily lives both in and out of the work force.

Science Educator Goals:

* To report locally, regionally, and nationally the results of the project to groups of teachers, administrators, counselors, parents, and community volunteers.

DESCRIPTION OF PROJECT

Project SCORES worked toward fulfilling the preceding goals with a sustained, cooperative plan which included the following five components: Development, Participation, Involvement, Dissemination, and Evaluation. The interaction among those components is shown in Figure 1.

FIGURE 1.

Five Components Used to Implement Project SCORES' Goals

DEVELOPMENT of intervention materials and evaluation strategies for SCORES Project.

PARTICIPATION in special activities, including a one day "Science Spark" workshop to introduce participating SCORES project teachers to the study.

INVOLVEMENT in science activities, including

a. laboratory assistance in high school biology classrooms by graduate and undergraduate women;
b. programs by community volunteers concerning volunteer opportunities and careers which involve science;
c. field trips to local and state scientific industries.

DISSEMINATION of project's results and intervention materials, including

a. participation in regional and national professional conventions such as NABT, HASTI, and NSTA; and

b. providing information to biology teachers and students in rural secondary schools.

EVALUATION of SCORES project, including

a. increased awareness of available science occupations;
b. increased interest in taking future science and mathematics courses;
c. more positive perceptions of women scientists and of science-related volunteer activities;
d. increased opportunities to participate in extracurricular science activities; and
e. parents', teachers', and community volunteers' perceptions of the program's effectiveness.

Development of Instructional and Evaluation Materials

The first stage of the project was development and formative evaluation of materials and resources by the project staff. This phase included the acquisition of science career and counseling information, development of gender-free instructional materials, and identification of science-related field trip opportunities in the local communities.

In order to provide the project teachers with access to a variety of teaching resources and information, the research team developed the following items as part of this phase.

Materials Evaluation Form: This form allowed teachers and staff to critique materials on the bases of content and technical quality. It used a 1 to 5 rating scale; 1 equaled excellent, 4 equaled poor, and 5 indicated not applicable. (See Appendix 1.)

Listing of Evaluated Materials: Using the MECC Datahandler, a database of evaluated materials was developed. Each resource, ordered by the SCORES research team, was evaluated and entered into the database. An ANNOTATED BIBLIOGRAPHY was compiled also. (See Appendix 1.)

Information Lists: A books/periodicals, professional organizations, and materials/information listing was developed in order to provide addresses for further sources of information.

SCORES Notebooks: A notebook containing philosophy, goals, activities, resources, and career information was developed and provided to the participating teachers.

Library: The Resource Library of the Biology Teachers' Resource Center, Purdue University was made available to all project personnel so that they could check out materials to preview or to use in their classrooms or other locations.

Gender-Free Instructional Materials: The project team developed labs which promoted science learning in a gender-free environment. Some of the [1] lab exercises were later used in the full and limited intervention schools.

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1 For additional information on these gender-free laboratories, contact Dr. Jane Butler Kahle, Biology Teachers Resource Center, 216 Chemistry Building, Purdue University, West Lafayette, IN 47907.

Biology 295: Biology Careers: A Practicum for Discovering Your Niche: A one credit hour course was developed to increase college students' knowledge about opportunities, advancements, and limitations in various biology careers and to increase student awareness of the special skills, prerequisites, and educational levels required for different types of work in the biological sciences. Selected class members assisted with laboratories in the full intervention school, providing appropriate role models for the high school students. (See Appendix 1.)

Concomitantly with the acquisition and development of the project materials, consultants were invited to work with the project team. Each consultant gave feedback and advice on the project areas that coincided with his/her area of expertise. The four primary consultants in the initial development stage addressed the issues of intervention strategies and model program dissemination and expansion.

Intervention Strategies

Dr. Alison Kelly (Purdue visit March 6-7, 1985)
Director of Girls into Science & Technology
Lecturer of Sociology
Manchester University, Manchester, England

Dr. Kelly was involved in an early phase of the project. Having recently completed the Girls into Science and Technology (GIST) study in England, she discussed areas of commonality between GIST and SCORES and possible problems that might arise. Specifically, Dr. Kelly gave her overall impressions of the project and discussed the geographic spread, the experimental design, the individual quantitative tests, and the intervention strategies proposed.

Dr. Elizabeth K. Stage (Purdue visit April 3, 1985)
Director of Evaluation, EQUALS Program
University of California, Berkeley, California

Dr. Stage focused on the areas in which the project teachers would be involved. With her extensive teaching background and continued work for EQUALS as Director of Evaluation, Dr. Stage has had a great deal of experience working with secondary school science teachers. She offered valuable input on the summer workshop, on methods for evaluating the workshop's continuing effects on the project teachers, and on effective ways in which to implement relevant labs into cooperating classrooms.

Model Program Dissemination and Expansion

Dr. Lyn Erb (Purdue visit April 30, 1985)
Director of Indiana Facilitator Center
Logansport, Indiana

Since the SCORES project will ultimately be used as a model for others interested in encouraging rural students to continue in science, Dr. Erb was invited to provide information on the Indiana Facilitator Center and the National Diffusion Network (NDN). He explained the review process for getting onto the Indiana facilitator network, and the services that the Indiana Faciltator Center can provide. In addition, he discussed the format for applying for funds from NDN as well as priority areas for NDN funding.

Dr. Heather Johnston Nicholson (Purdue visit May 14, 1985)
Senior Research Associate
Girls Clubs of America, Inc.
National Resource Center
Indianapolis, Indiana

Dr. Nicholson explained the functions of the Girls Clubs of America and proposed ways in which the Indianapolis Resource Center might assist with Project SCORES. She provided information on the Center, the Girls Club library information services, and the research being conducted by Girls Clubs throughout the country.

In order to facilitate future implementation of Project SCORES, written evaluations were requested from each consultant and were used to revise the proposed activities. Some deviation from the original grant proposal was deemed necessary. As Dr. Kelly stated, "I see project evaluation as a sign that the researchers are continuing to think about the problems involved, and not merely following a predetermined formula." Dr. Kelly felt that the solitary SCORES workshop should be expanded to several extended sessions. Increased opportunities for project teachers to interact with each other and to share ideas and experiences were recommended. To facilitate this recommendation, the one day Saturday SCORES Seminar, discussed in the proposal, was replaced with more informal and frequent interactions of the project staff with students, teachers, administrators, and volunteers.

Since the classroom observation portion of the project required that the staff become proficient in several observation skills several observation protocals were tried. The project staff spent time observing classrooms, evaluating observation protocols, and adapting protocols to fit the complexities of observation in different laboratory environments.

The final phase of the project's development stage consisted of gathering evaluation instruments to assess changes in students' perceptions of and attitudes toward science careers and opportunities. The evaluation instruments are discussed in the evaluation portion of this report.

Participation in Special Activities:

The biology teachers who participated in Project SCORES were selected from rural secondary schools within a 50-mile radius of Purdue University. Every effort was made to select teachers with similar backgrounds and to select schools with equivalent student populations.

Benton Central Junior-Senior High School (the full intervention school) is a consolidated school which is located approximately 25 miles northwest of Purdue University in Benton County. The K-12 enrollment of the county school system is 2160 and includes students from the surrounding communities of Fowler (population 2643) and Oxford (population 1098). Applied Biology is offered to 9th grade students who do not plan to attend college, while college-bound 9th graders take General Biology or Honors Biology. In their junior or senior years, students may elect to take the one semester Human Physiology and/or a

Botany/Zoology course.

Michael Rathert, the participating biology teacher, has an earned Master's degree in biology and has been teaching for nine years. Mr. Rathert lives in the Benton Central community and is actively involved in community organizations.

Delphi Community High School (the limited intervention school) is located approximately 20 miles northeast of Purdue University in Carroll County. It, too, is a consolidated school. The school is located in Delphi (population 2582) and enrolls 1736 students in grades K-12. Non-college-bound 9th graders take Basic Biology, while college-bound 9th graders take General Biology. Students may enroll in the one-year Advanced Biology course in their sophomore, junior, or senior years.

David Hanna, the participating biology teacher, has a Master's degree in biology and has taught school for 26 years. Mr. Hanna lives in the Delphi community and is actively involved in community service organizations.

Attica Junior-Senior High School (the control school) is located in Attica (population 4262) in Fountain County. Attica is approximately 30 miles southwest of Purdue University. The school system includes 990 students in grades K-12 and is a consolidated school. General Science is offered to non-college-bound students in grades 9-12. College-bound students may take Biology I in grades 9, 10, 11, or 12 and may elect to take Advanced Biology in grades 10, 11, or 12.

Michael Ingram, the participating biology teacher, has a Bachelor's degree in biology and a Master's degree in biology education. Mr. Ingram has taught school for eight years. He does not live in the Attica community and is not directly involved in the community's organizations.

All three teachers received their advanced degrees at Purdue University. In addition, the two intervention teachers regularly supervise student teachers.

Therefore the project director was knowledgeable about their comparative strengths and their teaching methodologies as well as the organization of their respective schools.

The two teachers from Delphi and Benton Central, as well as another group of high school biology teachers who were interested in improving students' attitudes toward science, attended a one-day workshop on July 15, 1985, at Purdue University. The workshop provided an opportunity to introduce teachers and staff, to outline the philosophy behind Project SCORES and to provide resource materials to the participating teachers. (See Appendix 2).

Involvement in Science Activities

In order to evaluate the effectiveness of two types of intervention, Benton Central Junior-Senior High School was selected for a more intensive intervention program than that employed in Delphi Community High School. The programs were called the "full" intervention and the "limited" intervention, respectively. Attica Junior-Senior High School was used as a control school. In this school, biology classes were observed at the beginning and end of the semester, and students were posttested at the end of the semester. Mr. Ingram did not attend the summer workshop and other activities and resources were not available to the Attica school.

During the Spring semester of 1985, biology classes of three participating teachers (two of whom later participated in the study) were observed, and some of the survey instruments (PSS, SAQ, and SES) were administered to their students. Those students constituted a "cohort" group of students analogous to those actually involved in the study.

Initial observations in all three schools were made in September, 1985, and demographic data were collected from the students at that time. Resource materials were delivered to the limited intervention school throughout the semester upon request of the teacher, but no further assistance was offered. The classroom, however, was observed periodically, and the project team provided information to parents during National Education Week.

The full intervention school also received resource materials; in addition, the biology classes participated in several special programs. With the help of various consultants and community volunteers in science-related occupations, students at Benton Central Junior-Senior High School were able to participate in the following unique learning activities.

- College biology majors, from the Biology 295 course, assisted in laboratory activities in the classroom on four different occasions during the semester. During each lab period, two or three of the college students helped secondary school students with laboratory exercises. (See Appendix 3.)
- Panel discussions, presentations at Parents' Night, and guest speakers describing how they used science in their jobs were provided for the full-intervention school. (See Appendix 3.)
- Field trips were arranged for the students to Eli Lilly & Company and to Purdue University's Schools of Engineering and Department of Biological Sciences. (See Appendix 3.)

Final observations of the three schools were made in December, 1985. At that time, four survey instruments were administered to all students.

Dissemination of Project Results and Intervention Materials

Throughout the project, the SCORES staff presented talks at regional and national conferences. (See Appendix 4.) Initial observations and findings were discussed at the National Association of Biology Teachers (Oct., 1985); Delphi and Benton Central High Schools' Career Nights (Nov., 1985); the Indiana Academy of Science (Nov., 1985); the Hoosier Association of Science Teachers, Inc. (Feb., 1986); the National Science Teachers Association (April, 1986); and the National Association for Research in Science Teaching (April, 1986). In addition, the director compared the results to those of several international projects in her role as a discussant for papers concerned with gender-based research at the American Education Research Association (April, 1986). Furthermore, she has been asked to present the findings at several international conferences including the Conference of the Science Teachers' Association of Western Australia (CONSTAWA), Nedlands, Australia, the Conference of the South Pacific Association for Teacher Education (SPATE), Perth, Australia (July, 1986), and Girls and Science and Technology Conference (GASAT), Ann Arbor, Michigan (July, 1987).

In addition to the formal presentations, project staff were continually providing information on a more informal basis. They discussed SCORES with biology undergraduates at the Department of Biological Sciences informational evening, and they provided poster sessions for teachers attending a science conference at Purdue University. They solicited the help of a special education class from Western High School, Kokomo, IN, to make publicity buttons for the project. The teacher of the special education class used the opportunity to simulate a contracted job situation where quality control standards had to be maintained and certain job skills learned. The students also requested that staff members talk to them about Project SCORES. The opportunity to talk about science-related skills with the special students was an unplanned occasion to broaden the horizons of the project.

As additional work is done with Project SCORES, further dissemination of information and resources will occur. The principal investigator has received National Science Foundation funding for a follow-up project entitled "Science Education for Rural Girls: Educational Equity Through Master Teaching" (NSF Grant No. SEE-8470523). This three year project will build upon the findings of and extend the impact of SCORES.

Evaluation of Project SCORES

Four scales were developed or adapted to assess student attitudes toward, perceptions of, and interest in various aspects of science and science careers. (See Appendix 5 for information concerning scale reliability, validity, and scoring.) The following scales were used in all three schools.

Career Interest Survey (CIS)

The CIS was developed by Donovan and his colleagues (1985) to measure interest in science and engineering careers. Students were asked to indicate their preferred activity or career among three choices presented in each of 50 items.

Perceptions of Science and Scientists (PSS)

The PSS questionnaire was developed by the project staff to measure stereotyped perceptions of science and scientists. Students were asked to indicate the extent to which they agreed or disagreed with 39 statements using a 5-point Likert-type continuum.

Science Attitudes Questionnaire (SAQ)

Attitudes toward several dimensions of science were measured using a 30-item questionnaire, which was adapted from the Fennema-Sherman mathematics attitudes' scales (Fennema and Sherman, 1976). Students indicated the degree to which they agreed or disagreed with each of the 30 statements on a 5-point continuum.

Science Experiences Survey (SES)

The SES instrument measured students' participation in extracurricular science activities. The instrument was adapted from one used in a study, "Girls in School: Women in Science,"[2] commissioned by the National Science Board.

[2] "Factors Affecting the Retention of Girls in Science Courses and Careers: Case Studies of Selected Secondary Schools," funded by the National Science Foundation (Order No. 83-SP-0798), Jane Butler Kahle, principal investigator.

For each of 40 activities, students were asked to indicate whether they participated in the activities "never," "seldom," "fairly often," or "frequently," when the activity was not required for a class.

Demographic Survey

A demographic instrument was adapted from a similar survey used in the "Girls in School: Women in Science" study. It assessed demographic factors concerning students in the full intervention, limited intervention, and control schools.

RESULTS

A combination of quantitative and qualitative methods were used to evaluate the effectiveness of the intervention programs for encouraging positive science attitudes among rural secondary school students. Demographic data concerning the participating students were collected at the beginning of the fall semester; those results will be described first. At the end of the intervention program students were surveyed concerning their career interests, perceptions of science and scientists, attitudes toward various aspects of science, and extracurricular science experiences. A discussion of the science attitude results will be followed by students' science achievement and science coursework plans. Finally, all results will be interpreted in light of classroom observations and comments made by participating students and teachers during interviews with project staff members.

Several events caused evaluation problems that the project staff had not anticipated. Because the SCORES program was designed for ninth-grade, general biology students, three rural secondary school teachers who taught at least two general biology classes were selected for project participation. Project staff planned to collect data from students in two classes taught by each teacher. Unfortunately, the state-mandated requirement that all secondary students complete two years of science resulted in a shuffling of science teachers' class schedules immediately prior to the intervention period. The teacher initially selected for the limited intervention program was dropped because he was assigned no general biology classes for the 1985-86 school year. Another rural teacher was substituted before the summer workshop, but after pretest data from the Spring, 1985 cohort group was collected. Furthermore, the class schedule for the teacher in the control school was changed so that he taught only one general biology class during the 1985-86 academic year. Therefore, the project staff decided to collect survey data from students in a general science class taught by the control teacher as well as from students in his general biology class. Not surprisingly, students in the general science class were unlike students in the general biology classes on many demographic characteristics. For this reason, the project staff decided to eliminate data collected in the control school's general science class from statistical analyses if significant differences ($p = 0.05$) were found between students in the control school's general science and general biology classes. The following discussion of results will note such cases.

Demographic Results

The demographic survey was administered at the beginning of the intervention program in September, 1985. Tables 1 through 16 present the results. The significance level used for significant demographic differences was alpha = 0.05. Data from the control school's general science class is not included in the following tables because that class differed significantly from the control school's general biology class.

General Demographics

TABLE 1

Percentages of Male and Female Students in Participating Biology Classes of the Control, Limited, and Full Intervention Schools

SCHOOL	MALE	FEMALE	
Control	58.3%	41.7%	N = 24
Limited Intervention	40.0%	60.0%	N = 40
Full Intervention	55.4%	44.6%	N = 57

$X^2 = 2.877$, df = 2, p = 0.237.

TABLE 2

Percentages of White and Black Students in Participating Biology Classes of the Control, Limited, and Full Intervention Schools

SCHOOL	WHITE	BLACK	
Control	100.0%	0%	N = 24
Limited Intervention	100.0%	0%	N = 40
Full Intervention	98.2%	1.8%	N = 56

$X^2 = 1.152$, df = 2, p = 0.562.

TABLE 3

Percentages of 9th- and 10th-Grade Students in Participating Biology Classes of the Control, Limited, and Full Intervention Schools

SCHOOL	9TH	10TH	
Control	79.3%	20.8%	N = 24
Limited Intervention	100.0%	0%	N = 40
Full Intervention	98.2%	1.8%	N = 56

$X^2 = 15.990$, df = 2, p = 0.000.

TABLE 4

Percentages of Students in Participating Biology Classes of the Control, Limited, and Full Intervention Schools in the Indicated Age Groups

SCHOOL	13 YRS. OR YOUNGER	14 TO 15 YRS.	16 YRS. OR OLDER	
Control	4.2%	79.2%	16.7%	N = 24
Limited Intervention	7.5%	87.5%	5.0%	N = 40
Full Intervention	1.8%	98.2%	0%	N = 56

$X^2 = 11.906$, df = 4, p = 0.018.

Parental Characteristics

TABLE 5

Percentages of Students in Participating Biology Classes of the Control, Limited, and Full Intervention Schools Whose Fathers Have the Indicated Educational Levels

SCHOOL	LEVEL* I	II	III	IV	
Control	10.0%	55.0%	10.0%	25.0%	N = 20
Limited Intervention	5.1%	35.9%	17.9%	41.0%	N = 39
Full Intervention	8.9%	26.8%	26.8%	35.7%	N = 56

$X^2 = 7.153$, df = 6, p = 0.307.

*Educational levels are as follows:
- I = high school dropout;
- II = high school graduate;
- III = additional training through vocational programs, apprenticeship, military service, or 2-year college;
- IV = college study, including 1-3 years of college, bachelor's degree, or advanced degree.

TABLE 6

Percentages of Students in Participating Biology Classes of the Control, Limited, and Full Intervention Schools Whose Mothers Have the Indicated Educational Levels

SCHOOL	LEVEL* I	II	III	IV	
Control	9.1%	63.6%	13.6%	13.6%	N = 20
Limited Intervention	12.8%	43.6%	12.8%	30.8%	N = 39
Full Intervention	5.5%	45.5%	18.2%	30.9%	N = 55

$X^2 = 5.186$, df = 6, p = 0.520.

*Educational levels are as indicated for fathers' educational levels.

TABLE 7

Percentages of Students in Participating Biology Classes of the Control, Limited, and Full Intervention Schools Whose Fathers' Occupations are in the Indicated Categories

SCHOOL	BC	SS	WC	SCI*	
Control	69.6%	0%	26.1%	4.3%	N = 20
Limited Intervention	56.4%	7.7%	17.9%	17.9%	N = 39
Full Intervention	61.8%	10.9%	18.2%	9.1%	N = 55

$X^2 = 6.310$, df = 6, p = 0.389.

*Occupational categories include the following:
BC = Blue collar (mechanical, industrial, construction, general labor, agricultural work);
SS = Social service (clergy, social worker, mail carrier, police officer, teacher other than science);
WC = White collar (business, clerical, sales);
SCI = Scientific (science teacher, engineer, doctor, nurse).

TABLE 8

Percentages of Students in Participating Biology Classes of the Control, Limited, and Full Intervention Schools Whose Mothers' Occupations are in the Indicated Categories

SCHOOL	BC	SS	WC	SCI	HM*	
Control	17.4	17.4	8.7%	13.0%	43.5%	N = 23
Limited Intervention	12.8	15.4	23.1%	10.3%	38.5%	N = 39
Full Intervention	16.1	3.6%	17.9%	12.5%	50.0%	N = 56

$X^2 = 7.372$, df = 8, p = 0.497.

*Occupational categories are as indicated for fathers' occupational categories.
HM = Homemaker.

Career Plans

TABLE 9

Percentages of Students in Participating Biology Classes of the Control, Limited, and Full Intervention Schools Who Report the Following Post-Graduation Plans*

SCHOOL	WORK	VOC	COL	OTHER/ IDK	
Control	0%	16.7%	50.0%	33.3%	N = 24
Limited Intervention	2.5%	7.5%	60.0%	30.0%	N = 40
Full Intervention	1.8%	14.3%	48.2%	35.7%	N = 56

$X^2 = 2.729$, df = 6, p = 0.842.

*Plans include the following:
WORK = full-time work;
VOC = vocational training through military service, 2-year college, or other vocational programs;
COL = 4-year college;
OTHER/IDK = Other plans or "I don't know."

TABLE 10

Percentages of Students in Participating Biology Classes of the Control, Limited, and Full Intervention Schools Who Have Discussed Careers with Guidance Counselors the Indicated Number of Times

SCHOOL	NEVER	1-4 X	5 OR > X	
Control	41.7%	37.5%	20.8%	N = 24
Limited Intervention	25.6%	43.6%	30.8%	N = 40
Full Intervention	56.4%	34.5%	9.1%	N = 55

$X^2 = 11.322$, df = 4, p = 0.023.

TABLE 11

Percentages of Students in Participating Biology Classes of the Control, Limited, and Full Intervention Schools Who Have the Indicated Educational Aspirations*

SCHOOL	HS	VOC	BA/S	ADV	IDK	
Control	4.2%	25.0%	29.2%	29.2%	12.5%	N = 24
Limited Intervention	10.3%	10.3%	28.2%	43.6%	7.7%	N = 39
Full Intervention	5.4%	16.1%	41.1%	17.9%	19.6%	N = 56

$X^2 = 12.182$, df = 8, p = 0.143.

*Educational aspirations are as follows:
HS = high school graduation;
VOC = post-graduation vocational training, 2-year college, or military service;
BA/S = bachelor's degree or 1-3 years of college;
ADV = advanced college degree;
IDK = "I don't know."

TABLE 12

Percentages of Students in Participating Biology Classes of the Control, Limited, and Full Intervention Schools Who Perceive Encouragement to Pursue Science/Engineering Careers

SCHOOL	YES	NO	
Control	50.0%	50.0%	N = 24
Limited Intervention	64.1%	35.9%	N = 39
Full Intervention	39.3%	60.7%	N = 56

$X^2 = 5.666$, df = 2, p = 0.059.

Self-Perceptions of Ability

TABLE 13

Percentages of Students in Participating Biology Classes of the Control, Limited, and Full Intervention Schools Who Perceive Themselves Above Average, Average, or Below Average in Athletic Ability

SCHOOL	ABOVE	AVERAGE	BELOW	
Control	37.5%	58.3%	4.2%	N = 24
Limited Intervention	45.0%	42.0%	12.5%	N = 40
Full Intervention	48.2%	41.1%	10.7%	N = 56

$X^2 = 2.720$, df = 4, p = 0.606.

TABLE 14

Percentages of Students in Participating Biology Classes of the Control, Limited, and Full Intervention Schools Who Perceive Themselves Above Average, Average, or Below Average in Artistic Ability

SCHOOL	ABOVE AVERAGE	AVERAGE	BELOW AVERAGE	
Control	25.0%	33.3%	41.7%	N = 24
Limited Intervention	27.5%	42.5%	30.0%	N = 40
Full Intervention	19.6%	41.1%	39.3%	N = 56

$X^2 = 1.752$, df = 4, p = 0.781.

TABLE 15

Percentages of Students in Participating Biology Classes of the Control, Limited, and Full Intervention Schools Who Perceive Themselves Above Average, Average, or Below Average in Academic Ability

SCHOOL	ABOVE AVERAGE	AVERAGE	BELOW AVERAGE	
Control	50.0%	50.0%	0%	N = 24
Limited Intervention	52.5%	47.5%	0%	N = 40
Full Intervention	25.0%	71.4%	3.6%	N = 56

$X^2 = 10.374$, df = 4, p = 0.035.

TABLE 16

Percentages of Students in Participating Biology Classes of the Control, Limited, and Full Intervention Schools Who Perceive Themselves Above Average, Average, or Below Average in Scientific Ability

SCHOOL	ABOVE AVERAGE	AVERAGE	BELOW AVERAGE	
Control	45.8%	50.0%	4.2%	N = 24
Limited Intervention	52.5%	45.0%	2.5%	N = 40
Full Intervention	30.4%	57.1%	12.5%	N = 56

$X^2 = 7.223$, df = 4, p = 0.125.

General Demographics

No statistically significant differences in the proportions of males and females in the participating classes were found; nor were there statistically significant differences in race proportions (Tables 1 & 2). Significant differences in high school grade and average student age, however, did exist (Tables 3 & 4). There were significantly more tenth-graders in the control school than in either the limited intervention school ($X^2 = 6.378$, df = 1, p = 0.012) or the full intervention school ($X^2 = 6.255$, df = 1, p = 0.012). On the average, students in the control school were older than students in the full intervention school ($X^2 = 10.159$, df = 2, p = 0.006). No significant differences in ages of the control and limited intervention school students or the limited and full intervention school students were found.

Parental Characteristics

No statistically significant differences in parental characteristics were found among students in the participating biology classes of the three schools (Tables 5 through 8).

Career Plans

No significant differences in the post-graduation plans of students in the three schools were apparent (Table 9). Students in the limited intervention school had discussed careers with the school's guidance counselor significantly more often than had students in the full intervention school ($X^2 = 11.355$, df = 2, p = 0.003). This difference reflected differences in the two schools' guidance programs. The full intervention school utilized intensive guidance activities during the fall semester of the ninth-grade year, while the limited intervention school aided students in high school curriculum planning during the eighth-grade year. Since the demographic survey was administered at the beginning of the fall semester when most biology students were entering ninth-grade, students in the full intervention school had not yet met with their guidance counselors.

Differences in students' educational aspirations across all three schools were not statistically significant (Table 11); however, analysis of the educational aspirations of students in the limited and full intervention schools revealed that a significantly greater proportion of students in the limited intervention school aspired to college and advanced degrees than did students in the full intervention school ($X^2 = 9.964$, df = 4, p = 0.041). The observed significant differences in students' perceptions of encouragement to pursue science/engineering careers (Table 12) was due to a highly significant difference between students in the limited and full intervention schools. More students in the limited intervention school perceived encouragement to pursue science and engineering careers than did students in the full intervention school ($X^2 = 4.715$, df = 1, p = 0.030).

Self-Perceptions of Ability

No statistically significant differences were found among students on self-perceptions of athletic or artistic ability (Tables 13 & 14). This was not true for self-perceptions of academic and scientific ability (Tables 15 & 16). Students in the full intervention school had significantly lower self-perceptions of their academic ability than did students in the limited intervention school ($X^2 = 8.442$, df = 2, p = 0.015). In addition, students in the full intervention school had significantly lower self-perceptions of their scientific ability than did students in the limited intervention school ($X^2 = 6.351$, df = 2, p = 0.042).

Summary of Demographic Differences

Every effort was made to select similar rural schools within 50 miles of

Purdue University; however, the results of the demographic survey revealed some differences in background characteristics of students in the three participating schools. Statistically significant differences among students in the three participating schools were found for student age and grade level, as well as self-perception of academic ability. Significant differences in number of career discussions with guidance counselors, educational aspirations, perceived encouragement to pursue science/engineering careers, and self-perception of scientific ability were found between students in the limited and full intervention schools. In each case, the differences were in favor of students in the control and limited intervention schools.

Attitude Survey Results

The four attitude surveys (CIS, PSS, SAQ, and SES) and the qualitative methods described here were administered at the completion of the intervention program in December, 1985. The significance level used for these measures was alpha = 0.10.

Career Interest

Interest in science and engineering careers was measured quantitatively by the Career Interest Survey and more qualitatively by asking students to state their chosen careers. The results of the Career Interest Survey are shown in Table 17. A t-test indicated that there was a significant difference in CIS score between students in the control school's general science and general biology classes ($t = 2.11$, $p = 0.040$), so data from students in the general science class were omitted from the analysis.

A more qualitative assessment of students' interests in science careers was achieved by examination of students' chosen careers. Students were asked to provide a written response concerning the career they expected to enter. Careers were then categorized as science or non-science by the project staff.

Science careers included the following ones: Physicians, dentists, veterinarians, computer scientists, natural scientists, engineers, game wardens, electronic technicians, nurses, therapists, x-ray technicians, and dental hygienists. The results are given in Table 18.

Students in the control school exhibited significantly more interest in science/engineering careers than did students in the limited and full intervention schools, as measured by the Career Interest Survey. Further analysis revealed that the significant difference observed across the three schools was due to significantly higher CIS scores of male students in the control school ($F = 5.147$, $p = 0.010$). However the qualitative assessment of career interest revealed no significant differences among students in the three schools (Table 18). The accuracy of the data in Table 18 was confirmed by analyzing the last five questions of the Career Interest Survey. Those items requested information about the students' high school program, the amount of education they planned to complete, their favorite school subject, and the job group describing their future job interests. No significant differences across students in the three schools were found for those items ($F = 1.141$, $p = 0.324$).

Male students exhibited significantly more interest in science and engineering careers than did female students in the control and limited intervention schools ($t = 1.78$, $p = 0.087$, and $t = 2.55$, $p = 0.015$, respectively). Although males in the full intervention school obtained higher scores on the CIS than did their female counterparts, this difference was not statistically significant ($t = 0.54$, $p = 0.$[illegible]).

TABLE 17

Average Career Interest Survey Scores for Males and Females in Participating Biology Classes of the Control, Limited, and Full Intervention Schools

	CIS SCORE MALES		CIS SCORE FEMALES	
Control	30.13	(15)	21.00	(11)
Limited Intervention	22.56	(16)	15.64	(22)
Full Intervention	19.00	(17)	17.37	(19)

N = 100: Number in parentheses indicates number of students responding.
High score indicates interest in science/engineering careers.
Possible scoring range = 0 - 55.

School Effect: $F = 5.068$, $p = 0.008$.
Gender Effect: $F = 7.780$, $p = 0.006$.

TABLE 18

Percentages of Students in Participating Biology Classes of the Control, Limited, and Full Intervention Schools Who Named Science or Non-Science Careers

SCHOOL	SCIENCE CAREER	NON-SCIENCE CAREER	
Control	46.2%	53.8%	N = 26
Limited Intervention	33.3%	66.7%	N = 36
Full Intervention	31.3%	68.8%	N = 32

$X^2 = 1.584$, $df = 2$, $p = 0.453$.

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Perceptions of Science and Scientists

Stereotyped ideas of science and scientists were measured quantitatively by the Perceptions of Science and Scientists Survey. Student scores on that instrument were analyzed by analysis of variance; the results are shown in Table 19.

A qualitative assessment of students' image of scientists was determined by using the Draw-A-Scientist Test. Students were asked to sketch a picture of their image of a scientist. No other cues were given in the directions to the students. The number of male and female scientists drawn by students in each school was counted and crossbreak analysis was used to determine differences across the schools. The results are shown in Table 20.

No statistically significant differences in PSS scores were found among students in the three schools, nor were significant differences between male and female students observed. However, students in the two intervention schools pictured significantly more female scientists on the Draw-A-Scientist Test than did students in the control school. Further analysis revealed that that difference was due to a greater proportion of female students in the limited (52%) and full (33%) intervention schools drawing female scientists in comparison to girls drawing women scientists in the control school (12%). The chi-square value for the difference was 6.867 with two degrees of freedom, which had a probability of 0.032 of occurring by chance. In addition, three boys (10%) in the full intervention school drew female scientists. Although no boys in the control or limited intervention schools drew female scientists, there was no statistically significant difference among male students in the three schools ($X^2 = 3.873$, df = 2, p = 0.144).

TABLE 19

Average Perceptions of Science and Scientists Scores
for Males and Females in Participating Classes
of the Control, Limited, and Full Intervention Schools

SCHOOL	PSS SCORE MALES		PSS SCORE FEMALES	
Control	123.58	(25)	117.44	(18)
Limited Intervention	119.07	(15)	116.45	(22)
Full Intervention	118.00	(32)	117.80	(23)

N = 134: Number in parentheses indicates number of students responding.
High score indicates <u>less</u> stereotyped perceptions of science.
Possible scoring range = 39 - 195.

School Effect: F = 0.642, p = 0.528.
Gender Effect: F = 1.272, p = 0.261.

TABLE 20

Percentages of Students in Participating Classes
of the Control, Limited, and Full Intervention Schools
Who Drew Male or Female Scientists

SCHOOL	SEX OF SCIENTIST DRAWN MALE	SEX OF SCIENTIST DRAWN FEMALE	
Control	94.9%	5.1%	N = 39
Limited Intervention	69.4%	30.6%	N = 36
Full Intervention	79.2%	20.8%	N = 53

$X^2 = 8.183$, df = 2, p = 0.017

Attitudes Toward Various Aspects of Science

The science attitudes questionnaire measured students' attitudes toward several aspects of science. Factor analysis of Science Attitudes Questionnaire data indicated that the instrument was comprised of four subscales. Cronbach's alpha was used to determine the internal consistency reliabilities of each subscale. The subscales were: perceived usefulness of science (9 items; $r = 0.87$), confidence in science ability (6 items; $r = 0.82$), attitudes toward women in science (7 items; $r = 0.67$), and attitudes toward being successful in science (4 items; $r = 0.17$). Four questionnaire items loaded heavily on more than one factor and were not classified into a subscale. The subscale measuring attitudes toward being successful in science not only had the fewest number of items but also contained two items which were previously classified on the attitudes toward women in science subscale. The confusion of subscale identity among the four items would account for the low reliability of the subscale. Students' scores on the entire instrument and on each subscale were analyzed by analysis of variance. The mean score on the Science Attitudes Questionnaire by students in the control school's general science class was significantly different from the mean score for the general biology students ($t = 2.05$, $p = 0.047$), so data from the general science class was omitted from all of the following science attitudes analyses.

Overall Science Attitudes. No statistically significant differences between male and female students in overall science attitudes were found, but students in the control school had significantly more positive attitudes toward science than students in the intervention schools had (Table 21). Further analysis revealed that males in the control school had more positive science attitudes than males in the full intervention school had ($F = 2.311$, $p = 0.181$); no statistically significant differences were found among females in the three schools.

TABLE 21

Average Science Attitudes Questionnaire Scores
for Males and Females in Participating Biology Classes
of the Control, Limited, and Full Intervention Schools

SCHOOL	SAQ SCORE MALES		FEMALES	
Control	105.93	(15)	104.91	(11)
Limited Intervention	99.27	(15)	94.70	(20)
Full Intervention	96.03	(32)	95.08	(24)

N = 117: Number in parentheses indicates number of students responding.
High score indicates positive attitudes toward science.
Possible scoring range = 30 - 150.

School Effect: F = 3.603, p = 0.030.
Gender Effect: F = 0.479, p = 0.490.

TABLE 22

Average Scores on the "Usefulness of Science" Subscale
for Males and Females in Participating Biology Classes
of the Control, Limited, and Full Intervention Schools

SCHOOL	USEFULNESS OF SCIENCE SCORE MALE		FEMALE	
Control	30.87	(15)	27.45	(11)
Limited Intervention	28.07	(15)	24.45	(20)
Full Intervention	27.34	(32)	27.29	(24)

N = 117: Number in parentheses indicates number of students responding.
High score indicates high perceived usefulness of science.
Possible scoring range = 9 - 45.

School Effect: F = 1.538, p = 0.219.
Gender Effect: F = 2.057, p = 0.154.

TABLE 23

Average Score on the "Confidence in Science Ability" Subscale for Males and Females in Participating Biology Classes of the Control, Limited, and Full Intervention Schools

SCHOOL	CONFIDENCE IN SCIENCE ABILITY SCORE MALES		FEMALES	
Control	21.47	(15)	21.45	(11)
Limited Intervention	21.53	(15)	18.80	(20)
Full Intervention	18.56	(32)	16.33	(24)

N = 117: Number in parentheses indicates number of students responding.
High score indicates confidence in science ability.
Possible scoring range = 6 - 30.

School Effect: F = 7.356, p = 0.001
Gender Effect: F = 4.835, p = 0.030

TABLE 24

Average Score on "Attitudes Toward Women in Science" Subscale for Males and Females in Participating Biology Classes of the Control, Limited, and Full Intervention Schools

SCHOOL	ATTITUDES TOWARD WOMEN IN SCIENCE SCORE MALES		FEMALES	
Control	25.27	(15)	27.00	(11)
Limited Intervention	23.47	(15)	25.50	(20)
Full Intervention	23.94	(32)	26.46	(24)

N = 117: Number in parentheses indicates number of students responding.
High score indicates positive attitudes toward women in science.
Possible scoring range = 7 - 35.

School Effect: F = 1.340, p = 0.266.
Gender Effect: F = 8.735, p = 0.004.

TABLE 25

Average Scores on "Attitudes Toward Success in Science" Subscale for Males and Females in Participating Biology Classes of the Control, Limited, and Full Intervention Schools

SCHOOL	ATTITUDES TOWARD SUCCESS IN SCIENCE SCORE MALES		FEMALES	
Control	14.80	(15)	15.82	(11)
Limited Intervention	13.33	(15)	14.60	(20)
Full Intervention	14.66	(32)	13.92	(24)

N = 117: Number in parentheses indicates number of students responding. High score indicates positive attitude toward achieving success in science. Possible scoring range = 4 - 20.

School Effect: $F = 2.179$, $p = 0.118$.
Gender Effect: $F = 0.223$, $p = 0.637$.

Usefulness of Science Subscale. No statistically significant differences in students' perceived usefulness of science were found (Table 22).

Confidence in Science Ability Subscale. A highly significant difference in students' confidence in their own scientific ability was found (Table 23). Students in the full intervention school had significantly less confidence in their scientific ability than did students in the control school. This difference was apparent among both boys in the three schools and girls in the three schools. That is, males in the full intervention school had significantly less confidence in their scientific ability than did males in the other two schools ($F = 3.485$, $p = 0.037$), while females in the full intervention school had less confidence in their scientific ability than did females in the control school ($F = 4.440$, $p = 0.017$). The response of students on this subscale echoed their responses on self-perceptions of scientific ability (see Table 16). In all three schools, male students had significantly more confidence in their scientific ability than female students had.

Attitudes Toward Women in Science Subscale. Students in the three schools exhibited no significant differences in their attitudes toward women in science; however, females in the three schools had significantly more positive attitudes than males did (Table 24).

Attitudes Toward Success in Science Subscale. Although no statistically significant differences in students' attitudes toward achieving success in science were found (Table 25), analysis indicated that females in the control school had significantly more positive attitudes toward science success than did females in the full intervention school ($F = 2.633$, $p = 0.082$).

Extracurricular Science Experiences

The final survey administered measured the extent of students' participation in science activities when they were *not* required for a class. Although the intervention programs did not directly address this issue, it was hoped that stimulating science interest in class would lead students to select more extracurricular science activities. The results of analysis of data from the Science Experiences Survey are given in Table 26.

TABLE 26

Average Science Experiences Survey Scores for Males and Females in Participating Biology Classes of the Control, Limited, and Full Intervention Schools

SCHOOL	SES SCORE MALES		SES SCORE FEMALES	
Control	81.84	(25)	78.89	(18)
Limited Intervention	95.93	(15)	76.50	(20)
Full Intervention	88.28	(32)	82.09	(23)

N = 135: Number in parentheses indicates number of students responding.
High score indicates more extracurricular science experiences.
Possible scoring range = 40 - 160.

School Effect: $F = 1.429$, $p = 0.243$.
Gender Effect: $F = 9.191$, $p = 0.003$.

No statistically significant differences among students in the three schools were found (Table 26). Males participated in significantly more extracurricular science activities than did females across all schools.

Summary of Science Attitude Differences

Students in the control school scored higher (more positive) on all quantitative measures except the Science Experiences Scale than did students in the two intervention schools. Statistically significant differences among students in the three participating schools were found for scores on the Career Interest Survey, Science Attitudes Questionnaire, and the Confidence in Science Ability subscale of the Science Attitudes Questionnaire. Students in the control school exhibited more positive responses toward science on those measures than did students in either of the intervention schools. Except for the scores on the Confidence in Science Ability subscale of the Science Attitudes Questionnaire, significant effects were due to significant differences in the responses of males in the three schools; i.e., no significant differences among females in the three schools were observed.

The two qualitative measures showed a mixed pattern of results. No statistically significant differences in proportions of students naming science careers as their expected careers were found among students in the three schools, although more students in the control school named science careers than did students in the intervention schools. A significant difference among students in the three schools was observed in the results of the Draw-A-Scientist Test. A greater proportion of pictures of women scientists were drawn by students in the intervention schools than by students in the control school.

Significant gender differences were observed frequently. Males received significantly higher scores than females on the Confidence in Science Ability subscale of the Science Attitudes Questionnaire and the Science Experiences

Scale. In addition, male students in the control and limited intervention schools exhibited significantly more interest in science and engineering careers on the Career Interest Survey than did female students in those schools. A significantly greater proportion of females drew women scientists than did males, and females, compared with males, scored significantly higher (more positive) on the Attitudes Toward Women in Science subscale of the Science Attitudes Questionnaire.

Science Achievement and Science Plans

Biology Semester Grades

Science achievement was measured by students' semester biology grades. The proportions of students in each school who earned letter grades "A" to "F" are shown in Table 27.

TABLE 27

Percentages of Students in the Participating Biology Classes of the Control, Limited, and Full Intervention Schools Who Received the Indicated Semester Grades

SCHOOL	GRADE A	B	C	D	F	
Control	32%	32%	/ 16%	20%	0%	N = 25
Limited	13%	34%	32%	18%	3%	N = 38
Full	2%	29%	34%	34%	0%	N = 58

No statistical analysis of the data in Table 27 was made because the grades were based on different tests, quizzes, and homework assignments in each class. However, examination of the data in Table 27 revealed differences among the schools. For example, twice the proportion of students in the control school, compared with those in the limited intervention school, received "A" grades. Likewise, students in the control school were 16 times more likely to receive

"A" grades than were students in the full intervention school. Almost twice the proportion of students in the full intervention school, compared with those in the control school, received grades of "C" or below. The proportion of students receiving "A" or "B" grades in each school (64% of control school students, 47% of the limited intervention school students, and 31% of the full intervention school students) paralleled the pattern of differences found in students' responses to the attitude surveys. The relation of the attitude survey results to students' achievement levels in their biology classes will be explored in a later section.

Students' science coursework plans were determined because one of the principal goals of the SCORES program was to encourage students to keep their career options open by completing the high school mathematics and science courses required to pursue a science major in college. The goal was evaluated qualitatively by requesting that students prepare their anticipated high school course schedules. Project staff quantified student plans to take elective science courses by determining the proportion of students in each school who self-reported that they planned to take chemistry before high school graduation. The results of this analysis are presented in Table 28.

TABLE 28

Percentages of Students in the Participating Biology Classes of the Control, Limited, and Full Intervention Schools Who Intend to Take High School Chemistry

SCHOOL	PLAN TO TAKE CHEMISTRY	DO NOT PLAN TO TAKE CHEMISTRY	
Control	56%	44%	N = 25
Limited	86%	14%	N = 35
Full	80%	20%	N = 33

$X^2 = 7.79C$, df = 2, p = 0.020

A significantly greater proportion of students in the limited and full intervention schools, compared with the proportion in the control school, planned to take high school chemistry (Table 28). These differences should be interpreted cautiously. Official schedules for each student were planned in the spring semester for the following year only; thus, many students did not know what courses they would take and reported only their favorites.

DISCUSSION

The project staff collected information about the science interests of students in the three schools from student interviews and classroom observations in addition to the survey data. That information will be used in the interpretation of the project's results. Pretest data was collected from a cohort group of students in the Spring, 1985 semester as well. Recent research literature describes the influence a variety of factors exert on secondary school students' attitudes toward and achievement in science; the results of those studies also will aid data interpretation.

Pretest Results

The fact that control school students scored higher than intervention school students on most attitude surveys was not entirely unexpected. Analysis of pretest data collected from the cohort students in the control and full intervention schools during the Spring, 1985 semester yielded similar results. Although pretest data for the limited intervention school was not available for the Perceptions of Science and Scientists survey or the Science Attitudes Questionnaire, pretest data for the Science Experiences Survey was collected from all three schools. The Career Interest Survey was not administered to the cohort students.

The control school cohort obtained significantly higher scores than did the full intervention school cohort on the Science Attitudes Questionnaire and the

Confidence in Science Ability subscale of that instrument ($F = 4.207$, $p = 0.046$ and $F = 11.101$, $p = 0.002$, respectively). The control school cohort also scored higher than did the full intervention school cohort on the Perceptions of Science and Scientists survey, although that difference was not statistically significant. Analysis of the Science Experience Survey pretest data yielded the same pattern found later in the actual study; that is, the limited intervention school cohort received the highest scores, followed by the full intervention school cohort, followed by the control school cohort. Those differences were not statistically significant. In summary, pretest results indicated that the attitudes of the control school students were more positive than the attitudes of the intervention school students. Appendix 6 contains tables of the pretest results.

Qualitative Evaluation

Qualitative measures in addition to quantitative measures were used to evaluate the intervention program. Project staff members believed that a combination of quantitative and qualitative evaluation would yield the most information. The information from student interviews and classroom observations not only aided interpretation of the quantitative results, but also extended the evaluation of the program. The insight gained from those methods is described in the following sections.

Student Interviews

Randomly selected students from each school were interviewed at the end of the intervention program. They were asked about their feelings toward science in general, toward women in science, and toward their biology class. The interviews revealed very few differences among students in the three schools. A scientist was generally stereotyped as a "smart," "older man," who is "lonely," and "works in the lab all the time." Almost all students seemed to feel that it was good that more women were going into science, although several noted that "Men like science better than women," or "Men are smarter than women in science." Students in the full intervention school exhibited somewhat less confidence in their scientific ability ("I heard chemistry was hard," and "I'm not smart enough to be a scientist") than students in the other schools did. Students in the limited intervention school seemed somewhat more convinced than their peers at the other schools of the usefulness of science. Boys, in general, felt science would be more useful in their futures than did girls.

All three teachers enjoyed good rapport with their students. Students in the control and full intervention schools stated that their teachers gave good examples and explained topics well. One student in the control school noted that the teacher "doesn't make you feel stupid when you ask questions." Students in the limited intervention school had more ambivalent feelings toward their teacher, although they stated that they enjoyed the laboratory exercises he had developed.

Classroom Observations

Students' perceptions of their biology classes were corroborated by observations made by the project staff. The teachers were relaxed with their students but insisted that pupils be attentive to the classroom discussion or activity. The control school teacher tended to stress the use of "algorithms" and questions with one "right" answer. Although students in all three schools seemed to want an algorithm or "the right answer," the limited and full intervention school teachers emphasized problem solving, rather than rote memorization. Students in the control school liked their teacher, but they also displayed some disrespect for him. One student interviewed stated that her teacher should "...make the kids treat him with more respect."

The control school teacher expressed some anxiety toward having his classes observed. He jokingly told project staff members that he had "cleaned his room" the day before the scheduled observation and that he had warned his students not to "make me look bad." The other teachers were more at ease with classroom observations and proceeded with class as if the staff members were not present. Students knew that they were participating in a university project and that the surveys they completed were part of the project. It is the opinion of project staff members that the control school teacher's anxiety and students' loyalty to their teacher caused the control school students to express more positive attitudes toward science than they may actually have held. The control school students' positive attitudes were not translated into the same degree of positive behavior toward science when they stated their expected careers and their plans to continue science coursework in high school (Tables 18 and 28).

Research Literature

Research evidence has indicated that classroom strategies can effectively increase student interest in science; however, it also has indicated that demographic factors have a stronger effect on students' attitudes. Schibeci and Riley (1986) have reported that gender, race, home environment, amount of homework, and parents' educational levels significantly affect high school students' attitudes toward and achievement in science (1986). Only one of these variables, amount of homework, can be altered by the teacher. Similarly, Staver and Walberg have found that "fixed" factors, such as family income, parental expectations, and family composition, explain all but 1% of the accountable variance in science achievement among tenth-grade students in the "High School and Beyond" project.

Although the results described above suggest that intervention strategies which act within the classroom have little effect on students' science attitudes when compared with other student characteristics, other studies have indicated that classroom environment can significantly affect students' attitudes. Talton and Simpson (1985) have found that students' perceptions of their science teacher as encouraging and concerned are not significant predictors of secondary school students' attitudes toward science. However, emotional climate of the classroom, classroom activities, attitudes toward other students in class, and attitudes of students' friends toward science did correlate positively with students attitudes toward science. Two variables studied in the "High School and Beyond" program which may be altered by secondary school educators were significantly correlated with students' science achievement. They are the quantity of advanced academic courses completed and a lack of stress in academic courses (Staver and Walberg, 1986).

Project SCORES was designed to affect students' science attitudes through changes in the classroom environment. Unfortunately, the program was required to overcome preexisting differences in students' backgrounds in a very short period of time. For example, fewer students in the full intervention school, compared with those in the control or limited intervention schools, perceived encouragement to pursue science and engineering careers from their parents or significant others (Table 12). It was, therefore, not surprising that the full intervention school students held less positive attitudes toward science than the control and limited intervention school students held. The research studies that reported significant differences in students' attitudes due to aspects of the classroom environment indicated, however, that the goal of Project SCORES to encourage positive science attitudes through classroom activities was not unrealistic. A longer intervention might be required to observe these changes.

A compounding factor was the observed relationship of students' self-assessment of ability to both their attitudes and their achievement levels. Students in the full intervention school had significantly lower self-perceptions of academic and science ability than did the control and limited school intervention students (Tables 15 and 16). The full intervention students also had the lowest proportion of semester grades above an average "C" grade (Table 27) and, in general, held more negative attitudes toward science than did the students in the control and limited intervention schools (Tables 21 to 25).

Several studies have explored the relationship between attitudes and achievement. In a meta-analysis of studies on science attitudes and achievement, Haladyna and Shaughnessy (1982) have found a consistent, but weak association of the two attributes. A study of attitudes toward biology, achievement in biology, and self-perception of academic ability among community college students found significant, positive correlations between achievement and attitudes, but even stronger correlations between achievement and academic self-concept (Mitchell and Simpson, 1982). Bloom (1976) has noted similar findings in a synthesis of research studies relating student characteristics and learning. In fact, he grouped subject-related interests, school-related attitudes, and academic self-concept together in the "affective characteristics" category, explaining that those three aspects of affect were highly interrelated by the end of the primary school grades. Bloom felt that academic self-concept was the best index of affective characteristics because the correlation between affect and achievement was not strengthened by the addition of subject-related or school-related affect measures to academic self-concept measures (p. 97). He has stated that "...the major factor influencing affect in the school is the student's perception of his [sic] competence in school learning" (p. 140).

The results of Project SCORES has supported Bloom's suggestions. Comparatively lower perceptions of academic and scientific abilities among the full intervention school students were accompanied by lower achievement levels and less positive science attitudes. It was interesting to note that students' self-reports of ability were obtained at the beginning of the intervention, while the achievement and attitude measures were collected at the completion of the program. Therefore a causal effect of academic self-concept at the beginning of the semester on attitudes and achievement at the end of the semester was hypothesized. Bloom (1976) has proposed that success/failure experiences over a number of years lead to a student's generalization about him/herself as a learner. He noted that once affect has developed in the first few years of a student's experience with a subject it is unlikely to change rapidly thereafter (p. 85). Thus, a cyclical relationship is developed. School achievement affects both students' attitudes toward and self-perception of ability in a subject. Attitudes and academic self-concept, in turn, affect achievement in future courses. The SCORES intervention programs intersected this cycle. It may be due to the SCORES program that the full intervention school students obtained significantly lower scores on as few of the attitude measures as they did.

SUMMARY

Successful Outcomes

The project staff is convinced of the importance and necessity of the SCORES program. The SCORES program was run concurrently with another project for high schools in suburban, small city, and inner city communities. Students in the rural schools of the SCORES program consistently received lower scores on the survey instruments than did those in the other environments. Thus, there is a special need for programs stressing positive attitudes toward science and information about science careers among students in rural areas.

Project SCORES was successful in several respects. It had at least a short-term positive effect on students' willingness to picture science as an appropriate career for women (see the results of the Draw-A-Scientist Test, Table 20). In addition, the gap between males' and females' science career interests was reduced to a statistically non-significant level for students in the full intervention school (see Table 17). Observations of changes in teacher behavior indicated that the intervention teachers were sensitized to subtle classroom biases affecting their female students. Both intervention teachers began to use inclusive language ("he or she"), at least in the presence of project staff members. During one observation of the full intervention school class, the teacher questioned his students during a lecture in order to maintain student participation in the class. While male students volunteered to answer the questions, female students did not. This pattern effectively excluded girls from classroom participation. However, the teacher refused to allow this passive resistance by girls and began calling on them to answer his questions. Soon, girls as well as boys were volunteering to answer questions.

The project also provided resources for the selection or development of materials which could be used to create unbiased, stimulating classroom environments. Those materials were evaluated by staff members and classroom-tested by the intervention teachers.

Recommendations

The following major points were identified as critical for further work, and will be incorporated into future research. In addition, adaptations and refinements of the SCORES model will be based upon them.

1. Include more rural schools in the study for a more effective evaluation of the SCORES program.

2. Use the "limited" intervention strategy. Because the activities used in the full intervention program were not specifically requested by the teacher, they often did not flow with his curriculum and thus were not as effective as they might have been. Use of the "limited" intervention format would not only allow more teacher-control of the program but also would allow project staff to devote more time to gathering, developing, and evaluating resources for the teacher.

3. Implement an intervention program of longer duration. A program lasting at least one academic year is suggested.

4. Search for and develop resource materials that describe technical careers which do not require a four-year college degree.

5. Search for and develop materials which describe non-career-related aspects of science which are relevant to students' lives.

6. Search for and develop more "girl-friendly," relevant laboratory activities.

REFERENCES

Berryman, S.E. (1983, November). Who will do science?. Washington, DC: The Rockefeller Foundation.

Bloom, B.S. (1976). Human characteristics and school learning. New York: McGraw-Hill Book Company.

Donovan, E.P., Frank, R.H., & Horton, P.B. (1985). A new science and engineering career interest survey for middle school students. Journal of Research in Science Teaching, 22, (1): 19-30.

Fennema, E. & Sherman, J. (1976). Fennema-Sherman mathematics attitudes scale. JSAS Catalog of Selected Documents in Psychology, 6(1): 31. (MS. #1225).

Haladyna, T., & Shaughnessy, J. (1982). Attitudes toward science: A quantitative synthesis. Science Educaton, 66(4): 547-563.

Kahle, J.B., & Lakes, M.K. (1983). The myth of equality in science classrooms. Journal of Research in Science Teaching, 20, 131-140.

Kahle, J.B. (Ed.). (Fall 1983). Girls in school: Women in science. Washington, DC: National Science Board, Commission on Precollege Education in Mathematics, Science & Technology (No. 83-SP-0798).

Kahle, J.B. (Principal Investigator). (1985). Science education for rural girls: Educational equity through master teaching. (Proposal). Washington, DC: National Science Foundation (NSF No. SEE-8470523).

Mitchell, H.E., & Simpson, R.D. (1982). Relationships between attitudes and achievement among college biology students. Journal of Research in Science Teaching, 19(6): 459-468.

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

Staver, J.R., & Walberg, H.J. (1986). An analysis of factors that affect public and private school science achievement. Journal of Research in Science Teaching, 23(2): 97-112.

Talton, E.L., & Simpson, R.D. (1985, April). Relationships of attitude toward classroom environment with attitude toward and achievement in science among tenth grade biology students. Paper presented at the annual meeting of the National Association for Research in Science Teaching, French Lick, IN.