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ABSTRACT

The purpose of this study is to compare the academic performance of male and female students in high school elective science courses. The data for this study were drawn from the grade books of six teachers of elective science courses and consists of the grades earned by the males and females during one academic year. The number of students enrolled in the course, the average grade, standard deviation of grades, and pooled standard deviations were recorded. A summary of the average grades (male, female) and two-sample t-test results for each class by semester are included. Contains 44 references. (Author/DDR)

A STUDY OF THE ACADEMIC PERFORMANCE OF MALE STUDENTS COMPARED TO FEMALE STUDENTS IN SECONDARY ELECTIVE SCIENCE COURSES

A Thesis

Presented to

The Faculty of the Master of Arts Degree Program

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by

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Abstract

The purpose of this study is to compare the academic performance of male and female students in high school elective science courses. This study involved the males and females in the junior and senior classes. These elective science courses were selected by the students in these classes. The sophomores are required to enroll in a coordinated science course.

The schedules of the six teachers involved, and the number of male students and female students enrolled in the course during a particular class period, are placed in table form in Chapter 3. The duration for each course is also included.

The data were collected from the grade books of six teachers of the elective science courses. This study used the grades earned by the males and females during the 1995-96 school year. The duration of each course was one year or two semesters. Observations were made of the final grades earned by the male students and the female students for each semester in each class. The number of students enrolled in the course, the average grade, standard deviation of grades and pooled standard deviations were recorded. A summary of the average grades (male, female) and two-sample t-test results for each class by semester are included.

CHAPTER 1

Introduction

State and national goals call for increased competency by our graduates in mathematics and science. These goals reflect the concern that our students do not compare well in mathematics and science with other industrialized nations, and that our future as a nation depends on the competence and understanding of mathematics, science, and technology (Hennes et al, 1992).

The role of the female in science has not kept pace with the expanding effect of science and technology on society. A concerted effort is needed by all educators to change the attitude of early adolescent females toward science and their roles in the scientific community. Educators must make a conscious effort to eliminate the unconscious bias that exists in classrooms toward women in science (Manitoba Department of Education and Training, 1991).

The purpose of this study was to investigate the performance of females as compared to males in secondary elective science classes. The following question was answered by the study: Would the academic performance of males be higher than that of females? The study compared grades from the first semester of the 1995-96 academic school year. The study involved only the eleventh and twelfth grade students for that school year. There were 351 male students enrolled in these classes and 369 females. The study took place at Greenbrier East High School in Fairlea, West Virginia. The sophomore science students are required to take a coordinated science class while the juniors and seniors are allowed to enroll in classes of their choice. Seven science teachers were involved in the study, with three them teaching only elective classes: Chemistry I, Chemistry II, Physics, and Chemistry Honors. The other four teachers taught both elective courses--Biology II, Anatomy, and Earth-Space Science--and the required coordinated science classes for sophomores.

Research Question:

1. Are grades equivalent between males an females in elective science classes?

Teachers should be aware that habit and tradition may result in different teacher expectations for girls than for boys, and that the students' own expectations may be reflected in their success rates. Studies have shown that boys receive considerably more teacher feedback, occupy more physical space, are more critical of girls and each other, and generally assume the leadership role in a mixed group (Manitoba Department of Education and Training, 1991, p. 74).

As a group, girls have a more negative attitude than boys toward science. Fewer girls than boys study science in school, and girls' achievement on standardized tests of higher-level science skills is considerably less than boys' (Dalton, B., Rawson, P., Tivnan, T., S Moroco, C.C., 1993)

Definitions

EARTH-SPACE SCIENCE, GENERAL: "A first-level course addressing the fields of astronomy, geology, meteorology, and oceanography, using the knowledge and concepts in these fields to understand the earth in relationship to the large environment of time and space" (Hennes et al., 1991, p. 81).

ANATOMY: "A second level course to understand the structure and function of body systems, including support, digestive, circulatory, respiratory, excretory, nervous, endocrine, and reproductive" (State of Connecticut Department of Education, 1991 p. 1).

CHEMISTRY 1ST YEAR: "A first level course that uses the knowledge of scientific principles and concepts to understand the composition and properties of substances and the reactions by which substances are produced and/or converted into other substances" (p. 81).

CHEMISTRY 2ND YEAR: "A second level college preparatory course that builds on Chemistry I. It may be a broad field coverage of chemistry or a more specialized offering in one or more areas of chemistry, such as Organic Chemistry, biochemistry, or Analytical Chemistry" (p. 81).

CHEMISTRY HONORS: "A second level college preparatory course that requires a project design that will fulfill the course requirement.

PHYSICS: A first level course that uses knowledge of basic principals and concepts to understand the characteristics of matter and energy and how they are used in the physical world.

TEACHER: "Any full-time or part-time teacher whose primary assignment is teaching in any grade K-12" (Bobbitt, 1990 p. 110).

STUDENT: Any individual who engages in educational activities for the purpose of acquiring knowledge, skills, or values in any area.

SEMESTER: Any two nine-week sessions of the academic school year.

MSE: An acronym for "mathematics, science, and engineering" (Clewell, Anderson and Thorpe, 1992, p. 3).

Hypothesis

The mean scores of males and females will show no significant difference.

Variables

The courses used in this study were all elective courses and did not include the regular coordinated science classes of sophomores. The courses were in Earth-Space Science, Biology II, Anatomy, Chemistry I, Chemistry II, Chemistry Honors, and Physics. The study was conducted for the 1995-96 first semester school year at Greenbrier East High School in Fairlea, West Virginia. The study included the males and females of the junior and senior classes.

CHAPTER 2

Literature Review

The purpose of this study was to investigate the academic performance of females as compared to males in secondary school elective science courses. This chapter will review the literature in the academic performance of males and females as well as the existing studies measuring the academic performance of male and female students' evaluation.

In recent years, the graduation requirements in mathematics and science have expanded in response to state and national goals calling for increased competency by United States graduates in those areas (Hennes et al, 1992). According to Campbell (1992) just because a program exists does not mean that it is doing a good job. Programs created with the best of intentions may have no positive impact or may even have negative effects such as making girls feel that combing a science career with a family is just too much work. Teachers can assure that textbooks, reference materials, films, videos, and visual displays give equal consideration to both sexes in career and lifestyles portrayals. They can question not just the content of a curriculum, which often ignores or gives little attention to women's contributions, but the context or knowledge, which often predetermines what is seen as male and what is seen as a contribution are synonymous. Teachers can encourage projects which recognize skills and interests of both sexes and discourage put-downs or devaluing of "female" interests by male students (Manitoba Department of Education and Training, 1991, p. 74).

Changing Attitudes

Girls' self-selection out of science is a serious issue and negatively impacts their career choices later in life. The aim of the Cranbrook/Oakland project, "Girls in Science," is to prevent this self-selection process by enlightening teachers to be more gender equitable in their own classrooms. Implementation of gender-fair practice by teachers sends the message to their female students that their input is valued. This practice can have only a positive impact on continued participation by girls in science (Oakland University, 1997).

There is no place for bias of any kind in our public schools. But ask any female and they will tell you that gender bias against girls occurs in our school systems today. Like most bias situations, gender bias occurs because we, for the most part, inadvertently bring about unequal treatment of some of the children who we are attempting to teach and inspire to do their best (Perry, 1997).

Several simple adjustments in attitude and approach will help to make a difference:

- Demystify the profession and its view of itself
- Make way for a new group of students-- the "high verbals." Most women first demonstrate verbal skills--this too, is important in science. Motivation and high verbal scores can lead to high physical science scores. The idea that people will be good at just one type of knowledge (i. e. science, math, or humanities) is unfair to science and to students. It minimizes the importance and advantages of high verbal aptitude in science.
- Re-evaluate the significance of an early interest in science. Motivating students with a delayed interest is important in recruiting scientists.
- Provide role models for girls to emulate and to stimulate their motivations. Models of young women scientists who have survived college or are "living the life of the mind." Allow for a fourteen-year window of personal identification--women in their twenties are the most viable role models for young girls.
- Make persistence and hard work the success variables in science, not just a predetermined talent.
- Redefine a life in science. Foster the sense of mystery and meaning in science with which women identify. Validate the "Eureka" moments (Education Digest, 1994).

Role Models

Adults and peers serve as role models and may exert a powerful socializing influence that can serve as a positive force for promoting favorable attitudes. Therefore, providing students with opportunities to have contact with models who have favorable attitudes and experiences in science and mathematics may be an effective way to encourage students' participation and achievement in these areas. Research studies have also reported an association between role models and students' attitudes and career choices. One such study reported that exposing students to women scientists positively influenced both male and female students' attitudes toward scientists in general and toward female scientist in particular. Other investigations have underscored the effectiveness of peer models in reducing role stereotypes. In a study that asked college students and professionals to reflect on why they had chosen their professions, both females and minorities indicated that role models were important factors in their decisions to pursue their respective careers. Studies that support the positive influence of role models on students' attitudes and career choices include Armstrong (1980), Tennema and Sherman (1978), Parsons, Adler, and Kaczala (1982), Smith and Erb (1979), Scott and Feldman--Summers (1979), Ashby and Wittmaier (1978), Casserly (1975), and Thomas (1986) (Clewell, et al., 1992).

Mentoring

Mentoring has also been found to be highly effective in providing the encouragement and support needed for students to pursue in science or math. Mentors, who develop a sustained personal relationship with young minority and/or female students, not only serve as role models but also provide personal guidance, support, and direction for decisions and actions. Their role is to counsel young students to persist and succeed in their math and science studies and career goals. In addition to peer mentors, the Mathematics Engineering Science Achievement (MESA) program, operating through seventeen college campuses in California, provides several adult mentors. These mentors are program advisers who are typically mathematics or science teachers who direct all project activities.

In addition to arranging project activities (which may include club meetings, study groups, peer tutoring, community service activities, and field visits) they develop close personal relationship with their students. These advisers monitor student performance and provide students with academic and personal counseling to help them to persist and do their best (Clewell, et al., 1992).

Career Awareness

Females and minorities need to change their image of mathematicians and scientists. During adolescence, when students are building a more stable picture of themselves, consideration of a career is mainly a matter of finding an occupational role in which they can express themselves in a manner consistent with their concept of self. This suggests that as students develop a positive self-image and have confidence in their ability to do well in math and science, they are more likely to consider science-related careers as a possible occupational choice. Addressing career development needs through career awareness activities at the middle school level will help to foster vocational maturity and career competence. Career awareness activities for intervention programs during the middle school years include self-exploration and vocational planning activities that allow students to learn about career options. Career guidance during this period should take the form of exploring occupations and personal interests, not making vocational decisions. These activities span from learning about careers through readings or discussions with knowledgeable professionals or through direct exposure of internships (Clewell, et al., 1992).

There is strong evidence that seeing adults with whom they can identify in nontraditional occupations increases students' acceptance of these occupations and their willingness to prepare for them. Therefore, visuals can aid greatly in eliminating stereotypes as well as providing career information. Videotapes and films are often used at career days and career conferences for girls as a way of presenting female role models in the math and science world (Clewell, et al., 1992).

Some projects develop or collect materials that provide information on various non-traditional careers. For example, MESA maintains a library of career awareness materials for use by intervention programs. Many programs use guest speakers to persuade female and minority students to consider an array of career options in math and science. The lecturer serves as a positive role model and a career informant (Clewell, et al., 1992).

Conferences are another means for giving students contact with mathematicians and scientists. Various counseling strategies are used to improve female and minority students' motivation and preparation to enter scientific and technical careers (Clewell, et al., 1992).

Industry tours provide an opportunity for students to interact with role models as well as exposing students to career options. Industry tours and presentations are part of the students' activities of the Engineering Summer Institutes. The tours provide students with information about opportunities in engineering and its work environment. This strategy offers interaction on a one-to-one or small-group basis with practicing engineers in their actual work environments. The tours generally consist of a presentation from an engineer and/or executive staff member, a question-and-answer session, a guided tour, and lunch. Such a strategy is particularly useful in helping students not only to consider careers in these disciplines but also to understand the necessity of electing appropriate math and science courses during high school. Internships increase students' motivation to pursue majors in math and science by giving them first-hand knowledge of the challenges and rewards of scientific careers (Davis and Humphreys, 1985).

Internships help to familiarize students to the world of work. Often they provide an opportunity for first work experience and may result in valuable contacts, letters of recommendation, and even paid employment in the future. These field experiences give students an opportunity to determine whether they like a particular career. Understanding that minority and female students typically have very limited criteria by which to judge careers and job environments, some intervention programs have a student internship program to give students both information and experience. The goals of such programs are to prepare students for the technical work environments, reinforce their academic skills, and aid their economic development. Students are placed with companies for a short period of time during the summer (Clewell, et al., 1992).

Currently, researchers are examining socio-cultural factors that may contribute to the disparity in science performance between girls and boys. For example, in most cultures, science is defined in masculine terms. Additionally, differences have been found in the amounts and kinds of informal experiences boys and girls have with science and in the treatment and interactions they receive in the classroom (Dalton et al., 1993).

Several studies provide evidence that young girls have different and fewer out of school experiences with scientific phenomena, and that these are just as important for the student learning as more formal school experiences (Kahle and Lakes 1983). Based on interviews with twelfth grade students to determine the knowledge base they used to answer questions on a standardized science achievement test, Erickson and Tarkas (1991) found that females referred more to school based experience while males referred more to out of school experiences to explain their answers. The achievement of boys on this measure exceed that of girls. The author concluded that boys are able to supply the science knowledge they attain from out of school experiences to a broader range of tasks than girls, who draw upon predominately school experiences (Dalton et al., 1993).

Differential treatment by teachers and the way that boys and girls interact and participate in the science classroom have also been shown to contribute to differences in performance and interest in science. One explanation for the differential treatment by teachers is their perception that boys have stronger scientific abilities than girls. In one study, Shepardson and Pizzini (1992) found that teacher bias resulted from their inclination to ask boys more open-ended questions, such as experimental procedures and observations. Observations of high-school science classes (Jones and Wheatly 1989: Haggerty, 1987)revealed that males tend to manipulate the equipment more during labs while the females watch. These authors suggest that this pattern of performance reflects males' perceptions that "doing" science means finding the right answers. Males are also more likely to attempt responses to questions even when they are unsure of the correct answer, enabling the teacher to prompt and guide them to a more accurate response. In contrast, females tend to take fewer risks in volunteering an answer if they are unsure about its "correctness" (Haggerty, 1991). As a result, fewer girls than boys actively participate in and demonstrate scientific activities and experiments (Dalton, et al., 1993; Kahle, 1985).

A study of the comparison of the effect of gender on fourth-grade students' learning in hands-on science was part of a three-year classroom-based project in six urban and two suburban classrooms over a two-month period. The project compared two hands-on approaches to teaching electricity-supported inquiring science and activity-based science in six urban and two suburban classrooms over a two-month period. Results of the original study clearly demonstrated that hands on science benefited student leanings, and that the supported inquiry approach was particularly beneficial. Of special interest was the fact that hands on science benefited students with and without learning disabilities, low and high achieving students, and urban and suburban students. The positive results for these learners considered "at risk" in science suggested that these approaches to hands-on science might also benefit girls. Both approaches include features identified in previous research on programs that are successful in encouraging girls in hands-on activities, allowing them to become full partners in the discovery process and putting them in charge of their learning (Dalton, et al., 1993 p. 3; Ellis, 1992; Frederickson and Nicholson, 1991; Kahle, 1985, p.3).

Teachers of elementary and secondary mathematics and science classes have been the focus of increased attention in recent years. Many policy analysts argue that in order to prepare the nation's children to compete in the global economy of the 21st century, improvements in the teaching and learning of mathematics and science must become priority (Bobbitt, 1990).

In the past decade, many have called for educational reform in the United States. Parents, teachers, and educational professionals have called for innovative programs to English, mathematics, and science. Typically, these demands have only led to more hours added to the school day or more days added to the school year. The American Association for the Advancement of Science (1989), in its Project 2061 Report: Science for All Americans stated that "A fundamental premise of Project 2061 is that schools do not need to be asked to teach more and more content, but rather to focus on what is essential to scientific literacy and to teach it more effectively" (p. 4). This indicates that a new method of teaching is needed (Conners & Elliot, 1993 pp. 4-5).

The traditional feminist analysis of the factors that made science an unlikely career choice for women began by documenting the long history of discrimination faced by female scientists. The analysis then focused on socialization and gender stereotypes--how little girls were encouraged to play with dolls and deprived of such toys as Erector or Mecchano sets. In high school science labs, feminists noted, girls recorded data and wrote up reports while boys dissected frogs and wired up circuits with capacitors and galvanometers (Education Digest, 1994).

The moral of all this was clear, but daunting for reformers: For women to feel at home in science, special initiatives to make it accessible and interesting to girls would have to be systematically reinforced all the way through graduate school and the early years of post doctoral training (Education Digest, 1989).

Intervention Strategies

Ann O'Meara, chair of the Science Department at Massachusetts all-girl Winsor School, says, "One of the joys of watching science is watching our students move from concrete to abstract thinking." Science and math have been an important part of the curriculum at Winsor for nearly a century. Teachers have continued to develop a classroom style of "what works best for girls." Because of this, the school is in the middle of one of the most exciting stories in American education (Education Digest, 1995).

A decade of national research on gender difference in learning has documented that girls assimilate information differently than boys. More distressing is the recent report that widespread classroom bias favors boys. Coeducational classes tend to change girls by ignoring their unique learning styles and ways of knowing. Nowhere is the disparity in attitudes, persistence and achievement more apparent than in the traditionally male bastions of math and science. Suddenly girls' schools are regarded as successful models for teaching these disciplines. Girls' schools across the country are enjoying new recognition (and increased admissions applications) for their achievements. At most of these schools, students take four years of math and choose at least three years of science. A high percentage of girls take advanced placement courses in biology, physics, chemistry and calculus (Education Digest, 1995).

Many schools have joined Winsor in supporting the National Coalition of Girls' Schools, where we have found a forum and a voice to promote our perspective. The word is out about what we do. We asked fellow coalition members to tell about their math and science programs and give examples of especially successful teaching methods and classroom styles. Though the schools differ in size and grades, their answers were remarkably consistent. Below are some of the "girl friendly" classroom techniques that can help nurture a new generation of female scientists and mathematicians (Education Digest, 1995).

1.) Cooperative and collaborative learning

Working in small groups and sharing information and thought processes respects girls' interest in connectedness and enhances mutual understanding. Students have a chance to learn, practice, and then teach one another. Peer teaching is especially effective. Group learning is natural for girls and begins at an early age. Girls at the National Cathedral School in Washington, D.C., like their counterparts in girls' schools all over the country, design their own science experiments in groups. Pairs of lab partners sometimes compile findings to report to the class as a whole. Science chair, Margaret Jollow, notes that peer teaching at Ashley Hall School, South Carolina, is no longer casual, but assigned, building "research, organization, and presentation skills." The school also encourages joint laboratory projects between grades (Education Digest, 1995).

In a collaborative all-girl setting, it is easier to foster the longer response time some girls need to formulate an answer. Several teachers told us that when they pose a question, they do not allow any response for 10 seconds. Others ask students to think for a full minute, then share their answers with the person next to them. This pace helps create an atmosphere of cooperation--no competition (Kruschwitz and Peters, 1995).

2.) Creating an environment that encourages risk and builds self-esteem

Girls succumb to panic and disarray over errors much more than boys. They are vulnerable to the "whack" math will give you. It starts as early as fourth grade, over visualizing fractions. That is why grades are not given until seventh grade. The marks are an "A" for mastered work or "I" indicating more attention is needed. The hidden agenda is giving the experience of control and mastery and building confidence. Winsor's O'Meara believes you must tell girls "you can do it" before they try something (Education Digest, 1995).

3.) Illustrating abstract concepts concretely grounding math and science in everyday reality

For girls, hands-on applications are a key part of understanding abstract ideas.

Calculators and computers are introduced early, and everyone speaks of the exhibits, specimens, models, and equipment used in the classroom and lab. Traditionally, girls have had fewer opportunities to build, tinker, and play with mechanical devices or equipment. Several schools also told us about the real world experience some of their students receive as they work on projects in local laboratories, observatories, hospitals, and universities (Education Digest, 5).

4.) Making use of girls' verbal strengths both written and oral

Verbalizing their thought process is natural for girls, and it fosters on-the-spot thinking and clear communication skills. It is another important part of the collaborative learning style girls like best. Our respondents described classrooms where talking is not only tolerated, but encouraged. Oral presentations are always an integral part of the curriculum. Santa Catalina School, California, frequently uses the debate format to talk about issues such as the use of animals in research of human genome projects. Girls' schools recognize that writing exercises in math and science build not only communication skills but also the critical thinking necessary to understand complex abstract ideas. In math, writing may take the form of a "math autobiography" assignment on the first day of Algebra I, where girls not only tell their learning history, but their feelings about math as well. Science has an abundance of writing opportunities: formal lab reports, essay questions on tests, and research projects (Education Digest, 1995).

5.) Providing role models, career examples, and gender friendly metaphors

Our portrayal of the male-dominated arena of math and science must include examples and role models girls can relate to--especially the ones standing before them in class. Again and again, respondents told us how important it was to have women teaching these courses to girls. These schools strive to find textbooks in which women are portrayed as often as men, and they guide class discussion to break gender stereotypes. Most schools bring working scientists, mathematicians, and technologists into the classroom for special presentations (Education Digest, 1995).

Yes, we know what works for girls. We are also learning that these techniques work well for boys. Perhaps the next challenge will be to share our success with a larger audience of boys, coeducational and public schools. The Hockaday School summer program in Texas has extensive math and science offerings and it's nearly all coeducational. Ileana Jones, a Winsor science teacher, says "Women need to be a more equitable part of the five percent within this nation 's population who are scientists and engineers. But what about the other 95 percent? We need all our citizens to be scientifically literate. Our themes and strategies can serve all students....Our nation's success depends on it" (Education Digest, 1995).

Several educational programs have been set-up across the country that engage girls in the use of technology. Educators can incorporate these programs into their curriculum or encourage girls to attend the programs after school or during the summer. Girls, Inc., teaches both the SMART (science, math, and relevant technologies) and EUREKA (engaging girls in math, sports, and technology) curricula in each of which role models in injury meet with students. Because role models are critical, but often absent from girls' lives, several programs have women from industry visit girls' classes to discuss their careers. San Jose, California's Women of Vision at the Technology Museum, for example, sends women in the industry who are scientists, mathematicians, and technical writers to classrooms to discuss how they chose their field, the classes they took, and who their mentors were. They talk to coed classes but direct their message toward girls. If the girls do not ask questions, they try to draw them into the conversation. The volunteers in this program serve as role models for the girls (Education Digest, 1995).

Many program administrators as well as researchers on gender bias in education support all-girl classes. Bess Bendet, coordinator of the EUREKA and SMART programs at Girls, Inc., says all-girl classes are critical because females are more comfortable taking risks in these environments. They can, in the words of one 13 year old, "act smart without feeling dumb." In mixed classrooms, boys tend to take over, answering all the questions and using the equipment first. In all-girl classrooms, girls are forced to take on a variety of leadership roles and look to other girls for leadership. Girls' consciousness is raised (Educational Digest, 1994).

Energy and vision are needed from all gender perspectives. These efforts at recognizing gender bias and seeking solutions can make females active participants in technology. The female perspective, which many educators have ignored or devalued until now, is, ironically, at the heart of current struggles in technological development: improving technologies for the user, making better communication tools, and creating collaborative environments. It is up to educators to make the effort to involve a vital resource, the female gender (Education Digest, 1994).

Girls' lack of participation in science, at the middle school level, is a serious issue and one that is being addressed through a joint project between Cranbrook Institute of Science and Oakland University. This collaborative effort is funded by the National Science Foundation. The Cranbrook/Oakland project, Girls in Science, attempts to tackle the problem in several different ways. The collaborative objectives are threefold: training preserve teachers in gender-fair classroom practices, providing informal science experiences for girls, and facilitating mentoring assistance to girls via community services (Oakland University, 1997).

At Oakland University students receive information about gender-fair teaching and practices throughout their formal teacher preparation course work. This information is integrated into the teacher education program at several levels. These practices are then implemented during pre-service field placements and during student teaching experiences. When student interns do their semester of student teaching, they are formally assessed, by Oakland University field supervisors, for the implementation of gender-fair behaviors, using the Gender Equity Observation Form (GEOF) (Oakland University, 1997).

Informal science experiences are provided for girls both at the museum and in the community. Girls only classes are geared at increasing girls' participation in science by providing a non-threatening environment where they can have fun while learning about science. There are three Girls Science Clubs that operate in three urban junior high schools in Pontiac, Michigan. The girls' participation in these clubs is voluntary and the clubs are facilitated by Oakland University pre-service teachers. In addition, the museum offers after-school science classes, for girls only, every Thursday afternoon. Saturday "Science for Girls" workshops also occur at the museum on a periodic basis. All of these activities are aimed at increasing girls' participation in science in formal and informal ways. A resource center is currently being developed at Cranbrook Institute of Science. Many of the materials in the resource center are related to women in science and mathematics and other gender-related issues. The center also contains a wealth of science activity based materials. The purpose of the resource center is to make available to teachers, pre-service teachers, interns, community groups, as well as parents, materials that can be used with girls' groups with the hope that exposure will increase their interest and confidence (Oakland University, 1997).

The Association for Science Education is committed to achieving equal participation by all young people at all levels of science education. The Association will take action to promote awareness of the curriculum implications of an equal opportunities policy in science. The Association acknowledges that "Equal Opportunities" issues cover a much broader field than gender issues alone. Consequently, policy statements are also under consideration in relation to issues of multiculturalism, special needs, and class. At the present time, however, the Association believes there is a value in publishing a gender-specific paper because it will lead to heightened awareness of more general equity issues, and also because some areas of concern are specific to gender (The Association for Science Education, 1997).

The Association recommends that all teachers of science take steps to provide a science education that is equally encouraging, supportive, and challenging to both girls and boys. The National Curricula promise "science for all" but all teachers know that their desire to teach must be matched by their pupils' willingness to learn and that equal access is only a starting point to achieving a scientifically-literate population (The Association for Science Education, 1997).

The essays in which girls and boys respond to the content and style of science education are different. Their responses are influenced by their own attitudes and expectations, by those of their teachers and by the perceived opportunities for employment. Their perceptions are often based on outdated and inaccurate assumptions about the role of women and men at home and in the workplace. This situation cannot be tackled without considering the values transmitted by the overt and hidden curriculum and the attitudes which we are cultivating in and out of the science classroom. The Association believes that those who teach science should seek strategies to redress the imbalance created by pupils' previous gender-differentiated experiences. In meeting this challenge, the support of a wide-range of other agencies will also be required (The Association for Science Education, 1997).

ASE POLICY STATEMENT: GENDER AND SCIENCE EDUCATION POLICY

1.) Explicit Policies

All groups concerned with science education should have explicit, written equal opportunities policies to guide, monitor, and evaluate practices.

2.) The Curriculum and Approaches to Teaching and Learning

Teachers, departments, schools, and colleges should reinforce the importance of science education for girls and boys of all aptitudes and abilities.

All curriculum schemes should be regularly reviewed to ensure that science is shown as a human activity which relates to people's lives.

Teaching and Learning Styles Should:

- explore and build upon the personal experiences of pupils of both sexes and provide compensatory experiences to avoid reinforcing existing bias
- enable girls and boys to test out their own ideas

- enable girls and boys to practice a wide range of skills in a non-threatening environment
- provide opportunities for working in groups of various sizes and composition as well as individually
- provide opportunities for pupils of both sexes to use expressive language
- provide opportunities for pupils to make evaluative statements about the role of science and technology in society
- develop the "knowledge and understanding" objectives in the context of social and personal responsibility and morality
- involve pupils in discussion about sex-stereotyping

3.) Assessment

The values underpinning assessment schemes should complement equal opportunities policies, enabling all young people to recognize their own strengths and weaknesses and thus to influence their own learning. Greater emphasis on formative and diagnostic assessment will contribute to and enhance this aspect of teaching and learning.

4.) Resources

Classroom, laboratory, and workshop materials should reflect the principles developed in equal opportunity policies, particularly where people are featured. Careful selection of pupils' own work should be made to take account of equal opportunities provision.

Display and other materials should ensure that stereotypical views relating to adult roles and to aptitude and ability in science are not reinforced. Opportunities should be provided for girls and boys to interact with women and men in employment areas with a scientific an technological base. Both traditional and non-traditional roles should be represented. Role models in the form of secondary sources about the place of women in science in past ages should also be promoted.

5.) Counseling and Careers

Attitudes to careers are formed at an early stage. All schools should, therefore provide opportunities for girls and boys to interact with people working in non-traditional employment areas with a science base.

The importance of science and technology for a wide range of careers is to emphasized. While options systems continue in terms of time allocations for science, the frameworks for choice must not reinforce sex-stereotyping. In particular, girls as well as boys should be encouraged to take double science rather than single science where such choice exists.

6.) Initial and In-Service Training and Staffing Policies

Teachers training institutions and schools should ensure that teachers in all phases are provided with professional development opportunities to increase awareness of gender issues.

Advertisements for vacancies should encourage application from suitable candidates of both sexes.

Evaluation procedures should include the implementation of equal opportunities policies in classrooms, laboratories, an workshops.

7.) Parents and Governors

Parents and governors should be informed of the need to consider the achievement and participation rate of girls and boys in science and technology and the strategies needed to address any imbalances.

Governors should ensure good equal opportunities employment practice informs that recruitment and career development of teachers, auxiliary staff, and technical assistants in their schools (The Association of Science Education, 1997).

The middle school years provide opportunities for students to begin picturing themselves in the world of work and thinking about what they may wish to do with their knowledge and skills during their lifetime. It is a very appropriate time to increase students' knowledge of career options in math and science, to show the attractiveness of such careers and to emphasize them as appropriate and realistic career directions for female and minority students. Thus, when strategies to foster the participation and performance of young minority and female students in mathematics and science are considered, attention must be given to enhancing students' attitudes about these subject areas and expanding their knowledge about career options in mathematics and science-related fields (Clewell, et al., 1992).

Middle school intervention programs that focus on encouraging positive attitudes toward mathematics and science and on increasing students' awareness of career choices and work opportunities in these fields have used a number of approaches including role models and mentors, career awareness activities, exposure to extra-curricular science, and mathematics activities and provision of a supportive environment (Clewell, et al., 1992).

School-to-work programs are designed to better prepare publicly educated children for the work force. Roy Peters, director of Oklahoma's vocation education department, spoke at the Southern Legislative Conference promoting vocational and technical training. Encouraging students in junior high and high schools to think about what they might like to do for a living, exposing them to practical experiences in those fields and then telling them what skills they need to do those jobs makes school more relevant and encourages students to study harder, Peters said. Leonard Vernamonti, chief executive officer of the Institute for Technology Development in Jackson, Mississippi, said the biggest problem in American education is that students are not choosing engineering and science careers. They are also not choosing to teach in those fields. In Mississippi last year, 1,800 teachers graduated from college, but only one was certified to teach physics. Vernamonti believes that states must pay teachers in specialized fields more. Mississippi, for example, is implementing a technology preparation class in 6th grade. However, it may be too late because most girls are turned off by math and science by 4th grade. Vernmonti said states do not ask enough of high school students. Some states require just over half the course load that education specialists recommend (Bundy, 1997).

In districts across the country, public schools are experimenting with sexual segregation in the name of school reform. There is no precise tally, in part, because schools are wary of drawing attention to classes that may violate gender-bias laws, but researchers say, in more than a dozen states, including Texas, Colorado, Michigan, and Georgia, coed schools are creating single sex classes. Some, like Marsteller Middle School, believe that separating the sexes will eliminate distractions. Others, like Robert Coleman Elementary in Baltimore, made the move primarily to get boys to work harder and to tighten up discipline (Hancock and Kalb, 1996).

The vast majority of the experiments are designed to boost girls' math and science scores. The stimulus for these efforts was a report four years ago from the American Association of University Women, that argued girls were being shortchanged in public school classrooms, particularly in math and science. The single sex classroom, however, is not what gender equality researcher involved with AAUW had in mind as a remedy. Their report was meant to help improve coeducation, not dismantle it. Research shows single sex schools tend to produce girls with more confidence and higher grades. But single sex classrooms within coed schools? There are no long term studies of that approach, just a smattering of skeptics and true believers. "It's a plan that misses two boats," charges David Sadker, co-author of Failing at Fairness, "the education of boys and the reality that children need to lean how to cope in a cold world" (Hancock and Kalb 76). "In short," says University of Michigan researcher Valerie Lee, "these classes are a bogus answer to a complex problem" (Hancock and Kalb 76).

Critics worry that segregated classes will set back the cause of gender equality just as girls are finally being integrated into all male academics. As a general principle, federal law does not permit segregation by sex in the public schools. (Exceptions can be made for singing groups, contact sports, human-sexuality, and remedial classes.)

Some schools have survived legal challenges by claiming that their all-girl classes fill remedial needs. A middle school in Ventura, California faced down a challenge by changing the name of its all-girl class to Math PLUS (power learning for understanding students). Enrollment is open to boys, though none have registered, yet (Hancock and Kalb, 1996).

Despite the skeptics, single-sex experiments continue to spread. Teachers and students believe they work. Michigan's Rochester High School turns away 70 students every year from its girls only science and engineering class. Marsteller boys raised their collective average in language arts by one grade after a single term. Girls boosted their average by .4 of a point (Hancock and Kalb, 1996).

Improving Academic Performance

In an effort to increase the participation of minority and female students in advanced mathematics and science studies and careers, a number of intervention programs have targeted student performance as a primary objective. National and international studies have clearly documented achievement gaps among our nation's middle and high school youth particularly in higher-level skills. The achievement differences are most prominent among non-Asian minority students. While the achievement gap between males and females is less pronounced in the early middle school grades, differences begin to emerge in grades of higher-level mathematics problem solving and in physical science (Clewell, et al., 1992).

Instructional Approaches

Instructional approaches to increase students' achievement differ from traditional instruction in a number of ways. First, these approaches are consistent with what we know about students' developmental needs including their need for structure, challenge, action, social interaction with peers, and close personal interactions with role models or mentors. For example, we know that middle school children learn best not by passively listening to a teacher's lecture but by performing their own actions. Second, intervention programs recognize the link between achievement and motivation. They strive to bolster students' self-esteem and self-concept in mathematics and science through successful, meaningful experiences. Students learn through their own successes that they can do math and science and that learning can be fun. Third, programs teach students to focus on the process of problem solving, not solely on the products. By understanding how to solve problems and monitor their own thinking during the solution process, students are better able to undertake and succeeding novel situations. Most programs use multiple strategies for instruction to increase students' confidence and motivation as well as their thinking skills and academic achievement. Frequently used instructional strategies in middle school intervention programs include inquiry learning, activity-based instruction, cooperative learning, and direct instruction.

Research and Theory

Cognitive and developmental theories support inquiry learning by emphasizing the importance of students' own activity in learning (Piaget, 1952; Gagne, 1977). Prigetian theory proposes that cognitive schemata are developed and reformulated as children actively engage in their own problem-solving activities. Gagne (1977) also supports student exploration to assist students in developing their own ideas and to provide them with opportunities to test their assumptions. A number of theorists, including Piaget (1959), Dewey ([1916]1986), and Gagne (1977), emphasize the importance of children's own actions and manipulation of objects in learning. Manipulating objects allows children to examine phenomena at their own pace. Activity-based instruction also allows children the opportunity to repeat actions as needed in order to understand and assimilate new information (Clewell, et al., 1992).

Support for cooperative approaches is derived from theories of child development (Piaget, 1956; Sullivan 1953) and motivation (Lewin, [1935] 1959) that suggest that peer interactions is a powerful mechanism to influence students' interests and learning. Linguistic theories also support language and interaction to discuss and redefine ideas through communication with others (Cocking and Mestre, 1988; Is Vestra, 1974; Vygotsky, 1962; Whorf, [1956] 1989). Support for direct instruction is based on several learning principles of behaviorism, including (1) frequency of repetition to guarantee retention and (2) generalization and discrimination, which suggest the importance of practice in varied contexts (Hilgard and Bower, 1975). Skinner (1953) and Gagne (1977) advocate instruction that is structured and hierarchical. According to Gagne (1977), once the teacher has "properly structured" the learning environment, the desired learning will occur (Clewell, et al., 1992).

The practices used by intervention programs for minorities and females are supported by the research base on effective mathematics and science instruction for all students (Clewell, 1987). Instructional arrangements promote students' responsibility and involvement in their own learning through cooperative groups. Problem-focused and activity-based learning as well as direct instructional approaches have also been shown to promote learning among minority and female students (Clewell, et al., 1992).

There is some research evidence favoring inquiry learning over traditional approaches for middle school students generally and females in particular (Linn and Their, 1975; Lawton and Wollman, 1976; Saunders and Shepardson, 1987). The majority of studies comparing the effect of inquiry learning with that of traditional approaches in promoting knowledge of subject matter or thinking skills have been done in science. While most studies have not examined effects from students of different ethnic backgrounds, there is also some evidence supporting the positive effects of hands-on inquiry activities for middle school Black and Hispanic students (Cohen and De Avila, 1983) (Clewell, et al., 1992).

Research on cooperative goal structures has shown that they result in improvement in achievement and attitudes of diverse student populations in a variety of subject areas (Johnson and Johnson, 1987). Slavin (1985) reports positive effects in mathematics from cooperative instructional arrangements for diverse student populations. Research studies also lend support to the use of activity-based learning, including hands-on experiences and engagement with concrete objects (Lawton and Wollman, 1976; Linn and Their, 1975; Saunders and Shepardson, 1987). There is some evidence that more structured, direct instructional approaches may be needed for students of lower ability (Ryman, 1977; Clewell, et al., 1992).

A number of intervention approaches have been based on inquiry learning, which actively engages students in the learning process through their own exploration of phenomena. This instructional approach differs from traditional practice, where the teacher's role is to provide knowledge and the student's role is passively to receive "given truths" in that it requires students to construct their own knowledge through thoughts and actions. Students explore situations (most often through the use of objects), develop their own ideas about the nature of what they are studying, and test their assumptions to confirm or refute their hypotheses (Clewell, et al., 1992).

Inquiry learning approaches differ in the degree of structure or direction that teachers provide. At one end of the continuum is discovery learning, in which the teacher serves as a facilitator. Using this strategy, teachers create an environment for learning by providing students with material and general instructions for free exploration. Students select their own problems while the teachers seek to encourage and expand the students' thinking through questioning directed at the students' own avenues of investigation. This approach can be highly motivating, because students are pursuing their own questions. It also simulates problem solving in real work environments where problems may be instructed and individuals must develop questions and approaches to generate solutions. At the other end of the continuum, teachers take a more active role to guide student inquiry. Teachers present a specific problem to be solved and guide students' exploration of selected concepts with directive questioning that prompts students to describe and explain certain phenomena. Guided inquiry is a useful strategy to bridge traditional and free-inquiry approaches. Teacher-selected problems provide the initial direction or focus;

students generate their own questions and solutions with teacher assistance only as needed (Georgia Sate Department of Education, 1982; Clewell, et al., 1992).

Tutoring

Tutoring is a vehicle to provide additional academic support to students. The focus of tutoring can be remediation or enrichment--to help students to master previously presented material to extend and provide a challenge to the information that they have already learned. Tutoring may be either a one-to-one teaching-learning situation or academic-oriented instruction in a small-group setting (Clewell, et al., 1992).

Research and Theory

Tutoring promotes learning through an exchange of ideas between the tutor and the student. Explanation and instruction require that both student and tutor examine and articulate their own thinking. These exchanges are consistent with cognitive theories of formulating one's own knowledge within the context of social interactions (Piaget, 1970; Bruner, 1963; Clewell, 1992). There has been substantial research on peer tutoring (Allen, 1976; Strain 1981; Bowers, 1991; Vergason and Anderegg, 1991), but relatively little attention has been given to the nature or effects of peer tutoring for minority students or females. The consensus is that the students receiving tutoring learn from their peers while the students providing the tutorials learn from teaching (Gartner, Kohler, and Riessman, 1971). Giving students the chance to teach is to give them an additional opportunity to learn (Scribner and Stevens, 1975; Clewell, et al., 1992).

Many middle school intervention programs use peer and/or adult tutoring for remediation and enrichment purposes. With peer tutoring, the tutor may be the same age as the tutored student or older; with both same-age and cross-age peer tutoring the students receive instructional help and support from each other (Clewell, et al., 1992).

The MESA program uses both tutoring and study skill and to increase achievement by helping students improve their ability to understand a wide range of mathematical and scientific concepts (Clewell, et al., 1992).

Test Preparation and Study Skills

Test preparation and study skills training encompasses a number of related approaches. One of these is teaching students strategic knowledge about learning and test taking. With this approach, students are taught strategies to organize their studying as well as strategies to use in testing situations. Another approach is to provide student with direct instruction and practice on specific skills or problem formats that are particularly difficult. By learning effective strategies and mastering skills, students are enabled to anticipate demands and to approach tests knowledgeably and with confidence (Clewell, et al., 1992).

Research and Theory

Learning theory (Skinner, 1953) and cognitive theories (Brown and Campione, 1978) lend support to test preparation strategies by suggesting the positive effects of practice on performance. The learning strategies emphasized include strategic knowledge, task demands, practice, schema development, and automaticity (Clewell, et al., 1992). Research shows that females tend to perform better on essay questions and males to perform better on multiple-choice questions (Harding, 1979). Extended answers allow females to develop the context in which a scientific idea is useful, rather than remembering it in isolation (Smail, 1984). The findings suggest that females need training and confidence building for dealing with questions that require recall and speed in marking one single right answer. Research on a number of different test-taking interventions has found that mathematics achievement can be improved through the use of practice problems (Bookman and Iwanicki, 1983) and training in test-taking skills (Benson, Urman, and Hocevar, 1986). Moreover, a move away from multiple-choice exercises to less structured, essay-style assessment would facilitate higher thinking processes and be more equitable for females.

Program Examples

Among the strategies for study skills and test preparation are focusing on test anxiety for minority students and math anxiety for females; helping students, particularly minority students, to brush up on their skills and knowledge in a specific subject, helping students to improve their test performance by improving their study skills and work habits, and teaching students test-taking techniques. Most programs do not seem to emphasize test preparation, though there is a need to help students in this area (Clewell, et al., 1992).

Many competition programs offer test preparation activities. Student competitions provide opportunities for sharpening skill and recognition of accomplishment. Mathcounts, a nationwide mathematics competition program offered by the National Society of Professional Engineers for seventh and eight-graders, demonstrates that coaching can be fun, educational, and a way to improve performance. Coaching activities include mock competitions with awards for success and developing students' problem-solving skills by asking and answering each others' questions that they have rewritten from the program's handbook. In addition to skills-building activities, the program also emphasizes the importance of self-confidence for success. An important aspect of coaching is helping students to want to be successful, to believe that they can by successful, and to develop within them the will to prepare, compete, and win (Clewell, et al., 1992).

MESA provides students with tips on study skills, including time management, reading with a purpose, exam strategies (how to study the right material for a test and how to approach tests calmly) group study, and outlining. The Pre-Engineering Summer Workshops for Women and Minorities, conducted by the college of Engineering at Arizona State University, provide a session on test-taking and study skills. Students are instructed on test-taking strategies and provided examples through a practice exercises from an actual exam. Instructors demonstrate approaches for improving note-taking skills by pointing out major points of a sample lecture (Clewell, et al., 1992).

Teacher Training

Teachers are influential in determining students' participation and performance in mathematics and science. Students who indicate a strong liking for and/or do well in these subjects frequently point to a teacher as an important influential factor. Similarly, students who express negative attitudes and opt out of future mathematics and science course work often attribute their thinking and decisions to a bad experience with a teacher. In a variety of ways, teachers contribute to differential participation and performance in mathematics and science for minority and female students. For example, during mathematics and science instruction, teachers may give more attention to majority and male students than minority and female students, and, too often, minority and females students infer from such differential interactions that mathematics and science are more essential for males and majority students. Some teachers perceive minority and female students as less able than majority and males students to learn mathematics and science; such perceptions and expectations often result in behaviors on the part of both teachers and students that conform to gender and racial stereotypes. To combat these barriers to academic excellence in mathematics and science, intervention programs often provide workshops, seminars, or other forms of training to help teachers improve the performance of minority and female students (Clewell, et al., 1992).

Research and Theory

Since teacher behavior and attitudes strongly affect student achievement, teacher training and staff development should be emphasized in intervention programs. Guskey (1986) has developed a theory of teacher training that includes three goals: changes in teachers' behavior, enhancement of students learning, and changes in teachers' attitudes, and beliefs. An important contribution of Guskey's theory is the order in which he advocates that these three components should be addressed in staff development programs. Guskey believes that such programs should focus first on changes in teachers' behavior: such changes should have a positive impact on student achievement, which in turn should produce changes in teachers' beliefs and attitudes. Irvine (1990) outlines a model of teacher training and staff development designed to improve the motivation and learning of Black students. Building on Guskey's theory, Irvine incorporates Guskey's model of teacher change into a program of staff development that involves teachers, principals, and parents (Clewell, et al., 1992).

Research has shown that important dimensions of teachers' expectation and behavior as they affect science and math achievement are the amount of material taught and the level of teacher-pupil interaction (Brophy and Good, 1974; Persell, 1997). In a study of science classrooms, Kahle and Lakes (1983) found that more opportunities were provided for boys to use scene instruments and equipment than were provided for girls, and Contreras and lee (1990) found cultural bias in teachers' treatment of minority students in middle school science classes. While these studies underline the relationship between teachers' expectations and effects of the self-fulfilling prophecy, they also suggest a need for teacher training programs that focus on cultural rather than individual differences (Clewell, et al., 1992).

Program Examples

The format of teacher training programs ranges from school-based in-service programs to out-of-school workshops and conferences. They may be led by a single facilitator or by an instructural team of familiar or unfamiliar to the teacher participants. They many be designed to train teachers in particular instructional strategies to raise their awareness of gender difference and show them how to implement classroom practices that address the needs of females, or to help them address and eliminate the performance deficiency of minority students in mathematics and science (Clewell, et al., 1992).

The efficacy and expectations component emphasizes that teachers can and do make a difference in the achievement of their students. Teachers with a high sense of efficacy are more likely to be attentive to the individual needs of students and to respond to students in a positive, accepting, and supporting way. Promotion of student achievement also requires that teachers believe in their students' ability to master information, earn good grades, complete school, and go on to institutions of higher education. Minority students will greatly benefit from favorable teacher expectations (Clewell, et al., 1992).

The component on facilitative teaching gives attention to an empowering atmosphere for growth, one in which students are certain of acceptance. Teacher behaviors addressed included helping students feel that they are accepted and respected and eliciting higher-level responses from students. Training includes asking person-centered questions and using response techniques such as clarifying, summarizing, and reflecting feeling. Active listening is emphasized. The instructional delivery component focuses on teacher competencies effective in promoting academic achievement for minority students. Among the teaching behaviors that are developed, refined, and observed are positive reinforcement patterns: asking students to extend answers or elaborate on ideas, asking questions that lead students to analyze, synthesize, and think critically, seeking and using student ideas as part of the teaching procedure, nurturing students' creativity, and discovery, and encouraging active student participation (Clewell, et al., 1992).

Parent Involvement

There has recently been an increase in the social influences that affect students' participation and achievement in mathematics and science. The family is one of the societal forces that is influential in the learning process: parents who value and have confidence in their children's ability to do well in math and science have a positive influence on their children's attitudes and performance (Clewell, et al., 1992).

Research and Theory

Parents can help their children to improve their performance by acting as teachers, role models, and support people (Clewell, Anderson, and Thorpe, 1988; Parsons, Adler, and Kaczala, 1982). Developmental psychology (Hurlock, 1972; Myers, 1986) emphasizes the significant role of parents in helping their children to develop cognitively and socially. Parental presence and participation ensure a culturally consistent social and academic program for students (Comer, 1984). Additionally, theoretical constructs of home-school relationships hold parental involvement to be integral to the development of sound educational programs for children (Lasa, 1982; Clewell, et al., 1992).

Several research studies lend support to the idea of involving parents in skills development, Clark (1985), Prillwitz (1983), and Thoas (1986) report that parental encouragement and support are important to participation in mathematics and science. Correctional research has encouragement (Armstrong 1980) and parental expectations (Parsons, Adler, and Kaczala, 1982), and young females' interest and achievement in mathematics. [On the other hand, a lack of significant others, especially parents, who have an interest in math and science or see their relevance in everyday life has been cited as a reason for the underachievement of minority and females students in these disciplines (Beane, 1985; Clewell and Anderson, 1991; Olstad, Juarez, Davenport, and Hawry, 1981)] (Clewell, et al., 1992).

Program Examples

Parent expectations and support are needed in most skills development and enrichment programs. Such programs have found that it is important to involve parents early in the program and to maintain positive relationships throughout the period of student participation. Intervention programs use several approaches to promote this type of parental involvement. Initial contact is often through program literature describing the objectives and activities of the program. Parents are invited to orientation meetings. Some programs ask parents to sign a contract stipulating student requirements and pledging to support and actively encourage full participation. Through regular mailings or conferences with program staff, parents may receive information about heir children's progress and program activities. They may also be invited to attend the program's year-end awards ceremony and are asked about their perceptions of changes in their children's attitude toward and performance in the academic subjects (Clewell, et al., 1992).

Most programs welcome parent volunteers to share their experiences with students, to plan social events, and to chaperon student activities. A few programs use parents who are employed in math and science fields to stimulate students' participation in these areas. Fore example, MESA encourages parents and guardians to talk about their math-based careers with MESA students at different schools. MESA considers family involvement a critical part of the support network. Family members promote student achievement by encouraging the students in their studies and by working with other parents to help with such activities as study groups, field trips, and social events. One important task of the parents is to reinforce MESA requirements that students attend regular tutoring and study group sessions and that students study a sufficient number of hours each day (Clewell, et al., 1992).

"A Plan for Action" released recently by the Triangle Coalition for Science and Technology Education, in College Park, Maryland represents 80 national organizations seeking to improve science and technology education for all students. The program advocated by the coalition includes:

- massive reform of curriculum content and delivery
- a new elementary school science program
- an elementary school science facilities program to provide resources on a 50 percent matching basis for science equipment in elementary schools
- a set-aside of 5 percent of federal student aid funds for loans, grants, and scholarships to prospective teachers
- increased graduate fellowships and internships in the sciences and engineering, with special emphasis on support for women and minorities
- full funding of support for local and statewide business/education partnerships on matching basis (Education Digest, 1989, p.73)

In their book, "Breaking the Barriers: Helping Female and Minority Students Succeed in mathematics and Science," Clewell, Anderson, & Thorpe (1992) provide an in-depth examination of the strategies, structure, and operation of intervention programs for minority and female students in grade 4 through 8 (p.1). The primary goal of education is the development of individuals who possess the knowledge, skills, and human characteristics necessary to enable them to live meaningfully as individuals and as positive contributors to society. To achieve this goal, the individual must be provided experiences to develop skills in language and thinking, scientific understanding, mathematics, historical perception, aesthetic appreciation, social interaction, movement, fitness, health, and career. The secondary school should provide the opportunity for every student to have a challenging educational experiences that will prepare him/her to pursue a fulfilling and productive role in society (Utah State Board of Education, 1992 p.3).

The need to impart to all students some familiarity with modern science has come to assume major importance beyond the rational education. Even if their future goals and occupations should be far removed from scientific fields, all of today's students will have to live in a world increasingly dominated by the rapid proliferation of its technological consequences. Furthermore, they will often by called upon to make decisions involving scientific considerations which could significantly affect the quality of like in our society. Science should help students to live meaningfully and responsible in a changing world, to perceive that order exists in the universe--that cause and effect relationship are present everywhere, to learn to search for answers and to question the accuracy and validity of those answers, to understand the importance of living their lives in harmony with all of nature's other creatures, and to relate the concepts of science to the practical application in future employment choices and careers (Utah State Board of Education, 1992).

Policy makers and the American public are demanding better science education for all children growing up in a technologically advanced society (National Science Testing Board, 1983). The majority of science educators agree that such improvements can be accomplished only through a program that addresses both science fundamentals and higher order cognitive skills. Therefore, a comprehensive, broad program is necessary if children are to be prepared to enter a global community that is increasingly scientifically dependent (National Science Testing Board, 1983; Sachse, 1990). Some argue for methods that provide "direct instruction" to students while others believe that only through instructional procedures that utilize "discovery learning" will we be able to research our science education aims (Guskey, Thomas R.& Passaro, Perry D., 1992, p.2).

Policy makers and the American public are demanding that these ambitions and worthy aims be addressed quickly, without large funding increases and with strategies based upon carefully validated instructional practices to ensure student success (Gushey & Passero, 1992. p.2).

Chapter 3

Method

The purpose of this study was to investigate the academic performance of females as compared to males in secondary elective science courses. The juniors and seniors of the 1995-96 school year were used in the study. The study did not include the regular sophomore coordinated science classes. Data collection came from each grade book of the six teachers involved in the study. Of those teachers, three were male and three were female.

The following tables indicate their schedules and conference and planning periods.

SCHEDULES, CONFERENCE, AND PLANNING PERIODS

TABLE 1 INSTRUCTOR #1

Period	Courses
1	Coordinated Science
2	Coordinated Science
3	Environmental Earth Science
4	Advanced Biology
5	Environmental Earth Science
6	Environmental Earth Science
7	Conference and Planning

The elective science courses were taught at Greenbrier East High School With a Student population of 1271 for the 1995-96 School year.

TABLE #2 Instructor #2

Period	Courses
1	Coordinated Science
2	Environmental Earth Science
3	Coordinated Science
4	Conference and Planning
5	Coordinated Science
6	Coordinated Science
7	Coordinated Science

The duration of each course was one year, two semesters. Seven class periods were taught per day.

TABLE 3 Instructor #3

Period	Courses
1	Algebra I
2	Algebra I
3	Anatomy
4	Coordinated Science
5	Anatomy
6	Coordinated Science
7	Conference and Planning

Each class period was forty-eight minutes long with the exception of the fourth period which was one hour and a half long. It is broken down into three thirty minute lunch periods need to feed the school population.

TABLE 4 Instructor #4

Period	Courses
1	Chemistry Honors
2	Conference and Planning
3	Chemistry I
4	Chemistry I
5	Physics
6	Chemistry Honors
7	Chemistry II

Homeroom was scheduled after the first period class with a duration of 13 minutes. In homeroom, attendance was taken and announcement concerning the school day were made.

TABLE 5 Instructor #5

Period	Courses
1	Chemistry I
2	Chemistry I
3	Conference and Planning
4	Chemistry I
5	Chemistry I
6	Chemistry I
7	Chemistry I

TABLE 6 Instructor #6

Period	Courses
1	Algebra II
2	Chemistry I
3	Chemistry I
4	Conference and Planning
5	Algebra II
6	Intermediate Math
7	Intermediate Math

CLASS PERIODS AND TIMES

TABLE 7

Class Period	Duration
1	48 min.
Homeroom	13 min.
2	48 min.
3	48 min.
4	90 min (3 - 30 min. lunch periods)
5	48 min.
6	48 min.
7	48 min.
Total for the School Day	436 min.

Five minutes were allowed for students to report to their next class period.

The student population samples in the elective science classes were juniors and seniors. They were allowed to select their own elective classes. The total number of females enrolled in the elective science classes was 368. The total number of males in the elective science classes was 352.

ENROLLEMNT IN THE ELECTIVE SCIENCE CLASSES

Instructor	Courses	Number of Males	Number of Females	Periods
#1	Environmental Earth Science Advanced Biology	44 28	31 39	3 & 5 4 & 6
#2	Environmental Earth Science	22	5	2
#3	Anatomy	33	37	3 & 5
#4	Chemistry Honors Chemistry I Physics Chemistry II	26 38 22 16	34 40 24 29	1 & 6 3 & 4 5 7
#5	Chemistry I	99	105	1,2,4,5,6, & 7
#6	Chemistry I	24	24	2 & 3
Totals		352	368	21

DATA COLLECTION

The data were collected from the grade books of the six elective science teachers from August 28, 1995 through June 13, 1996 at Greenbrier East High School. The data were counted and recorded in table form. These tables indicate the number of students, average grade, standard deviation of grades, and the pooled standard deviation. A table with the t-values and average grades for each male and female group for the first semester and the second semester of each class is also included. The calculations were determined

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using the HP-215 Stat/Math Calculation.

Chapter 4

Results

TABLE 1 Instructor #1 Classes and Class Periods

Course	Period						
	1	2	3	4	5	6	7
Environmental Earth Science			*		*		C & P
Advanced Biology Biology				*		*	
Coordinated Science	*	*					

Instructor #1 schedule included Coordinated Science which is a required subject for sophomore students during the first and second periods; the seventh period was a conference and planning period

TABLE 2 Frequency Data and Summary Statistics for Students Enrolled in Environmental Earth Science, Third Period

Grade	First Semester		Second Semester	
	Male	Female	Male	Female
A (=4)	1	1	2	1
B (=3)	7	3	4	3
C (=2)	2	3	1	3
D (=1)	2	0	2	0
F (=0)	0	0	1	0
# of students	12	7	10	7
ave. grade	2.58	2.71	2.4	2.71
std. dev. of grades	0.9	0.76	1.35	0.76
pooled std. dev.	0.85		1.15	

Two male students withdrew second semester.

TABLE 3 Frequency Data and Summary Statistics for Students Enrolled in Environmental Earth Science, Fifth Period

Grade	First Semester		Second Semester	
	Male	Female	Male	Female
A	0	0	0	0
B	1	1	0	2
C	3	4	3	4
D	2	1	3	3
F	5	2	5	0
# of students	11	8	11	9
ave. grade	1	1.5	0.82	1.89
std. dev. of grades	1.1	1.07	0.87	0.78
pooled std. dev.	1.08		0.83	

One female student entered second semester.

TABLE 4 Frequency Data and Summary Statistics for Students Enrolled in Advanced Biology, Fourth Period

Grade	First Semester		Second Semester	
	Male	Female	Male	Female
A	2	2	2	2
B	3	1	3	4
C	1	3	2	0
D	1	1	0	0
F	0	1	0	0
# of students	7	8	7	6
ave. grade	2.86	2.25	3	3.33
std. dev. of grades	1.07	1.39	0.82	0.52
pooled std. dev.	1.25		0.7	

Two female students withdrew second semester.

TABLE 5 Frequency Data and Summary Statistics for Students Enrolled in Advanced Biology, Sixth Period

Grade	First Semester		Second Semester	
	Male	Female	Male	Female
A	1	6	0	6
B	4	6	6	6
C	1	1	0	0
D	1	0	0	0
F	0	0	1	0
# of students	7	13	7	12
ave. grade	2.71	3.38	2.57	3.5
std. dev. of grades	0.95	0.65	1.13	0.52
pooled std. dev.	0.76		0.79	

One female student withdrew second semester.

TABLE 6 Instructor #2 Classes and Class Periods

Course	Period						
	1	2	3	4	5	6	7
Coordinated Science	*		*	C & P	*	*	
Environmental Earth Science		*					*

Fourth period was a conference and planning period.

TABLE 7 Frequency Data and Summary Statistics for Students Enrolled in Environmental Earth Science, Second Period

Grade	First Semester		Second Semester	
	Male	Female	Male	Female
A	5	0	8	3
B	3	1	2	0
C	2	1	0	0
D	2	0	0	0
F	0	0	0	0
# of students	12	2	10	3
ave. grade	2.92	2.5	3.8	4
std. dev. of grades	1.16	0.71	0.42	0
pooled std. dev.	1.13		0.38	

TABLE 8 Instructor #3 Classes and Class Periods

Course	Period						
	1	2	3	4	5	6	7
Algebra I	*	*					C & P
Anatomy			*		*		
Coordinated Science				*		*	

Seventh period was a conference and planning period.

TABLE 9 Frequency Data and Summary Statistics for Students Enrolled in Anatomy, Third Period

Grade	First Semester		Second Semester	
	Male	Female	Male	Female
A	1	6	1	5
B	4	2	3	4
C	4	1	4	1
D	1	1	1	1
F	0	0	0	0
# of students	10	10	9	11
ave. grade	2.5	3.3	2.44	3.18
std. dev. of grades	0.85	1.06	0.88	0.98
pooled std. dev.	0.96		0.94	

One male student withdrew second semester; one female student entered second semester.

TABLE 10 Frequency Data and Summary Statistics for Students Enrolled in Anatomy, Fifth Period

Grade	First Semester		Second Semester	
	Male	Female	Male	Female
A	0	3	1	5
B	5	4	4	2
C	1	1	1	1
D	0	0	1	0
F	1	0	0	0
# of students	7	8	7	8
ave. grade	2.43	3.25	2.71	3.5
std. dev. of grades	1.13	0.71	0.95	0.76
pooled std. dev.	0.93		0.85	

TABLE 11 Instructor #4 Classes and Class Periods

Course	Period						
	1	2	3	4	5	6	7
Chemistry Honors	*	C & P				*	
Chemistry I			*	*			
Physics					*		
Chemistry II							*

TABLE 12 Frequency Data and Summary Statistics for Students Enrolled in Chemistry Honors, First Period

Grade	First Semester		Second Semester	
	Male	Female	Male	Female
A	4	6	3	5
B	0	2	1	3
C	1	0	0	0
D	1	0	2	0
F	0	0	0	0
# of students	6	8	6	8
ave. grade	3.17	3.75	2.83	3.63
std. dev. of grades	1.33	0.46	1.47	0.52
pooled std. dev.	0.93		1.03	

TABLE 13 Frequency Data and Summary Statistics for Students Enrolled in Chemistry I, Third Period

Grade	First Semester		Second Semester	
	Male	Female	Male	Female
A	2	1	1	1
B	1	1	2	0
C	3	3	4	3
D	5	2	2	4
F	1	0	1	0
# of students	12	7	10	8
ave. grade	1.83	2.14	2	1.75
std. dev. of grades	1.27	1.07	1.15	1.04
pooled std. dev.	1.2		1.1	

Two male students withdrew second semester; one female student entered second semester.

TABLE 14 Frequency Data and Summary Statistics for Students Enrolled in Chemistry I, Fourth Period

Grade	First Semester		Second Semester	
	Male	Female	Male	Female
A	1	2	1	1
B	0	5	0	5
C	4	4	3	3
D	3	3	2	1
F	1	0	1	1
# of students	9	14	7	11
ave. grade	1.67	2.43	1.71	2.36
std. dev. of grades	1.12	1.02	1.25	1.12
pooled std. dev.	1.06		1.17	

Two male and three female students withdrew second semester.

TABLE 15 Frequency Data and Summary Statistics for Students Enrolled in Physics, Fifth Period

Grade	First Semester		Second Semester	
	Male	Female	Male	Female
A	3	8	3	5
B	6	4	5	6
C	1	0	2	1
D	1	0	1	0
F	0	0	0	0
# of students	11	12	11	12
ave. grade	3	3.67	2.91	3.33
std. dev. of grades	0.89	0.49	0.94	0.65
pooled std. dev.	0.71		0.8	

TABLE 16 Frequency Data and Summary Statistics for Students Enrolled in Chemistry Honors, Sixth Period

Grade	First Semester		Second Semester	
	Male	Female	Male	Female
A	5	6	4	6
B	2	3	3	3
C	0	0	0	0
D	0	0	0	0
F	0	0	0	0
# of students	7	9	7	9
ave. grade	3.71	3.67	3.57	3.67
std. dev. of grades	0.49	0.5	0.53	0.5
pooled std. dev.	0.49		0.52	

TABLE 17 Frequency Data and Summary Statistics for Students Enrolled in Chemistry II, Seventh Period

Grade	First Semester		Second Semester	
	Male	Female	Male	Female
A	3	9	2	8
B	3	4	4	4
C	2	1	2	1
D	0	1	0	1
F	0	0	0	0
# of students	8	15	8	14
ave. grade	3.13	3.4	3	3.36
std. dev. of grades	0.83	0.91	0.76	0.93
pooled std. dev.	0.89		0.87	

One female student withdrew second semester.

TABLE 18 Instructor #5 Classes and Class Periods

Course	Period						
	1	2	3	4	5	6	7
Chemistr I y Honors	*	*	C &P	*	*	*	*

Third period was a conference and planning period.

TABLE 19 Frequency Data and Summary Statistics for Students Enrolled in Chemistry I, First Period

Grade	First Semester		Second Semester	
	Male	Female	Male	Female
A	2	2	1	3
B	0	8	3	5
C	5	5	2	6
D	2	0	4	1
F	1	0	1	0
# of students	10	15	11	15
ave. grade	2	2.8	1.91	2.67
std. dev. of grades	1.25	0.68	1.22	0.9
pooled std. dev.	0.94		1.05	

One male student entered second semester

TABLE 20 Frequency Data and Summary Statistics for Students Enrolled in Chemistry I, Second Period

Grade	First Semester		Second Semester	
	Male	Female	Male	Female
A	0	0	1	0
B	4	3	2	1
C	5	0	3	2
D	1	1	1	0
F	0	0	2	0
# of students	10	4	9	3
ave. grade	2.3	2.5	1.89	2.33
std. dev. of grades	0.67	1	1.36	0.58
pooled std. dev.	0.77		1.25	

One male student and one female student withdrew second semester.

TABLE 21 Frequency Data and Summary Statistics for Students Enrolled in Chemistry I, Fourth Period

Grade	First Semester		Second Semester	
	Male	Female	Male	Female
A	0	2	0	1
B	2	1	1	4
C	3	1	3	0
D	0	0	2	0
F	0	0	0	0
# of students	5	4	6	5
ave. grade	2.4	3.25	1.83	3.2
std. dev. of grades	0.55	0.96	0.75	0.45
pooled std. dev.	0.75		0.64	

One male student and one female student entered second semester.

TABLE 22 Frequency Data and Summary Statistics for Students Enrolled in Chemistry I, Fifth Period

Grade	First Semester		Second Semester	
	Male	Female	Male	Female
A	0	0	0	1
B	0	2	0	1
C	4	2	3	2
D	3	3	4	3
F	2	0	0	0
# of students	9	7	7	7
ave. grade	1.22	1.86	1.43	2
std. dev. of grades	0.83	0.9	0.53	1.15
pooled std. dev.	0.86		0.9	

Two male students withdrew second semester.

TABLE 23 Frequency Data and Summary Statistics for Students Enrolled in Chemistry I, Sixth Period

Grade	First Semester		Second Semester	
	Male	Female	Male	Female
A	1	1	0	1
B	3	6	4	0
C	3	2	1	3
D	3	4	2	3
F	0	0	1	5
# of students	10	13	8	12
ave. grade	2.2	2.31	2	1.08
std. dev. of grades	1.03	1.03	1.2	1.24
pooled std. dev.	1.03		1.22	

Two male students and one female student withdrew second semester.

TABLE 24 Frequency Data and Summary Statistics for Students Enrolled in Chemistry I, Seventh Period

Grade	First Semester		Second Semester	
	Male	Female	Male	Female
A	0	3	1	1
B	2	3	1	4
C	0	4	2	2
D	4	0	2	1
F	1	1	1	1
# of students	7	11	7	9
ave. grade	1.43	2.64	1.86	2.33
std. dev. of grades	1.13	1.21	1.35	1.22
pooled std. dev.	1.18		1.28	

Two female students withdrew second semester.

TABLE 25 Instructor #6 Classes and Class Periods

Course	Period						
	1	2	3	4	5	6	7
Algebra II	*			C & P	*		
Chemistry I		*	*				
Intermediate Math						*	*
Chemistry II							*

Fourth period was a conference and planning period.

TABLE 26 Frequency Data and Summary Statistics for Students Enrolled in Chemistry I, Second Period

Grade	First Semester		Second Semester	
	Male	Female	Male	Female
A	0	3	0	3
B	2	1	0	2
C	1	2	4	1
D	0	1	0	0
F	3	0	1	1
# of students	6	7	5	7
ave. grade	1.33	2.86	1.6	2.86
std. dev. of grades	1.51	1.22	0.89	1.46
pooled std. dev.	1.35		1.27	

One male student withdrew second semester.

TABLE 27 Frequency Data and Summary Statistics for Students Enrolled in Chemistry I, Third Period

Grade	First Semester		Second Semester	
	Male	Female	Male	Female
A	2	1	2	0
B	3	3	1	1
C	0	1	1	3
D	1	0	0	1
F	2	0	1	0
# of students	8	5	5	5
ave. grade	2.25	3	2.6	2
std. dev. of grades	1.67	0.71	1.67	0.71
pooled std. dev.	1.4		1.28	

Three male students withdrew second semester.

Summary of Average Grades (Males, Females) and Two-Sample T-Test Results for Each Class by Semester, Referencing Each Class by the Corresponding Table in Chapter 4

Class	Semester	Average Grade		T-Value	DF	P-Value
		Male	Female			
2	1st	2.58	2.71	-0.3231	17	0.7506
2	2nd	2.4	2.71	-0.5547	15	0.5873
3	1st	1	1.5	-0.9921	17	0.3351
3	2nd	0.82	1.89	-2.8557	18	0.0105
4	1st	2.86	2.25	0.9375	13	0.3656
4	2nd	3	3.33	-0.8605	11	0.4079
5	1st	2.71	3.38	-1.8716	18	0.0776
5	2nd	2.57	3.5	-2.4594	17	0.0249
7	1st	2.92	2.5	0.4813	12	0.639
7	2nd	3.8	4	-0.7966	11	0.4425
9	1st	2.5	3.3	-1.8628	18	0.0789
9	2nd	2.44	3.18	-1.7478	18	0.0975
10	1st	2.43	3.25	-1.7089	13	0.1112
10	2nd	2.71	3.5	-1.7826	13	0.098
12	1st	3.17	3.75	-1.164	12	0.2671
12	2nd	2.83	3.63	-1.4244	12	0.1798
13	1st	1.83	2.14	-0.5419	17	0.5949
13	2nd	2	1.75	0.4774	16	0.6395
14	1st	1.67	2.43	-1.6883	21	0.1061
14	2nd	1.71	2.36	-1.146	16	0.2686
15	1st	3	3.67	-2.2409	21	0.036
15	2nd	2.91	3.33	-1.2641	21	0.2201
16	1st	3.71	3.67	0.1909	14	0.8513
16	2nd	3.57	3.67	-0.3669	14	0.7192
17	1st	3.13	3.4	-0.7092	21	0.486
17	2nd	3	3.36	-0.9239	20	0.3665
19	1st	2	2.8	-2.0807	23	0.0488
19	2nd	1.91	2.67	-1.8251	24	0.0805
20	1st	2.3	2.5	-0.4395	12	0.6681
20	2nd	1.89	2.33	-0.5345	10	0.6047
21	1st	2.4	3.25	-1.6868	7	0.1355
21	2nd	1.83	3.2	-3.5522	9	0.0062
22	1st	1.22	1.86	-1.4609	14	0.1661
22	2nd	1.43	2	-1.1882	12	0.2577
23	1st	2.2	2.31	-0.2481	21	0.8065
23	2nd	2	1.08	1.6423	18	0.1179

24	1st	1.43	2.64	-2.1179	16	0.0502
24	2nd	1.86	2.33	-0.7395	14	0.4718
26	1st	1.33	2.86	-2.0217	11	0.0682
26	2nd	1.6	2.86	-1.6943	10	0.1211
27	1st	2.25	3	-0.941	11	0.3669
27	2nd	2.6	2	0.7385	8	0.4813

"*" denotes a significant t-value at the alpha = 0.05 significance level, as indicated by p-value < 0.05

Chapter 5

Discussion

The two-sample t-test has three basic assumptions. The first assumption is independent samples of male students and female students, which is reasonable within the same semester and class. The second assumption is normally distributed data, which is difficult to assess for the small sample sizes observed for each class and semester-fortunately, the two-sample t-test is not particularly sensitive to mild or moderate deviations from normality which may be present in the data. The third assumption is equal group population variances for male students and female students. This assumption may not be reasonable for selected cases.

Of the 42 t-tests performed, eight involve group standard deviations with a ratio (larger over smaller) greater than 2, yielding a sample variance ration greater than 4 (see second semester of Table 5, second semester of Table 7, both semesters of Table 12, second semester of Table 20, second semester of Table 22, and both semesters of Table 27). Unequal group population variances may be indicated, in which case an alternate approximate two-sample t-test is available. For the eight cases listed, only one originally resulted in a significant t-value (t= -2.4594, df = 17, p = 0.0249 for second semester of Table 5). Using the alternate two-sample t-test, none of the eight t-values are significant)for second semester of Table 5: T1 = -2.0439, df1 = 7, of Table 19 (t = -2.0802, df = 23, p = 0.0488) has an associated sample variance ratio of about 3.4, and the alternate t-test result is not significant (t1 = -1.8548, df1 = 12, p1 = 0.0883).

Thus of the five significant t-values tabulated, two are of questionable significance (second semester of Table 5, first semester of Table 19). Actually, other t-test results may be questionable, since the group sample sizes should be similar for a reliable two-sample t-test, and four cases have noticeably dissimilar group sizes (see both semesters of Table 7 and both semester of Table 20). None of the four cases listed have remotely significant t-values, though, so overall only three of the 42 t-tests reliably yield significant t-values.

If the 42 two-sample t-tests can be considered independent of one another, and if there is actually no difference in average grade between males and females, then by chance 42 (0.05) = 2.1 or approximately two t-tests should yield significant t-values. The three significant t-values observed are not much better than pure chance would predict. If Bonferroni's procedure was applied to limit the overall significance levels to no approximate significance level of 0.0012 and none of the 42 t-values would be significant (since all 42 p-values are greater than 0.0012). Bonferroni's procedure is perhaps too conservative, and is intended for independent tests-but the tests are probably not independent.

The data contains two possible sources of dependence which preclude independent t-tests. The first source is dependence between semesters for each class, since most if not all students in each class attend both semesters. The second source is dependence between classes, since some students attend more than one of the 21 elective science classes. The specific impact of these suspected dependencies is unknown and is beyond the scope of this paper.

The observed difference in overall average grade between males and females is about half of a letter grade-the average of the 342 grades for males is 2.31 and the average of the 368 grades for females is 2.82; the overall pooled standard deviation is 0.99, or approximately 1, obtained by pooling the 42 individual pooled standard deviations. To detect a difference of half a letter grade with a two-sample t-test 90% of the time using a significance level of 0.05 and assuming equal group variances (males, female) of 1 would require a sample size of 170 (85 males, 85 females) - about 10 times the average amount of data used in the 42 tests. Even if a one-sided two-sample t-test was used (assuming the true average grade is higher for females than males), the required sample size is 138 (69 males, 69 females). The group sample sizes for the 42 t-tests are simply too small to yield powerful tests able to consistently detect differences in average grade similar to the observed overall difference of about half of a letter grade. The data needs to be combined somehow to yield a more powerful test.

Assuming that the unknown effects of dependencies in the data are negligible, two simple tests can be used to compare average grades between males and females across classes and semesters. The first test is a variation on the nonparametric sign test, based on the assumption that if the average grade is the same for males and females, then neither should be predominately larger than the other among sample estimates. Note from the summary table that in 36 of the 42 tabulated cases, the average grade for females is higher than the average grade for males (apparent from the 36 negative t-values). Assuming no difference in average grade between males and females, implying that each has a 50% probability of exceeding the other in sample estimates (ignoring ties, which were not observed), then the probability that 36 or more averages are higher form females than males (or vice-versa) is literally one in a million (probability = 0.0000014). Note in the six cases where the average grade is higher form males than for females, the opposite is true for the other semester of the same class in every case-the suspected dependency between semesters is at the least not consistent for all classes.

The sign test does not take the magnitude of individual differences into account (only the sign, hence the name of the test). Again, assuming that the unknown effects of dependencies in the data are negligible, and assuming that group averages can be treated as individuals (hence equally weighted, despite differences in group sample sizes), then a second test, a paired t-test, can be applied to the average grades for males and females paired by class an semester. Like the sign test, the paired t-test yields highly significant results ($t = -5.9804$, $df = 41$, $p = 0.0000005$). Both the sign test and paired t-test results serve only as indicators of a significant difference in average grades between males and females, rather than rigorous statistical tests, since the impact of suspected dependencies in the data is unknown.

Several methods may be useful for eliminating suspected data dependencies. Averaging each student's first and second semester grades would eliminate dependency between semesters, and the average semester grade may be more normally-distributed. However, this average grade is an artificial measure equally weighting first and second semester grades, and this average may have a "sawtooth" distribution (that is, having alternating high and low frequencies) if first and second semester grades are highly dependent. If first and second semester grades are averaged, data for students that enter or withdraw second semester should be eliminated.

Another method which can also be used to eliminate data dependencies is to exclude students taking more than one elective science course or to combine data by course type (e.g. Chemistry I) or by class period. In either case, students entering or withdrawing second semester should still be eliminated to exclude students changing courses or class periods second semester. Unfortunately, results obtained using this method may not generalize-that is, results may not represent students taking more than one elective science course or students in other courses or class periods.

In conclusion, evidence does exist that the average grade in elective science classes differs between males and females. However, the two-sample t-tests applied to the data do not support this conclusion, probably because group sample sizes for individual tests are too small to yield powerful tests. Since larger group sample sizes are impractical, data needs to be combined across semesters and classes; combining this data necessitates addressing data dependency problems. Suspected data dependencies were not analyzed or eliminated in this paper to preserve the raw data as much as possible.

BIBLIOGRAPHY

Achievement Testing Program, Provincial Report: June 1991. Grade 3 Science. Grade 6 Mathematics. (1992). Alberta, Canada: Alberta Department of Education. (ERIC Document Reproduction Service No. ED 347 177)

The Association for Science Education. (1997). Gender and Science Education. (Internet).

Atwater, Jay. (1991). Achievement and Enrollment of the Applied Learning Magnet Elementary Schools, 1990-1991. Kansas City School District, MO. (ERIC Document Reproduction Service No. ED 346 967)

Barth, P. (1994). From Crisis to Consensus: Setting Standards in Chicago. Council for Basic Education, Washington, D.C. (ERIC Document Reproduction Service No. ED 382 693)

Bobbit, Sharon A. (1990). Characteristics of Mathematics and Science Teachers. Washington D.C.: National Center for Education Statistics. (ERIC Document Reproduction Service No. ED 326 385)

Brookhart, S. (1995). Effects of the Classroom Assessment Environment. Achievement in Mathematics and Science. U.S.; Pennsylvania. (ERIC Document Reproduction Service No. ED 382 637)

Bundy, J. (1997, July 20). School Myths Bite the Dust at Conference. The Sunday Gazette-Mail. pp. a-1, A-20.

Campbell, Patricia B. (1992). What Works and What Doesn't? Ways to Evaluate Programs for Girls in Math, Science, and Engineering. Washington D.C.: Women's Educational Equity Act Program. (ERIC Document Reproduction Service No. ED 350 171)

Clewell, Beatriz C., Anderson, Bernice T., & Thorpe, Margaret E. (1992). Breaking the Barriers San Francisco: Jossey-Bass Publishers.

Collison, G.E. (1993). Teacher Attitudes Toward Hands-On Science Instruction Versus Traditional Teaching Methods. Georgia. Georgia Southwestern College Graduate School Division of Education. (ERIC Document Reproduction Service No. ED 380 271)

Conners, J.S., Elliott, J.F. (1993). The Influence of Agriscience and Natural Resources Curriculum on Students' Science Achievement Scores. Tuscon: University of Arizona, Department of Agriculture. (ERIC Document Reproduction Service No. ED 383 861)

Dalton, B., Rawson, P., Tevnan, T., S Morocco, Catherine C. (1993). Equal Opportunity Learning: Hands-on Science for Girls and Boys. Newton, MA: Education Development Center. (ERIC Document Reproduction Service No. ED 360 191)

Fry, J., (1992). Activity in the Lifestyle of Adolescent Girls. New South Wales, Australia.

(ERIC Document Reproduction Service No. ED 342 734)

Guskey, T.R., & Passaro, P. (1992). How Mastery Learning Can Address Our Nation's

Science Education. Missouri. (ERIC Document Reproduction Service No. ED 370 760)

Hall, F.R., & Bailey, B. (1992). Relationship of Medical Students' Admission Interview Scores to Their Dean's Letter Ratings. Dartmouth Medical School, New Hampshire. (ERIC Document Reproduction Service No. ED 441 532)

Hancock, Lyn Nell, Kalb, Claudia (1996, June 24). A Room of Their Own. Newsweek, p. 76.

Helgeson, S.L. & Others. (1990). Science: Promising and Exemplary Programs and Materials in Elementary and Secondary Schools. [Science Education Information Report.] Columbus, Ohio. (ERIC Document Reproduction Service No. ED 335 234)

Hennes, J.D. et al. (1992). A Survey of Enrollment of Colorado Public School Students, Grades 7-12 in Science, Mathematics, a Computer Science Courses. Denver: Colorado Sate Department of Education. (ERIC Document Reproduction Service No. ED 355 100)

The Influence of Testing on Teaching Math and Science in Grades 4-12. (1992). Boston College, Chestnut Hill, Massachusetts. Massachusetts Center for the Study of Testing. (ERIC Document Reproduction Service No. ED 370 772)

Item Specifications, Mathematics Grade 8. Blue Prints for Testing Minimum Performance Test. (1988). Little Rock, Arkansas. Arkansas State Department of Education. (ERIC Document Reproduction Service No. ED 325 346)

Item Specifications, Science Grade 6. Blue Prints for Testing Minimum Performance

Test. (1988). Little Rock, Arkansas. Arkansas State Department of Education. (ERIC Document Reproduction Service No. ED 325 347)

Koch, M. (1994 November). Opening Up Technology to Both Genders. Education Digest. 110 (3), 18-22.

Koertge, N. (1994, December). Do Feminists Alienate Women from the Sciences? The Chronicle of Higher Education. Education Digest, 60 (4), 49-50.

Kruschivitz, K., & Peter, Carolyn (1995 February). Al-Girl Settings for teaching Math and Science. Education Digest. 60 (6), 60-64.

Lee, E., & Smith, J.B. (1994). Effects of High School Restructuring and Size on Gains in Achievement and Engagement for Early Secondary School Students. Wisconsin Center for Education Research. Madison, Wisconsin. (ERIC Document Reproduction Service No. ED 370 210)

Lenehan, M.C. & Others. (1994). Effects of Learning-Style Intervention on College Students' Achievement Anxiety, Anger, and Curiosity. Molley College, Rockville Center, New York. (ERIC Document Reproduction Service No. ED 497 339)

Leslie, C. (1996). Will Johnny Get A's? Newsweek. p. 72.

Science: Grade 9. Interim Guide. (1991). Winnipeg: Manitoba Department of Education and Training. (ERIC Document Reproduction Service No. ED 344 768)

Marable, P. (1990). Focusing on Teachers: ESEA Title II Mathematics and Science. Austin, Texas. Office of Research and Evaluation. (ERIC Document Reproduction Service No. ED 325 520)

Oakland University. (1997). Girls in Science [Computer Software]. Oakland. (Internet).

O'Neil, J. (1991). Raising Our Sights: Improving U.S. Achievement in Mathematics and Science. Alexandria, Virginia. Association for Supervision and Curriculum Development. (ERIC Document Reproduction Service No. ED 342 651)

Perdue, P.K. (1991). Schoolyard Science Grades 2-4. Illinois. (ERIC Document Reproduction Service No. ED 324 221)

Perry, William C. (1997). Gender-Based Education: Why It Works at the Middle School Level [Media Software]. (Internet).

Science: A Guide to Curriculum Development. (1991). Albany, New York. New York State Education Department. (ERIC Document Reproduction Service No. ED 348 213)

Science: A Guide to Curriculum Development. (1991). Hartford: Connecticut State Department of Education. (ERIC Document Reproduction Service No. ED 348 213)

Science: Grade 1. Interim Guide. Winnipeg, Canada. Manitoba Department of Education and Training. (ERIC Document Reproduction Service No. ED 344 760)

Science: Grade 6. Interim Guide. Winnipeg, Canada. Manitoba Department of Education and Training. (ERIC Document Reproduction Service No. ED 344 765)

Science: Grade 8. Interim Guide. (1991). Winnipeg, Canada. Manitoba Department of Education and Training. (ERIC Document Reproduction Service No. ED 344 767)

Science, Levels 7-12; Secondary Core Curriculum Standards. (1992). Salt Lake City, Utah. Utah State Board of Education. (ERIC Document Reproduction Service No. ED 383 523)

Science/Math/Technology, (1989, October). Education Digest, 55 (2), 73.

Stecher, B. (1995). The Cost of Performance Assessment in Science: The Rand Perspective. Santa Barbara, California. University of California. (ERIC Document Reproduction Service No. ED 383 732)

Stevenson, D.L., & Others. (1994). Sequences of Opportunities for Learning. National Education Longitudinal Study. (ERIC Document Reproduction Service No. EJ 493 915)

Tobias, Sheila. (1994 September). Keep Culture From Keeping Girls Out of Science. Education Digest. 60 (1), 19-20.

Wilson, D.L. (1991). New Computer Package Provides a Flexible Tool for Teaching Physics Concepts to Non-Majors. University of Maryland. (ERIC Document Reproduction Service No. EJ 433 142)

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