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A Comparison of Science and Mathematics Achievement, Attitudes, Curricular Experiences, and Career Interest Resulting from Magnet and Traditional High School Programs

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A COMPARISON OF SCIENCE AND MATHEMATICS ACHIEVEMENT, ATTITUDES, CURRICULAR EXPERIENCES, AND CAREER INTEREST RESULTING FROM MAGNET AND TRADITIONAL HIGH SCHOOL PROGRAMS

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CHAPTER I

BACKGROUND AND STATEMENT OF THE PROBLEM

Background of the Problem

The role of public financial support for general education in the United States began with the establishment of the Massachusetts Laws of 1642 and 1647 (Cubberley, 1934). These laws were the basis for compulsory support of primary education by public taxation. Generally, awareness of the need for science education began at the post-secondary level and was first supported by federal funds with the establishment of the Morrill Act of 1859 (Cubberley, 1920; Thayer, 1938). This Act provided support for the development of science and engineering programs in all states at the college level. The Act required the Federal government to grant 20,000 acres of public land in each state for the purpose of establishing a College of Agriculture and Mechanical Arts. This provision was later increased to 30,000 acres in 1862 when military science was added as a requirement (Cubberley, 1920).

The development of secondary schools or academies in the United States, however, began many years before the Morrill Act of 1859 (Morril Act of 1859, 1862). During the mid-1800s, the primary subjects taught in these academies involved classical preparation for the professions of law, medicine, clergy, or military careers. Substantial interest in providing science instruction began with the advent of the land-grant colleges, and better academies and schools responded by offering preparatory classes in the sciences including botany, chemistry, and astronomy (Cubberley, 1934). These courses, however, were often miniatures of college courses and were

designed with the college-bound student in mind (Johnson, 1978).

During the mid 1800s, many advanced subjects were added to the curriculum of high schools. Since many students could not afford to enter private academies, and some questioned the need for compulsory education beyond the basis of reading, writing, and arithmetic, questions were raised about the public's responsibility to support secondary education. Issues over the legality of taxation for the maintenance and support of secondary schools were debated. The Kalamazoo Case, Michigan (Stuart v. School district no.1 of the village of Kalamazoo, 1874) by the Michigan Supreme Court ruled that schools could collect additional taxes to cover the expenses needed for secondary schools. This decision ranks as an important milestone in establishing the legality of providing a high school education at taxpayer expense (Johnson, 1978).

Science curricula in secondary schools were, however, disjointed and unsequenced until the 1930s (Cubberley, 1934). They were college dominated and primarily served a college preparatory function. This was true despite the fact that many students were not interested in or able to enter college. Science was generally viewed as a collection of facts to be memorized rather than an understanding of important generalizations and principles. The predominant teaching method of the period consisted of "assigning material in the textbook and hearing pupils orally repeat the same material" (Fay, 1931, p. 1546).

In 1913, a committee on the Reorganization in Secondary Schools was appointed by a commission of the National Education Association (NEA) to focus attention on public concerns. This report recommended the selection and organization of an introductory science course. It further suggested some academic standards for secondary education and specific requirements for the high school diploma. Thus, the general science course evolved into a very important part of the science curriculum in the

secondary schools (Johnson, 1978). In order to further articulate and standardize secondary school courses, the Carnegie Unit was implemented which required four academic units each year and a total of sixteen units for graduation (Cubberley, 1934).

Before secondary schools could make satisfactory adjustments in science curricula and teaching methods, World War I intervened. Hardly any notable changes occurred in secondary science education during this time; however, heavy industries grew at a rapid rate during this period and into the 1920s. The world-wide economic and social changes which followed precipitated changes in educational philosophy and established who should attend high school. During this time and up to World War II, the U.S. was rapidly changing from an agricultural to a mechanical and industrial nation. This in turn, brought new pressures to bear on the science curriculum (Williamson, 1978).

During the Depression, a major statement on K-12 science education policy was published (Powers, 1932). This was the Thirty-First Yearbook of the National Society for the Study of Education, (NSSE), A Program for Teaching Science. This publication was the first that addressed major problems in science education and its relationship to general education. Two important recommendations in the publication were: (1) an integrated, sequential science program from kindergarten to the twelfth year; and (2) a change in emphasis in science education from recall of factual information to a concentration on four objectives: (1) understanding scientific facts that have broad applications, (2) understanding principles of science (concepts) needed for general education, (3) developing scientific attitudes, and (4) applying the skills of the scientific method. Unfortunately, these ideas were not readily adopted because an implementation program was not available. The full impact of the report, however, was not realized until many years later.

Despite the economic hardships of the 1930s, three major views concerning

science education were established. It was accepted that: (1) science education experiences were important to every student, not just to those going to college; (2) objectives beyond factual acquisition should receive attention; and (3) science education was a discipline in which research was required and dissemination of those findings was necessary.

Although World War II delayed many initiatives, the latter 1940s saw many efforts to implement changes in science education. One important effort was that of the Cooperative Committee on the Teaching of Mathematics and Science of the American Association for the Advancement of Science. The Committee made several recommendations on improving secondary school science education and was partly responsible for the formation of the National Science Foundation. Another important effort during the 1940s was the Steelman report (1947), a series of five volumes that dealt with topics in science education research and problems concerning the shortage of science teachers and lack of educational funding (Steelman, 1947).

Following World War II, local, state, and national groups began studying changes to improve science education in secondary and primary schools. Mallinson (1960) reported that the critical shortage of scientists and teachers in the country was due to a decrease in the absolute number of secondary school students resulting from the decreased college-age population during World War II. The launching of the Sputnik in 1957 by the USSR increased public awareness that American pupils might not be keeping pace with advances in science and technology. This event precipitated federal funding initiatives and major innovative changes in science education directed toward producing more and better scientists and engineers (Hausman, 1978). The National Science Foundation (NSF), established in 1950, was the lead federal agency charged to "develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences" (National Science Foundation, 1983).

During the golden age of science education (1955-1974), a crash program of educational reform was initiated. Many new science curricula were developed through the combined efforts of scientists, teachers, psychologists, and other experts. These curricula addressed elementary, junior high, and high school science curricula. The emphasis of all these programs was on the development of scientific process skills and teaching the nature of scientific inquiry. Curricula were organized according to the structure of science disciplines (Kyle, Shymansky, & Alport, 1982; Shymansky, Kyle, & Alport, 1982). Teacher guides and in-service workshops stressed strategies and teaching methods based on theories of how students learn.

Much of the emphasis in the new curricula was on theoretical science, scientific explanation, and major scientific concepts but not its applications (Kyle et al., 1982). Laboratory activities that focused on introducing scientific concepts were stressed as an integral part of the learning process. This was a change from traditional strategies, in which laboratories were only viewed as verification experiences to reinforce understanding of previously learned concepts. Moreover, teaching strategies suggested in the teacher guides and teacher training workshops emphasized higher cognitive thought processes beyond the rote memorization of facts (Hofstein & Yager, 1982; Kyle, et al., 1982).

Perhaps due to the post-Sputnik activities in science education, the shortage of scientists and engineers appeared to have abated in the 1970s (Rutherford, 1980). The United States achieved notable success in space technology and other areas of basic research. However, science educators realized the necessity to make science a useful as well as a theoretical subject for students of all ages (Rutherford, 1980). At the same time, test results indicated downward trends in science achievement. Nonetheless, new national priorities caused Congress to almost eliminate NSF funding to education (Yager, 1981). Simultaneously, the threat of an economic challenge from Europe and

east Asia loomed on the horizon. It was not long before a second major crisis in science education was identified and began to take shape.

As a result, three status studies (Helgeson, Blosser & Howe, 1977; Stake & Easley, 1978; Weiss, 1978) were sponsored by NSF to assess new directions in science education and to evaluate the impact of the training and curriculum activities of the 1960s. Harms and Yager (1981) synthesized and analyzed these studies to determine the state of science education in the country. They determined that the goals of prior curriculum efforts established during the 1960s and the 1970s had not been achieved. Goodlad (1983) came to the same conclusion in a study on the state of the nation's schools. These researchers found that there was very little evidence of increased "intellectual development": the ability to think rationally, intellectual curiosity, and a desire to seek further knowledge (Yager, 1984).

The new crisis was reported in A Nation at Risk: The Imperative for Educational Reform (National Commission on Excellence in Education, 1983). This publication indicated heavy declines in scientific and technological literacy at a time when the demand for skilled workers in the fields of computers and robotics was greatly increased. The Commission determined that the country's decline in educational performance was the direct result of declines in the educational delivery system. Schools had lowered their educational standards to keep students in school. Furthermore, a comparison of achievement and the structure of educational systems in the United States with its counterparts in the developed industrial nations found that students in this country spend less time in schools, and this classroom time is often not spent effectively.

The Commission made a list of recommendations to parents, students, and teachers in an effort to remind everyone of the need to acquire a good education. It suggested that an educational reform was needed to renew the commitment of the U.S.

to producing high quality progress and scholarship. According to A Nation at Risk, "to keep and improve on the slim competitive edge we still retain in world markets, we must dedicate ourselves to the reform in our educational system for the benefit of all" (National Commission on Excellence in Education, 1983, p.7).

The Commission's findings were studied extensively by many educators. As a result, interest in educational reform became a nationwide agenda. However, cutbacks in federal budgets and state fundings offered little hope for financing change. Thus, some schools began to make requests to local businesses and industries for funds and assistance to create linkages and programs to address these needs.

In the last few years, the range and magnitude of business support for schools in terms of financial and technical resources has increased dramatically. Adopt-a-school types of programs have been widespread in certain areas (Holden, 1984). Some of the results of these linkage programs include special tutoring, counseling, field trips, guest speakers, and summer jobs for students and faculty. These cooperative partnerships are mutually beneficial to both schools and businesses. The sponsoring organization can help meet the school's special needs such as providing in-service training and internships for teachers. In return, the school can serve as a field test site or demonstration site to allow teachers to preview new products or software used in instruction. Business and industry, in turn, receive better trained employees for their work force.

Another type of program which frequently involves partnerships with local businesses is the magnet school. The basis of magnet schools is to attract students based on interest and ethnic balance (Doyle & Levine, 1983). The school draws students and teachers from a number of local schools to one location where the curriculum focuses on a narrow field of study such as the sciences, the arts, or music. These schools frequently involve a pull-out program and are designed to fulfill

technical and special needs that regular schools cannot meet. Such special schools usually have greater funds that allow them to be physically better equipped and staffed compared to regular schools.

Concern over the national problems of declining scientific literacy, declining enrollment in science and mathematics, the shortage of qualified teachers, and reduced funding for education, led The Upjohn Company in Kalamazoo, Michigan to propose the establishment of a specialized school for science and mathematics in the area. Initially, there were not many programs available for the gifted and talented students beyond the elementary level in Kalamazoo. Although Advanced Placement classes in mathematics and science are available in some area high schools, few of them offer access to a sophisticated laboratory or computer equipment.

Realizing these issues, a unique and cooperative partnership was initiated between the public and private sectors to establish the Kalamazoo Area Mathematics and Science Center (hereafter KAMSC) in 1985. Upjohn provided initial start-up funding as well as endowment for continual support for the center. Furthermore, KAMSC benefited from being a demonstration site for Apple Computers and a field test site for graphing calculators used in mathematics instruction. Loans or gifts of equipment and furnishings continue to be provided by other participating companies that formed partnerships with KAMSC.

Statement of the Problem

A pullout program such as that at KAMSC is one that recruits students having certain qualifications from schools in the region. Since pullout programs concentrate significant resources on a special segment of the student population, it is reasonable to question their efficiency in achieving the following curriculum objectives: science knowledge, skills, attitudes, and educational experiences. The Kalamazoo Area

Mathematics and Science Center, a specialized high school established in account with this concept, is an example of such a school designed to address present day science and technological needs. A successful program would contribute to a stronger educational system, thus benefiting the entire community.

The primary purpose of this study is to compare the science and mathematics experiences, achievement, attitudes, and career interest of high-ability students who are involved in a special pullout program at KAMSC with similar students who did not have these experiences.

This investigation is designed to answer the following questions:

1. How do students who were selected to attend the KAMSC program compare in science and mathematics experiences with qualified students who declined the invitation or who left the program? Specifically,

(a) What were the science and mathematics subjects taken in grades nine, ten, and eleven; and how many science and mathematics courses were taken during the three years?

(b) How many hours of laboratory activity were scheduled each week during the eleventh grade?

(c) How many field trips were attended in the last year?

(d) How many hours were spent each week doing homework in mathematics and science?

2. How do the same groups of high-ability students compare in achievement in science and mathematics? Specifically,

(a) What types of standardized tests related to science and mathematics were taken by each group?

(b) and how did their scores compare?

3. Are there any differences in career interests between the students who

experience the KAMSC program and those who did not? Specifically,

(a) What are the professed career interests of these groups?

(b) Is there greater interest in careers relating to science and mathematics for one particular group?

4. How do students who were selected to attend KAMSC compare in their attitudes towards science and mathematics with qualified students who declined the invitation or who left the program?

Importance of the Study

The primary importance of the study is to determine whether the pullout specialized program for science and mathematics at KAMSC produces substantial differences in student experiences, attitudes, career interests, and achievements. At the present time, developing science concepts and enhancing scientific thinking skills are the primary objectives of most science curricula. At KAMSC, there is additional emphasis on basic skills including scientific communication and higher level problem-solving skills. It is important to determine whether a specialized science and mathematics program such as that at KAMSC is able to promote enhancement of student attitudes towards mathematics and science, a higher scholastic achievement, a broad educational experience in science and mathematics, and a preliminary career identification in mathematics and science.

CHAPTER II

A REVIEW OF THE LITERATURE

Specialized Schools for Science and Mathematics in the U.S.A.

The establishment of magnet-type specialized schools in the United States is not a new concept. The Boston Latin School was the first such highly selective school that began operating in 1635 to serve the children of professional people, particularly clergy (Cubberley, 1920). The Bronx High School of Science, designed to recruit talented youngsters, was a leader in establishing specialized science schools in this country in the period between 1930-1960. Originally, these schools were established to serve the specific needs of a small privileged intellectual group. Now, specialized schools are designed mainly to fulfill technical and special needs that regular schools cannot meet (Gaines, 1986). Furthermore, they provide talented students with educational opportunities to work with other advanced individuals in accelerated courses. Specialized schools differ from magnet schools in that they attract high-ability students in a specialized area, such as science and mathematics. Magnet schools, however, attract students and faculty on the basis of their special interests and abilities while increasing multiracial participation. This latter factor encourages racial and ethnic integration while reflecting the larger population that the system serves (Doyle & Levine, 1983). Generally, magnet schools are organized around a pedagogical theme, such as science and mathematics, or music and art. In 1981-82, there were 1,018 elementary and secondary specialized and magnet schools in the

United States (Doyle & Levine, 1983).

Holden (1984) described the present trend towards increasing numbers of science/technology magnet schools that are receiving corporate backing, donations of equipment, and training, through school-industry partnerships. This is particularly true in California, where many companies have donated money and equipment to schools, their instructional programs, and special competitions. The numbers of "adopt-a-school" company-school partnerships have increased dramatically. The sudden surge of interest by business and industry has been attributed to their concern over the competitive position of U.S. technology compared with that of other countries, the shortage of high-quality technical manpower, and the decreased standards for science education in this country. Presently, there are 21 schools that belong to The National Consortium for Specialized Schools in this country (Appendix A).

The move toward specialized programs of study may also be credited to The National Science Foundation 1983 report titled Educating Americans for the 21st Century: A Plan of Action for Improving Mathematics, Science and Technology Education for All American Elementary and Secondary Students So That Their Achievement is the Best in the World by 1995. This report focused on issues of appropriate content and process goals in the teaching and learning of mathematics, science, and technology in grades K-12. Recommendations included changing some of the content of traditional elementary and secondary education to include particular stress on the fundamental understanding of basic concepts in mathematics, science and technology.

Sendor (1984) described North Carolina's first publicly financed residential science magnet high school for the gifted. She stressed its innovative structure partly characterized by a racially balanced student body (70% white, 30% black). The main

goal of the school's academic program is to develop each student's potential by emphasizing individual inquiry and group cooperation. Students can choose from structured courses such as microbiology and astrophysics, or they can design their own one-on-one tutorials. Students must perform work and community service requirements: four hours a week doing chores such as raking leaves or assisting in the library, and three hours a week in helping senior citizens, or working with handi-capped people. The teachers also participate in professional outreach programs by consulting with other public schools. The only negative report which appeared was the concern that the school receives proportionately too much money from the state. This promotes a policy of elitism that takes the better students away from the local community and school programs.

Schafer (1979) prepared a detailed evaluative report of the Dallas Independent School District's Science and Technology Magnet High School. This evaluation led to the development of a model for creating similar magnet schools elsewhere. In the model, variations in school needs are important considerations, as are a curriculum that is meaningful, complete, and meets student needs and state requirements. Schafer also described the concerns that must be considered in developing a magnet school. They include a Curriculum Writing phase, pilot testing the curriculum, having consultants from outside the district review and assist in the curriculum writing, and flexibility to revise the curriculum to address the stated needs. The Dallas Magnet High School model received good evaluations from three educators who found that the curriculum was excellent and that the building and management plans could be replicated elsewhere.

Another district in Texas which offers magnet school programs for the gifted and talented at the elementary and secondary levels is the Austin Independent School District. Gaines (1986) summarized an evaluative report sponsored by the Department

of Education, Washington, DC, that followed a one-year Assistance Program grant to expand and improve magnet schools in the Austin Independent School District (AISD). The objectives of the Assistance Program grant were to improve overall enrollment and ethnic balance in science and technology, and to provide alternatives through an enriched curriculum and to increase interest, knowledge, and understanding of students in the content area of focus. Gaines then conducted a student survey to assess student attitudes of the science, mathematics, and computer technology programs at the Science Academy in Austin, Texas, a magnet high school implemented in 1985. Her findings were generally positive; 80 % of the students planned to attend college on completion of the high school and 86 % would encourage others to apply. More than 50 % felt motivated to do well at the Academy. Those students who felt inspired by their teachers also felt motivated to do their best. Although students with lower grade point averages believed that the Science Academy expected too much from them, those with high GPAs did not. Students who felt well-prepared in mathematics also believed they were well-prepared in science.

Gaines (1987) also found that magnet schools have become increasingly popular as alternatives to traditional curriculum offerings. In a separate study, she compared the achievement of students at the Science Academy with those of other students in the Austin school district. Gaines realized that comparisons would be difficult because the students at the Science Academy were high achievers and therefore a higher level of achievement should be expected due to a previous lead or by out-of-school reading or experiences of individuals who are already highly motivated. Regression analysis techniques were used to correct for these factors. The findings indicate the tenth-grade magnet students' achievement gains did not significantly out-gain their district-wide counterparts in science. The author reasoned that this was because the Tests of Achievement Proficiency (TAP) (Riverside Basic Skills Assessment Program), did not

address the specific curriculum taught to tenth-grade magnet school students (that included Chemistry and Physics). Only 6% of the TAP questions covered subjects that constituted a majority of their program. By further scrutiny, Gaines concluded that the TAP test was not measuring what it purports to measure. Generally, the author concluded that Science Academy students exceeded their predicted levels of achievement in all areas, though not all the differences were significantly larger than the gains made by similar students who were not in the program.

Sawyer (1986a, 1986b, 1987) prepared a series of three reports for Thomas Jefferson High School for Science and Technology in Fairfax, Va. The first report studied the impact of Thomas Jefferson High School on the programs of high schools in its service areas. A negative impact was not observed on the ability of the other high schools to sustain ninth-grade programs in English, mathematics, and social studies. However, the impact of the magnet school on their science program is unclear because the freshmen at Thomas Jefferson High School select biology whereas the freshmen in the regular public schools select earth science. It was noted that before Thomas Jefferson High School opened, two public schools did not offer earth science. Subsequently, after its first student intake, six public schools did not offer earth science. The reasons were that there was a decline in student enrollment in the public schools due to loss of potential students to Thomas Jefferson High School, and preference for selecting biology over earth science. Transfers of faculty to the magnet school were not found to have a negative impact on home school programs at any grade level.

Sawyer (1986b) also evaluated the selection and admission processes for students. Although some refinements were discussed, it was concluded from the enrollment patterns that selection procedures produced highly motivated, interested students who were successful in the program. The applicant selection process was

based on: (a) an aptitude for successful study of science, mathematics, computer science and related technical fields as determined by a subscore from an aptitude test; (b) the record of prior academic achievement (GPAs of academic courses in grades 7 and 8); (c) an admission examination consisting of a standardized multiple choice test portion that measured abstract reasoning, numerical reasoning, space relations, and verbal reasoning, and an essay portion; and (d) a student essay describing their interest and motivation in science, mathematics, and computer science.

Sawyer (1987) further summarized the findings of several separate surveys designated to assess opinions concerning the first year experience of parents, freshmen students, senior experience students (one year special program for high school seniors), and staff. Overall, the results of the surveys indicated positive responses. Specifically, data reflected strong positive opinions of a challenging curriculum and coursework, a strong academic climate, intellectually stimulating experiences, and feelings that students achieved a great deal during the year. In addition, the faculty was comfortable with its role at the school, and students stated that they would encourage others to participate. Some concern was indicated about travel time to and from the magnet (special) school, and the value of the technology laboratories, especially those in telecommunications.

Program Objectives of Kalamazoo Area Mathematics and Science Center

Overview of the Curriculum Design

Improving the quality of secondary school mathematics and science education has been an important issue in the United States for many decades (Hurd, 1983; Yager, 1984). Research in schools throughout this country has frequently indicated a lack of "hands-on" experiences to complement the teaching of theory (De Rose, Lockard, &

Paldy, 1979). Such an approach, however, would neccessarily require more equipment and supplies than may normally be available in a typical high school. KAMSC, a specialized high school for students with high aptitude and ability in science and mathematics, was established to address these needs.

The curriculum at KAMSC is bimodal: a "vertical" component is designed to accelerate the standard course; and a "horizontal" program would provide a more enriched experience in mathematics and science. Besides the development of communication skills, higher level thinking skills, problem solving skills and basic research are also stressed. Furthermore, the center is able to provide sophisticated laboratory instruments and equipment rarely available to high schoolers. Students also have many opportunities to engage in hands-on activities and conduct research independently with help from the center's staff or from experts from outside the center.

The center has developed over a five-year period. A new class of approximately seventy five students is admitted each year. Students who were admitted in 1986 were seniors in 1989-90. They could elect various senior level courses that year that include Biomedical Science, Organic Chemistry, PASCAL Programming, Mathematics Applications, Science Communications, Advanced Chemistry, Advanced Computing, KAMSC Science Corps, Astronomy, Introduction to Engineering, Discrete Mathematics, and Independent Research. The junior class enrolls in Physics, Integrated Mathematics III, and a choice of one of the above electives. The sophomore class takes Chemistry, Integrated Mathematics II, and Computer Studies. Finally, the freshmen class takes Biology, Integrated Mathematics I, and Interdisciplinary Studies at KAMSC. The students are at the center for one half-day to receive their mathematics, science, and technology instruction. They then return to their home schools for their non-mathematics and non-science classes.

The Mentorship Program

The Mentorship program is an important component in the enrichment experience at KAMSC. Mentors are usually practicing mathematics and science professionals who volunteer their expertise to the center in the form of lectures and mini-course instruction. Some mentors act as curriculum and instructional development consultants to the center. Others work on a one-to-one basis with their mentee at their work sites. Groups of students may visit mentor sites for field experiences, or the mentors may help students on class projects at the center.

KAMSC Mission and Goals

An important goal of KAMSC is to deliver high-quality instructional opportunities in science and mathematics to academically talented and motivated students in the Kalamazoo region. While this goal is the most visible, the center is also a model for partnerships between industries, schools, and the community, designed to improve education. KAMSC also provides a student enrichment program, a teacher training program and acts as a resource for the community by allowing use of its facilities and loans of equipment. The KAMSC Mission Statement and Goals (Appendix B) outlines the philosophical commitments behind the establishment of the center.

The Outreach Program

KAMSC also has a commitment in the area of outreach programs. Outreach is enrichment through sharing (Kalamazoo Area Mathematics and Science Center, 1988). A major goal is to provide leadership, coordination, and technical assistance in curriculum development and change in the various home schools. Some expected outcomes are that the effort can foster goodwill among the home schools and the community, as well as help kindle student interest in mathematics and science. The program aims at

improving community awareness that the center is a community resource, and it is there to improve the quality of mathematics and science education at all levels of the educational spectrum. Furthermore, the Outreach program offers increased enrichment experiences for high school students by allowing them to use the center's resources and by providing laboratory instruments and instructional materials to teachers at area schools. Educator visitations to KAMSC are also encouraged during the school year.

A variety of outreach summer programs are held at KAMSC during the summer holidays as well. These provide high interest experiences to elementary and junior high students while promoting a greater awareness of the benefits of a thorough science and mathematics education. The summer programs include advanced mathematics and algebra courses for students who have conditional admission to KAMSC but lack these requirements.

Instruments and Tests

Attitude Instruments

An important facet of any science education experience is to assess student attitudes towards science and their high school experiences. Fishbein and Ajzen (1975) define an attitude as "a learned predisposition to respond in a consistently favorable or unfavorable manner toward an attitude object" (p.6). Definitions of science attitudes vary greatly (Haladyna & Shaughnessy, 1982; Haney, 1967). They have been used to denote opinions, feelings, beliefs, and appreciations individuals have for science; as well as traits of the mind such as curiosity, objectivity, and rationality when dealing with facts, evidence, and objects of science (Ramsey & Howe, 1969).

Attitude, as it relates to science, is often subdivided into scientific attitude and

attitude toward science. One definition of scientific attitude is the approach a person takes when solving problems, in assessing ideas, information, and for making decisions (Germann, 1988). This includes scientific outlooks such as objectivity, suspended judgment, and critical evaluation (Gauld, 1982; Kozlow & Nay, 1976). The term "attitude toward science" includes scientific attitudes as defined above as well as attitudes toward scientists, scientific interests, scientific careers, methods of teaching science, and the subject of science in the classroom (Blosser, 1984). Attitudes toward science may also refer to beliefs about processes, theoretical products, or the science-technology relationship (Munby, 1983a).

One common characteristic noted about attitudes is that they are learned (Fishbein & Ajzen, 1975; Shrigley, 1983). Thus, they are susceptible to change, although they do not change automatically or without the influence of experiences. Attitudes often result in predictable responses, thus the right stimuli tend to result in consistent responses that reflect previous experiences (Ajzen & Fishbein, 1980). Since consistency between attitudes and responses has not always been supported by research, most experts believe that attitudes and behaviors are not related in a totally predictable manner (Fishbein & Ajzen, 1975; Wicker, 1969). Therefore there is concern that attitude scores may not predict human behaviors.

The Scientific Attitude Inventory (SAI)

Germann (1988) reviewed studies on scientific attitude and the instruments used to measure them. He concluded that a valid and reliable instrument that measures this entire span of attitude is not available. Munby (1983a) collected and examined 204 attitudinal instruments of which fifty-six measured attitude toward science. Thirty-one of these instruments reported reliabilities greater than 0.7, but the reliability findings were verified by a second study for only seven of these instruments. Also, validation

studies for only seven instruments could be verified; thus these were the only instruments that satisfy minimal criteria for acceptibility. Munby (1983b) found that the instrument used most frequently in assessing attitudes toward science was the Scientific Attitude Inventory (Moore & Sutman, 1970).

The "Scientific Attitude Inventory" (SAI) is a 60-item Likert-type instrument with a 5-point response scale designed for high school students. It has been used in at least 30 studies since it was developed by Moore and Sutman (1970). The outcomes assessed by this instrument were divided into positive and negative attitudes towards science and were based upon the concerns of science educators for attitudes resulting from science teaching as indicated in Barnard (1960), The National Society for the Study of Education's (NSSE) Fifty-ninth Yearbook . They are:

1. The laws and /or theories of science are approximations of truth and are subject to *change.*

2. Observations of natural phenomena are the basis of *scientific explanation.* Science is *limited* in that it can only answer questions about natural phenomena and sometimes it is not able to do that.

3. To operate in a scientific manner, one must display such *traits* as intellectual honesty, dependence upon objective observation of natural events, and willingness to *alter one's position* on the basis of sufficient evidence.

4. Science is an *idea-generating* activity. It is devoted to providing explanations of natural phenomena. Its value lies in its *theoretical* aspects.

5. Progress in science requires *public support* in this age of science, therefore, the public should be *made aware* of the nature of science and what it attempts to do. The public can *understand* science and its ultimate *benefits* from scientific work.

6. Being a scientist or working in a job requiring scientific knowledge and thinking would be a *very interesting and rewarding* life's work. I would *like* to do

scientific work.

Negative attitudes with respect to science are those in opposition to the italicized words in the six statements.

Moore and Sutman (1970) reported a reliability of .93 by the test-retest method; a similar method by Popowicz (1975) reported a reliability of .79, while McDuffie (1973) obtained a reliability of .64 by the split-half method.

The face validity of SAI was established by Moore and Sutman by submitting the original collection of 112 items to a panel of judges and to a group of high school students. Construct validity was established by field testing the instruments with three groups of low-ability tenth-grade students. One group was taught by the regular teacher, another was taught lessons to develop the six positive attitudes described above, and the third group was taught lessons to develop negative attitudes. Significant attainment of higher levels of positive attitudes was found between the pre-test and the post-test means for the group receiving lessons designed to develop attitudes assessed by the Inventory (Moore & Sutman, 1970).

In tests involving college and university studies, results from five studies that used the SAI indicated significant differences favoring curricula whose content is related to an understanding of science. Gunsch (1972) found a significant difference in attitudes between two groups of freshman nonscience majors taking a laboratory-oriented course compared with that of a lecture-demonstration course, the difference favoring the former. Two of the subscales in the SAI were found to be related to significant attitudinal differences in experimental and control groups in two studies (McDuffie, 1973; Wilson, 1975). Significant attitudinal gains were also found in new programs over traditional courses (Boes, 1973; Gadson, 1976). However, Allison (1972) failed to find significant differences between the SAI pre- and post-tests of students enrolled in a semester course who received different laboratory experiences.

Similarly, Costa (1973) and Riley, (1975) did not find any significant attitudinal differences among students having direct, vicarious inquiry, or written narrative laboratory experiences.

In studies involving school curriculum, student, and teacher effects, significant differences were found in several studies. LaShier and Nieft (1975) found a significant relationship between cognitive achievement and scores in two subscales of the SAI in the Intermediate Science Curriculum Study (ISCS) students, but not for non-ISCS students. Welch (1972) found significant differences between SAI scores of students who completed the Physical Science for Non-Science (PSNS) course and students in other college level physical science courses.

However, contradictory findings were found on comparing effects of gains made in SAI scores for teachers who had undergone a five-week in-service workshop on ISCS. Lauridsen (1972) and Pinkhall (1973) found significant differences favoring the ISCS group, whereas Giese (1971) failed to find any significant differences.

Martinez-Perez (1973) did not find significant differences in SAI scores between grade six and seven ISCS and non-ISCS students. Martin (1972) compared students using the Blue, Green, and Yellow versions of BSCS and failed to find significant gains for any version. Novick and Duvdvani (1976), surveyed tenth grade students and failed to find attitude differences for type of school and type of curriculum.

Therefore, the studies reviewed above indicated contrary and anomalous results involving the SAI. For example, the instrument appeared to be related highly in self-concept, 0.76 (Campbell & Martinez-Perez, 1976), but not so in an earlier study (Martinez-Perez, 1973). Geiger (1974) and Lucas (1974) reported a significant relationship between SAI score and attitudes toward science and mathematics as school subjects, but Wilson (1975) reported none. Other studies on the relationship between SAI scores and science achievement were also inconclusive (LaShier & Nieft, 1975;

Lucas, 1974; Martinez-Perez, 1973; McDuffie, 1973; Popowicz, 1975; Ward, 1976). The mixed findings obtained on the SAI led Munby to the conclusion that the instrument's subscales have problems of conceptual difficulties. This was because many items in the inventory thought to assess an attitude can be interpreted differently. Therefore it was not certain what is being measured in some items of the SAI. Some revisions were deemed necessary before the instrument can be used with confidence (Munby, 1983b).

Other Instruments on Attitudes toward Science

Another instrument reported in the science education literature is the attitude toward science subscale of the Simpson-Troost Attitude Questionnaire (Simpson & Troost, 1982). This questionnaire was developed to investigate the influences on commitment to the learning of science among adolescent students. The instrument has 58 items covering a total of 15 subscales. Attitude toward science represents one subscale containing seven items. Four of the items addressed general attitude toward science in the classroom, two items addressed attitude toward scientists, and one item addressed science as a value. Cronbach's alpha estimates of reliability for the seven items in the attitude toward science subscale have been reported as 0.94 (Simpson & Oliver, 1985). In addition, Cannon & Simpson (1985), reported a Kuder-Richardson 20 reliability estimate of 0.95 in their study that found that attitude toward science appeared to be an important factor in science achievement.

The Attitude toward Science in School Assessment (ATSSA), developed by Germann (1988), is another instrument designed to evaluate students' attitude toward science. It was designed to measure how students reacted toward science as a school subject. The instrument showed an ability to discriminate between attitudes of students taught by experienced and inexperienced teachers. Cronbach's alpha

estimates of reliability were greater than 0.95 in four studies reported in the literature.

Assessment and Ability Tests

The most common ability and assessment standardized tests taken by graduating high school students are those for the purpose of college entry. The American College Testing Program (ACT) (ACT Registration) was first initiated by Lindquist in 1959. It has a four-part academic section consisting of English Usage, Mathematics Usage, Social Studies Reading and Natural Sciences Reading. Presently the ACT ranks second as a college admission examination to the Scholastic Aptitude Test (SAT) (Educational Testing Service) in terms of the number of students who take it nationwide (Aiken, 1985). It has a similar philosophy as the Iowa Tests of Educational Development (ITED) (Aiken, 1985).

Internal consistency reliability data of the ACT tests administered in 1976 indicate values between .85 for Natural Sciences Reading to .92 for English Usage (Aiken, 1985). Kifer (1985) believed that the ACT is a large, well-organized, technically competent test. Guessing answers is allowed without penalty. Items in the test are well-written and are in straightforward prose. Up to 70% of the items appear to require students to do cognitively complex things and not merely recall knowledge (Kifer, 1985).

The College Board Scholastic Aptitude Test (SAT), initially developed by Brigham in 1926, is designed to offer a measure of the developed verbal and mathematical abilities of high school candidates for college entrance (Cohn, 1985). The SAT can discriminate candidates of the highest calibre due to the the precise and complex thought process needed in interpreting items on analogies or acronyms (Cronbach, 1985). Presently, the SAT is the best documented instrument with detailed manuals describing aspects of administration, use, and standardized test

conditions.

Numerous studies concerning the reliability and validity of the SAT have been and continue to be conducted. Internal consistent reliability coefficients using an adaptation of the Kuder-Richardson 20 estimation typically exceed .90 (Cohn, 1985). Since 1964, the College Board has also initiated a Validity Study Service to examine how well SAT scores correlate with college grades and other criteria. Students who had high SAT scores should tend to receive higher grades in college than those with lower SAT scores. The studies indeed showed that SAT scores correlate with college performance.

Summary

The literature search failed to find more than ten studies of specialized mathematics and science centers in the nation. The pertinent materials available on specialized school programs were often descriptions and quasi-experimental evaluative reports rather than experimental research.

The literature search has also shown that attitude measurement of students towards science is an imprecise science. Out of over 204 instruments on attitudes towards science reviewed by Munby (1983a), only seven had their reliabilities and validities verified by a second study. The Scientific Attitude Inventory (SAI), has been reported as a reliable and valid instrument (Moore & Sutman, 1970). However, Munby (1983b), on reviewing thirty studies that have used the SAI, has indicated some doubts about the instrument's validity. According to him, some items require a cognitive and not an attitudinal response.

Two common assessment and ability tests for college entrance are the American College Testing Program (ACT) (ACT Registration) and the College Board Scholastic Aptitude Test (SAT) (Educational Testing Service). Both are well-documented and

show excellent reliabilities and validities. In this study, the ACT was chosen as the instrument used to determine achievement in science and mathematics. However, it must be noted that the ACT is only one of the instruments that can be used to make comparison of student achievement. The high school students in this study take their academic courses in mathematics and science at either one or a combination of the following places: KAMSC, their local high school, and colleges. Grades that students obtain in these courses, however, are difficult to compare, since they involve different teachers, curricula, and expectations. In addition, the students are all recognized as high-ability scholars and therefore most obtained scores of 4.0 or A's in courses taught at the high school level. Since all subjects took the ACT, a test that discriminates well even among high-achieving students, it was believed to be the most appropriate choice for this study.

CHAPTER III

METHODOLOGY

In the previous chapter, the literature pertinent to specialized schools in science and mathematics was reviewed. Furthermore, key studies on assessment of student attitudes towards science and achievement were described. The growth of specialized schools that concentrate on the sciences has raised questions on their efficacy in achieving such objectives as science knowledge, student attitudes, and achievement. As a result, the following basic research question was identified: How do the science and mathematics experiences, achievement, attitudes, and career interests of high-ability students involved in a special pullout program compare to those of similar students in regular high school programs? In this chapter, a detailed description of the study designed to address this question and the methodology employed are discussed. This discussion falls under five main topics: (1) overview of the study, (2) subjects, (3) instruments, (4) the procedures, and (5) data analysis.

Overview of the Study

The purpose of this study is to compare science and mathematics experiences, achievement, student attitudes, and career interests of talented students who attend a specialized science and mathematics program at the Kalamazoo Area Mathematics and Science Center (KAMSC) and of those who do not. In order to understand the setting for this study, an overview is useful to describe the background of the problem and the research setting.

Background of the Problem

Interest in educational reform became a nationwide concern after many research studies and reports indicate declining educational performance in mathematics and science in the nation's schools (examples: Goodlad, 1983; Harms & Yager, 1981; National Commission on Excellence in Education, 1983). Specifically these studies and reports indicated that problems of declining scientific literacy, smaller enrollments in mathematics and science classes, and shortages of qualified teachers were prevalent. One solution proposed to overcome these problems was to establish specialized or magnet schools in mathematics and science to attract and nurture those with identified talent and interest in these areas.

Specialized and magnet schools frequently involve a pull-out program that draws students having certain desired qualities from local schools in a community. Students in these programs usually take specialized courses in the magnet schools and return to their home schools for their other classes. Such specialized courses may be in any area, such as science and mathematics or the arts and music. Normally, such programs require greater funding compared to regular schools because of their more sophisticated program and specialized equipment needs. This is especially the case with magnet schools that provide accelerated science and mathematics courses. In many cases, financial and technical support to equip and begin such schools came from local industry and business. However, the effectiveness of magnet school programs in achieving their stated objectives to improve specialized knowledge, skills, attitudes, and related educational experiences in mathematics and science is uncertain. In this study, the researcher will determine whether one such program is effective in promoting the following objectives: a broad educational experience in mathematics and science, a higher scholastic achievement, enhancement of student attitudes toward science and mathematics, and career choices in the general areas of mathematics and

science. This study is designed to compare those objectives for students who are involved in one such pull-out program in science and mathematics and those who are not. Specifically, this investigation was designed to answer the following questions:

1. How do students who were selected to attend the KAMSC program compare in science and mathematics experiences with similarly qualified students who declined the invitation or who left the program?

2. How do students who were selected to attend the KAMSC program compare in achievement in science and mathematics with similarly qualified students who declined the invitation or who left the program?

3. Are there any differences in career interests between the students who experience the KAMSC program and those who did not?

4. How do students who were selected to attend KAMSC compare in their attitudes towards science with qualified students who declined the invitation or who left the program?

The Research Setting

The population for this study was the eleven high schools in the nine publicly supported school districts comprising the Kalamazoo Valley Intermediate School District (KVISD), and the area's three non-public supported high schools. This geographic region follows approximately the borders of Kalamazoo County. The primary site of this study was KAMSC, a specialized high school for mathematics and science located in downtown Kalamazoo. Each year, qualified students nominated from area high schools are selected to attend half days at KAMSC throughout their high school career for their science and mathematics coursework.

Subjects

At the beginning of the second semester of school, students in the KVISD attending the eighth grade who are interested in attending KAMSC may nominate themselves or are nominated by their parents or teachers. Applicants have to demonstrate their interest to attend KAMSC, and take the School and College Ability Tests (SCAT), (Educational Testing Service) at KAMSC. A selection committee evaluates their applications on three criteria: (1) academic achievement, (2) aptitude and interest in science and mathematics, and (3) their verbal and analytical scores on the SCAT. Admission standards for selection are heavily weighted towards previous demonstrated achievement. This achievement includes past grades in academic subjects, courses taken, and test scores on the SCAT (School and College Aptitude Tests). Teacher and counselor recommendation, and personal interviews also contribute to the selection process.

Applicants are informed of the outcome of their applications in May. Some students are placed on conditional admission status requiring them to take a summer algebra course. Approximately 75 students from the area high schools (identified in Appendix C) are finally selected for admission into the ninth-grade class each school year. In this study, all of the subjects were nominated and applied to attend KAMSC in the Winter of 1986 for entrance as freshmen in the charter class during the Fall of 1986. Eleven additional students were admitted to this group in 1987 to replace those who originally attended KAMSC but later left the program.

The high-ability students who were successful applicants for the KAMSC program were classified into three groups for the purpose of this study. They were:

1. Members of the charter class (class of 1990) at KAMSC who entered the program in Fall 1986 or joined the class in Fall 1987.

2. Students in the class of 1990 who originally attended KAMSC but who have

since left the program.

3. Potential students in the class of 1990 who applied, received an invitation, and declined to attend KAMSC.

A total of 63 subjects who met the Group 1 criterion were identified. These included the original charter members admitted to KAMSC and those admitted as members of the same class in their sophomore year in 1987. These subjects attend KAMSC for two and a half hours a day for their science and mathematics courses, and take their other non-science and non-mathematics requirements in their regular high schools.

There were eighteen students in Group 2 who were originally enrolled in KAMSC during the Fall of 1986 but did not continue this program at KAMSC. Most students left to return to their home schools although some left because their families moved from the area.

Group 3 consisted of six students who were accepted into KAMSC but then declined admission in the freshmen year in 1986. These students met the KAMSC admission standards but decided against enrolling for various reasons discussed in the Results section.

Instruments

Since the study involved comparing students on four different components, four separate assessment techniques were required. These components were: (1) student experiences in science and mathematics, (2) comparing scores in a standardized test for the purpose of assessing student achievement, (3) surveying student career interest in science and mathematics, and (4) assessment of student attitudes towards science. The following section describes these instruments and the procedures employed.

Science and Mathematics Experiences

With the help of three science educators, a questionnaire on science and mathematics experiences (SME) (Appendix D) was designed to determine the type and extent of science and mathematics experiences of students in the study during their freshman to junior years (1986-1989). The first draft of the SME was checked by the committee of science educators and modified to reflect their concerns and advice. Later, this draft was modified to fit a standard format. Students were asked to respond to a series of questions designed to elicit the type, level, and their perceived mastery of the science and mathematics course in the program. Also included were questions concerning the average amount of time spent per week in science experiments, with science and mathematics homework, and consulting with science and mathematics teachers.

Standardized Achievement Tests

All the subjects in this study had taken either or both of two standardized tests for college entrance and application. They are the Test Battery of the American College Testing Program (ACT) (ACT Registration), or The College Board Scholastic Aptitude Test (SAT) (Educational Testing Service). Furthermore, all students took the ACT, which is more frequently administered in the Midwest. Both tests attempt to measure aptitude for college studies and both have good validities in predicting college achievement (DuBois, 1978; Wallace, 1978). The ACT appears to be a better choice for evaluating scholastic achievement in this study since the ACT reports the natural science and mathematics test scores separately whereas the SAT reports only verbal and mathematical scores. Since the ACT was available for all subjects, it was used to measure achievement in the study. Furthermore, the ACT provides separate scores for the natural sciences and mathematics, a useful disaggregation of data for the purpose

of this study.

Career Interest Survey

Items to determine perceived career interest were also included in the questionnaire developed by the researcher (Appendix D) on Science and Mathematics Experiences (SME). It consisted of an item to elicit three top career preference choices and another item on previous career interests, if any. The main purpose of these questions was to determine if a relationship existed between career choices and student experiences in a specialized program. A second purpose was to determine if there was a change in career interest between entering high school and the junior year for the subjects in the study.

Attitudes Towards Science

The Scientific Attitude Inventory (SAI) (Moore & Sutman, 1970) was used as a measure of attitudes towards science in this study. Munby (1983a), indicated that out of 56 instruments that measure attitudes toward science, 31 instruments had reliabilities over 0.7, and that only seven instruments had their reliabilities verified by a second study. The SAI was judged the best instrument available among those reviewed for this particular group of high-ability students. This instrument is the most popular choice among instruments in studies on attitudes towards science, having been used in at least 30 studies; furthermore it is suitable for students in eighth grade and above (Munby, 1983b).

Procedures

Contacts With School Superintendents and Parents

In order to insure the needed cooperation for the study, letters were sent to the nine superintendents and the three private school directors to describe the purpose and design of the study and to seek their support of the project (Appendix E). These administrators understood the intent of the study and promised their support and assistance.

Subjects in the study were those on the list of successful applicants admitted into KAMSC in the Fall of 1986. All students who accepted the offer and remained at KAMSC until their graduation in 1990 were identified as Group 1. In addition, eleven students who joined the 1986 class and were admitted into KAMSC in the Fall of 1987 as sophomores were also included as a part of Group 1. Those who rejected the offer in 1986 were identified as Group 3. Those who initially attended KAMSC but left for any reason during 1986-1988 were placed in Group 2.

Permission to carry out the study was sought from the Human Subjects Institutional Review Board (HSIRB) at Western Michigan University (Appendix F). The Board decided that since the study involved looking into school records, and that subjects were below 18 years of age, it was necessary to obtain written permission from both students and their parents to participate in the study. A list of parents' names and addresses was obtained from student application files. A letter was sent to the parents of each subject describing the study, and requesting them to sign a permission statement to use information about their child (Appendix G). In addition, students were informed about the purpose of the study and they signed a "consent to participate" form (Appendix H). Confidentiality and anonymity was stressed throughout the study. A stamped, self-addressed return envelope was included for returning

the letter and forms.

Data Collection

A second mailing consisting of the Science and Mathematics Experiences instrument (SME), the Scientific Attitude Instrument (SAI), and a stamped self-addressed return envelope was sent to each participant in Groups 2 and 3 after receiving letters of consent from both parent and student. Current addresses were not available for two participants in Group 3 who declined an invitation to attend KAMSC. Apparently, these students had moved away without leaving a forwarding address. Out of 18 original subjects of Group 2, those who left the KAMSC program, four declined to participate and two more left the Kalamazoo area without a forwarding address. Therefore, a total of twelve participants in Group 2 and four participants in Group 3 agreed to participate. About half of the surveys from subjects in Groups 2 and 3 were received within two weeks from the date they were mailed. Follow-up telephone calls were made to those who had not returned the survey forms after three weeks to remind them to return their surveys to the researcher.

Since Group 1 subjects, those who received their mathematics and science courses at KAMSC, were a large group, the researcher requested and received permission from the Director of KAMSC to administer the Science and Mathematics Experiences instrument (SME) and the Scientific Attitude Instrument (SAI) during class time. Most students completed the two surveys within one hour and thirty minutes. Those who did not were allowed to take the surveys home and to return them the next day.

Data from the SAI and the SME were collected at the end of the junior school year in May 1989. Table 1 summarizes the information on the subjects' responses to the invitation to participate in this study. A total of 74 students out of a possible 87

returned all survey forms: 58 in Group 1, twelve in Group 2, and four in Group 3. This group constituted the study sample. Five students in Group 1, and four students in Group 2 declined the opportunity to participate. Two students in each of Groups 2 and 3 had moved out of the Kalamazoo area and their addresses were not available.

Table 1

Descriptive Information on Subjects' Response to Participate in the Study

	Group No.		
Response	1	2	3
Participated	58	12	4
Declined to participate	5	4	0
Unknown address	0	2	2
Total possible participants	63	18	6
% of participants in each group	92	67	67

During the second semester of the senior year (April, 1989), personal contact was made with school counselors of each student to obtain confidential information on the ACT and SAT test scores of students in Groups 2 and 3. Similarly, personal contact was made with the school counselor at KAMSC to obtain information on the ACT and SAT test scores of each subject in Group 1.

Data Analysis

Each participating subject was assigned a code number and their names and other identifying information were removed from all materials. The following information was recorded for each subject: (a) coded response to the items on the questionnaire on science and mathematics experiences, (b) total scores and sub-scores in science and mathematics for the ACT, (c) present top three career choices and previous job interest before entering high school as indicated on the job interest survey, and (d) a score for the Scientific Attitude Inventory.

Research Questions

Since the research involved comparisons of four different parameters, the following research questions based on those in Chapter I were formulated.

Science and Mathematics Experiences

Research Question 1. Is there a difference between the number of science and mathematics subjects taken by each of the three groups in grades nine, ten, and eleven?

Research Question 2. Is there a difference between the number of scheduled hours of laboratory activity for each of the three groups during the eleventh grade?

Research Question 3. Is there a difference between the number of field trips attended by the three groups during the junior year?

Research Question 4. Is there a difference between the number of hours spent studying and doing homework in mathematics and science for each of the three groups?

Achievement in Science and Mathematics

Research Question 5. Is there a difference between the median scores in the ACT in the Mathematics and Science sub-sections for each of the three groups?

Career Interest

Research Question 6. Is there a difference in the percentage of students interested in a career in science and mathematics for the three groups?

Attitudes toward science

Research Question 7. Is there a difference in the median score of the Scientific Attitude Inventory (SAI) for the three groups?

Statistical Treatment

Since this study involves groups of highly unequal sizes, nonparametric statistics was selected as the most suitable tool to determine the significance of the comparisons. Such tests of significance do not involve inferences about the population parameters, and no assumptions need to be made about the distribution of the population being sampled (Klugh, 1986). The more powerful parametric test, 1-way ANOVA, cannot be used for this study because of the extreme differences in group sizes. A suitable statistical test for each research question is the Kruskal-Wallis 1-way ANOVA (Daniel, 1978; Klugh, 1986). This technique is appropriate since it is a nonparametric test which allows the investigator to conduct one-way analysis of variance by ranks and makes no assumptions about sample sizes. In cases of significant differences in the median, a multiple comparison procedure is computed to determine which median produced the significance. This procedure is described in the next chapter of this

research study. All calculations for the Kruskal-Wallis 1-way ANOVA can be computed using the statistical package Statworks® (Cricket Software, 1985) on the Macintosh computer.

CHAPTER IV

RESULTS

The purpose of this study was to compare the science and mathematics experiences, achievement, career interest, and attitudes of high-ability students who were involved in a special pull-out program at the Kalamazoo Area Mathematics and Science Center (KAMSC) with similar students who did not have these experiences. The comparison involved collecting data in four areas. Each subject: (1) responded to the Sciences and Mathematics Experiences (SME) questionnaire to obtain information about their science and mathematics experiences; (2) took the American College Test, (ACT) (ACT Registration), whose Natural Science and Mathematics scores were used as a measure of student achievement; (3) completed a section of the SME questionnaire that indicated career choices; and (4) completed the Scientific Attitude Inventory (SAI) (Moore & Sutman, 1970) to measure attitudes toward science.

Descriptive Information

Subjects

The design of the study involved the participation of three groups of subjects: (1) members of the class of 1990 at KAMSC, (2) students in the class of 1990 who originally attended KAMSC but who later left the program, and (3) students in the class of 1990 who declined the invitation to attend KAMSC. Members of the first group attended half-day sessions at KAMSC for their formal science and mathematics instruction and received their non-science classes in their home schools. The second group of students initially attended KAMSC in the Fall of 1986 but left KAMSC to

return to their home schools full time or moved out of the Kalamazoo region. These students attended KAMSC for at least one semester in the Fall of 1986 but left KAMSC for various reasons between 1986-89. The third group of students applied and were accepted into KAMSC but decided not to accept the invitation to participate in this program. The sample from Group 1 consisted of 58 participants out of a possible 63; whereas Groups 2 and 3 consisted of 12 and 4 participants, respectively, out of a possible 18 and 6 students.

The study was carried out after receiving permission from Superintendents in the nine participating school districts and from the Human Subjects Institutional Review Board (HSIRB) at Western Michigan University. The purpose and design of the study were described in a letter to all potential participants and their parents. The SAI and SME instruments were mailed to participants in Groups 2 and 3 on receiving their letters of consent and their parents' permission to participate. Participants in Group 1, those who attended KAMSC, responded to the SAI and SME instrument items during class time at KAMSC. Furthermore, all participants took the ACT at their home schools. Each participant's sub-scores for the mathematics and natural science sections of the ACT were obtained with the assistance of the school counselors.

Data Analysis

The statistical test selected to test six of the seven hypotheses in this study is the Kruskal-Wallis 1-way ANOVA. The test ranks scores and determines differences in the group median values. This non-parametric statistical test is appropriate for cases when samples are small, and very different in size, as is the case for the three groups in this study. This Kruskal-Wallis analysis is used to test hypotheses that are stated in the null form. The general way of representing such a hypothesis is that H_0: The population distribution functions of the k groups are identical, where H_0 is the symbol

for the null hypothesis, and k is the number of groups in the research study. The alternate hypothesis is H_1: The k populations do not all have the same median. The Kruskal-Wallis test involves ranking the data before they are analyzed. If the null is accepted, the distribution of ranks over the groups will be a matter of chance, so that small or large ranks do not tend to be concentrated in one sample (Daniel, 1978).

In the six hypotheses tested, the level of significance was set at $p=.05$. This implies that the null hypothesis of no difference will be rejected if p is found to be less than or equal to .05 ($p \leq .05$). In cases where the Kruskal-Wallis 1-way ANOVA tests produced significant findings, a multiple-comparison procedure described by Dunn (Daniel, 1978) was carried out to determine whether all three possible pairs of groups, that is, Groups 1 and 2, 1 and 3, and, 2 and 3, had significant differences at the $p \leq .05$ level. This procedure will identify where the significant differences exist among the pairs of groups being examined.

To use this multiple-comparison procedure, the mean of the ranks, R_1, R_2, and R_3 are calculated. The value of the error rate, alpha, which is the overall level of significance, is determined partly by the number of samples involved. Since there were three groups in this study, the level of alpha is .15 (thrice .05). The inequality whose equation follows (Daniel, 1978) is computed and if the difference in the mean of the ranks (R_i - R_j) is larger than the right hand side of the inequality, then there is a significant difference in those two median values.

$$\left| R_i - R_j \right| \leq z \sqrt{\frac{[N(N^2-1) - (t^3 - t)] \; \frac{1}{ni} + \frac{1}{nj}}{12\,(N-1)}}$$

In the inequality, the value of z obtained from the Normal Distribution Table is 1.96. N is the number of observations in the combined sample, and t is the number of values in the combined sample that are tied at a given rank.

Research Hypothesis 1

The null form for the first hypothesis was: There is no difference among the number of science and mathematics subjects taken by each of the three groups in grades nine, ten, and eleven.

In order to test this hypothesis, the number of semesters students elected mathematics and science subjects during the three years was requested in the SME questionnaire. For purposes of computation, two semesters were noted as one unit. This was because most major science and mathematics subjects lasted two semesters. The descriptive statistics and the Kruskal-Wallis analysis of variance were computed using the computer package Statworks®.

Table 2

Research Hypothesis 1: The Number of Science and Mathematics Courses Taken in Grades Nine, Ten, and Eleven

Participating Groups	Median	Mean	Range
Group 1	11.0	10.94	8-14
Group 2	8.0	7.58	5-9
Group 3	7.5	7.75	7-9
Kruskal-Wallis probability value, p=.000			

As shown in Table 2, the distribution in the numbers of mathematics and science classes taken by the three groups ranged from five to fourteen units. Students in Group 1 who attended KAMSC had the greatest range of number of classes taken, namely, between eight to fourteen units. On the other hand, the two comparison groups who did not attend KAMSC elected between five and nine units. The group of

students who left KAMSC to return to their home schools took between five to nine units, whereas the group of qualified students who did not attend KAMSC took between seven to nine classes in mathematics and science.

Also, from Table 2, one may observe that the median obtained for the KAMSC group (11.0) is higher than that obtained by Group 2 (8.0), and Group 3 (7.5). The Kruskal-Wallis analysis of variance produced a probability value of $p=.000$. Since p is less than .05, the null hypothesis that the three median values are similar is rejected. A multiple comparison procedure as previously described was carried out to determine if the difference is between Groups 1 and 2 only, between 1 and 3 only, or between 2 and 3 only. Results of the computation indicated a significant difference between Groups 1 and 2 only. Therefore, the number of science and mathematics courses taken during grades 9, 10, and 11 is greater for students in the 1990 class at KAMSC compared to the group that left KAMSC. The comparison of median values for the number of science and mathematics courses taken for Groups 1 and 3, and 2 and 3 did not produce significant differences at the $p=.05$ level for those pairs.

Research Hypothesis 2

The null form for the second hypothesis tested was: There is no difference among the number of scheduled hours of science laboratory activity for each of the three groups during the eleventh grade.

In testing this hypothesis, participants reported on the SME questionnaire the average number of hours they spent in the science laboratory in each week during the eleventh grade. As noted in Table 3, the distribution of hours ranged between three and nine. The group that studied at KAMSC reported between three and nine hours of laboratory activity, the group that left KAMSC had between four and nine hours, whereas the group that rejected an offer to attend KAMSC had between three and nine

hours of laboratory activity per week. The median for Groups 1, 2, and 3 were 6.0, 5.5, and 4.5 respectively. The Kruskal-Wallis analysis of variance procedure produced a probality value of p=.349. Therefore there was not a statistically significant difference between the three median values. As a result, there was not enough evidence to conclude that there was a difference between the numbers of science laboratory hours experienced by the three groups. Furthermore, it was not necessary to carry out the multiple comparison procedure since the null hypothesis was not rejected.

Table 3

Research Hypothesis 2: Hours of Science Laboratory Activity per Week in the Eleventh Grade

Participating Groups	Median	Mean	Range
Group 1	6.0	6.36	3-9
Group 2	5.5	5.92	4-9
Group 3	4.5	5.25	3-9
Kruskal-Wallis probability value p=.349			

Research Hypothesis 3

The null form of the third research hypothesis tested was: There is no difference in the number of field trips attended by the three groups during the junior year.

To test this hypothesis, students indicated on the SME instrument the number of field trips they experienced for their mathematics and science classes during the eleventh grade. A great disparity was noted in the range of scores for the three groups (see Table 4). Students attending KAMSC experienced between zero and ten trips

Table 4

Research Hypothesis 3: Number of Field Trips
Attended During the Eleventh Grade

Participating Groups	Median	Mean	Range
Group 1	3.5	3.76	0-10
Group 2	0.0	0.17	0-2
Group 3	0.0	0.25	0-1
Kruskal-Wallis probality value p=.000			

during their junior year, whereas the other two groups of students experienced between zero and two field trips. The large range in the number of field trips among KAMSC students was due to the nature of the different courses each student took during the junior year. For example, students taking the Anatomy and Physiology course had many opportunities for field trips to local hospitals and laboratories, but students who take mathematics and computer science courses spend more of their time in-class. Nonetheless, the median score for the number of field trips was much higher for the group that attended KAMSC (3.5) compared to the other two groups (0.0 and 0.0 respectively). The Kruskal-Wallis test of significance indicated a statistically significant difference (p=.000) for the hypothesis. Further multiple comparison test results indicated significance for groups 1 and 2, and groups 1 and 3, but not between group 2 and 3. Thus, students who attended KAMSC had experienced significantly more field trips compared to those students who either left the program or who rejected the offer to attend KAMSC.

Research Hypothesis 4

The null form of the fourth hypothesis was: There is no difference in the number of hours spent studying and doing homework in mathematics and science for each of the three groups during their junior year.

Participants reported on the SME questionnaire form the average number of hours they spent per week studying (item 3) and doing homework (item 4) in mathematics and science. To obtain a value for the descriptive statistics, the mid-point of the range for each item was determined with 12 hours recorded for the response "more than 12". The two scores were added to obtain a single score. Results indicate the range of hours was between 3 and 24 hours per week (Table 5). The range was greatest for students who attended KAMSC (Group 1), who reported a range between 3 and 24 hours per week. Students who left KAMSC to return to their home schools (Group 2) recorded between 6 and 18 hours of studying and doing homework in mathematics and science per week, whereas those who rejected the offer to attend KAMSC (Group 3) reported between 9 and 18 hours per week. As shown in Table 5, the median for Groups 1, 2 and 3 were 12.0, 13.5 and 10.5 respectively.

Table 5

Research Hypothesis 4: Number of Hours Spent Studying and Doing Homework During the Eleventh Grade

Participating Groups	Median	Mean	Range
Group 1	12.0	11.36	3-24
Group 2	13.5	13.25	6-18
Group 3	10.5	12.00	9-18
Kruskal-Wallis probability value $p=.262$			

The Kruskal-Wallis probability value obtained for this hypothesis was .262. This value is larger than .05; therefore there was not enough evidence to conclude that there was a significant difference among the three groups in the number of hours students spent doing homework and studying during the eleventh grade.

Research Hypothesis 5

The null form of the fifth hypothesis tested was: There is no difference between the mean scores on the ACT in the mathematics sub-section and the science sub-section for each of the three groups.

Both sub-scores in mathematics and science indicated greater ranges of scores for students who attended KAMSC. As shown in Table 6, the range in the mathematics sub-scores was 23 to 36 for the KAMSC group (Group 1), 22 to 33 for those who left KAMSC and returned to study at their home schools (Group 2), and 26 to 32 for students who rejected the offer to attend KAMSC (Group 3). Furthermore, sub-scores for the science portion for the ACT ranged from 19 to 35 for students attending KAMSC, 24 to 34 for those who returned to their home schools, and 28 to 32 for students who did not accept the invitation to attend KAMSC.

The group median values for the mathematics and science sub-scores of the ACT were compared using the Kruskal-Wallis one-way analysis of variance. At the 5% level of significance, it was found that the difference in medians for the science sub-section was not statistically significant (p=.248) (see Table 6). Therefore, although KAMSC students obtained the highest median science score, there was not enough evidence to conclude that significant differences existed in the science scores for the three groups.

A similar analysis was carried out for the mathematics sub-scores of the ACT. It was found that the difference in medians in the three groups for this sub-section was

statistically significant (p=.046) (see Table 6). The multiple comparison procedure was carried out for the mathematics sub-section for all possible group pairs to determine if there was a significant difference in their medians. The only significant difference found was that between the mathematics sub-score median of students attending KAMSC, Group 1 (29.5) and those of students who left KAMSC, Group 2 (26.0). Therefore, students who attended KAMSC scored higher in the mathematics ACT sub-scores compared with the group of students who left KAMSC to return to their home schools. The null hypothesis of no difference must be rejected in the case of the mathematics sub-section.

Table 6

Median and Range of ACT Scores by the Three Student Groups in Determining Student Achievement

	Science sub-score		Mathematics sub-score	
Participating groups	Median	Range	Median	Range
Group 1	31.0	19-35	29.5	23-36
Group 2	30.0	24-34	26.0	22-32
Group 3	30.5	28-32	29.0	26-32
Kruskal-Wallis p=.248			Kruskal-Wallis p=.046	

Research Hypothesis 6

The sixth research question queried students about their interest in careers related to mathematics and science. The first part of the analysis compared the difference in the percentage of students interested in a career in science and mathematics among the

three student groups. The second part of the analysis determined changes in career interest during high school. The null hypothesis is not involved in both sections since percentage reports of the results for the individual groups were thought to be more appropriate here.

In testing the hypothesis, participants indicated their top three career choices on the job interest survey, a section of the SME questionnaire. Students also indicated career choices made during their eighth grade. The following job groups were identified as those belonging to the mathematics and science category: agricultural and environmental sciences, life sciences, medicine, computers, mathematics and statistics, earth sciences, engineering, chemistry, physics and astronomy, psychologist, and technical writing. Examples of jobs identified as non-mathematics and non-science were business, banking, commercial artist, and law.

As shown in Table 7, 30 students (52%) who attended KAMSC indicated all three careers in the areas of mathematics and science. This compared to the other two groups where only one student (Group 2), and one student (Group 3), made each of the three career choices in science and mathematics. It is also worth noting that 58% of students who did not continue at KAMSC did not indicate at least one career choice in mathematics and science. In addition, all four students who declined an invitation to attend KAMSC chose at least one career in science and mathematics (see Table 7).

From Table 7, it is also observed that 17 KAMSC students (29%) chose two out of three careers in mathematics and science (whereas only 17% who left KAMSC made the same choice). Furthermore, 95% of KAMSC students chose at least one career in mathematics and science, whereas only 42% of those who left KAMSC did the same. Therefore a higher percentage of students who attended KAMSC chose career preferences in science and mathematics compared to similar students who left or did not attend KAMSC.

Table 7

Number of Career Choices in Mathematics and Science
by the Three Student Groups

	None	1 of 3	2 of 3	3 of 3	Total(%)
Group 1	3(5%)	8(14%)	17(29%)	30(52%)	58(100%)
Group 2	7(58%)	2(17%)	2(17%)	1(8%)	12(100%)
Group 3	0(0%)	1(25%)	2(50%)	1(25%)	4(100%)

A second purpose of the career interest survey was to determine whether there was a change in career interest between entering high school and the junior year for the subjects in the study (see Table 8). On the same Career Interest Survey, subjects indicated their career interest, if any, before they attended high school. This information was compared with their top three career choices during the eleventh grade. Any changes in career interest corresponding to a shift from a scientific career to a non-science profession, or vice versa, were recorded. Changes from interest in a career in science or mathematics to one involving both science and non-science were also noted.

Data from Table 8 indicate that ten students or 17% of those who attended KAMSC (Group 1) became interested in careers in science and mathematics whereas they previously were not interested in such careers. One other student from Group 1 (1.7%) also showed interest in both science and non-science careers whereas the same student was not interested in a scientific career before the ninth grade. No students in the other two groups showed similar changes in career interest for both the categories described above.

On the other hand, three students from Group 1 (5%) who attended KAMSC changed their career interest from science and mathematics to one in non-science. One

Table 8

Comparison of Changes in Career Interest Before Entering High School and During the Eleventh Grade

	Changes in Career Interest from				
	*Sc. to Non-Sc.	Non-Sc. to Sc.	No changes	Sc. to Sc. and Non-Sc.	Non-Sc. to Sc. and Non-Sc.
Group 1	3	10	44	0	1
Group 2	1	0	8	3	0
Group 3	0	0	4	0	0

*all Sc.(Science) includes Mathematics

student (8%) in Group 2 who left KAMSC to return to the regular high school program had a similar change of interest. Furthermore, three students (24%) in Group 2 had career interest changes from science and mathematics to careers that included those in the non-sciences as well. No other students in Groups 1 and 3 indicated the same changes of career interest.

The rest of the subjects, 44 (76%) in Group 1, 8 (67%) in Group 2, and 4 (100%) in Group 3, did not indicate career interest changes. Students who professed interest in specific careers in science and mathematics before the ninth grade indicated similar interests during their junior year. Similarly, those who chose careers in the non-sciences before entering high school made similar career choices during the eleventh grade.

At the close of this study, additional data were available on the particular college and the program of study each KAMSC student selected (see Tables 9 and 10). Thirty-four KAMSC students in Group 1 indicated interest in careers in mathematics

Table 9

KAMSC Students' Choice of College Programs*

Areas of Study	Number of Enrollees	Areas of Study	Number of Enrollees
Aerospace Engineering	4	Marine Biology	1
Astrophysics	2	Marine Research	1
Biological Research	2	Math/Statistics	1
Business	2	Mechanical Engineering	2
Business/Engineering	1	Medical Research	1
Business/Law	1	Medicine	12
Child Psychology	1	Paper Engineer	1
Computer Engineering	2	Planetary Science	1
Computer Science	2	Physics	1
Education	1	Professor/Research	2
Electrical Engineering	5	Psychology/Education	1
Engineering	6	Research Chemistry	1
International Business	2	Science Writer	1
Investment Banking	1	Sports Medicine	2
Journalism	1	Stats/Education	1
Law	3	Technical Writer	1
Management	1	Veterinarian	1

*adapted from KAMSC, A Profile (Kalamazoo Area Mathematics and Science Center, 1990).

Table 10

KAMSC Students' College Choice*

College/University	Number of Enrollees	College/University	Number of Enrollees
Alma	1	M.I.T.	2
Auburn U.	1	Michigan (U. of)	20
Barnard	1	Michigan State U.	3
Brigham Young U.	1	Michigan Tech.	2
Bryn Mawr	1	Northwestern U.	3
Cal. Tech.	1	Notre Dame (U. of)	1
Earlham U.	1	Pomona	1
Georgia Tech.	1	Purdue U.	1
Harvard U.	1	Chicago (U. of)	1
Harvey Mudd	2	Tampa	1
Hope	3	W. Ontario U.	1
Indiana U.	1	Western Michigan U.	3
Iowa (U. of)	1	Wisconsin (U. of)	1
Kalamazoo	12	Yale U.	1

*adapted from KAMSC, A Profile (Kalamazoo Area Mathematics and Science Center, 1990)

and science before they entered the ninth grade, whereas at least 48 students actually enrolled in those programs in their first year of college. Although it was not certain whether one can accurately categorize some of the areas of study as science or non-science, (example: Professor/Research and Psychology/ Education), it is clear that at least 80% of the KAMSC class of 1990 enrolled in programs of study involving

significant mathematics and science requirements. This percentage indicates an increase of about 22% more KAMSC students continuing the study of mathematics and science than they originally professed before the ninth grade.

Research Hypothesis 7

The null form of the seventh hypothesis tested was: There is no difference in the median score in the Scientific Inventory (SAI) for the three groups.

In testing this hypothesis, students responded to the Scientific Attitude Inventory (SAI) to determine their attitudes towards mathematics and science. The instrument consists of sixty items, and students respond to whether they strongly disagree, disagree, are neutral, agree, or strongly agree toward each item. Each item receives a numerical value between zero and three. Neutral responses always receive a numerical value of one. A strongly disagree response receives a numerical value of three if the accompanying statement is stated so as to reflect a negative attitude towards a negative statement. Similarly, if the statement reflects a positive attitude towards science, a strongly agree response receives a score of three. Likewise, a numerical value of two is recorded for an agree or a disagree response depending on the structure of the statement as previously described. A total numerical value below 60 indicates a generally negative attitude towards science.

Figures 1, 2, and 3 show the group frequency distribution of SAI scores, and Table 11 provides the mean, median, and range of these scores. The mean and median values for the three groups were between 97 and 107. The data indicated that no participant received a total score less than 60. The range in scores was greatest (67 to 145) for the group of students attending KAMSC, 80 to 115 for those who left KAMSC to return to their home schools, and 97 to 117 for students who declined the invitation to attend KAMSC. From Figure 1, it is observed that 13 students obtained

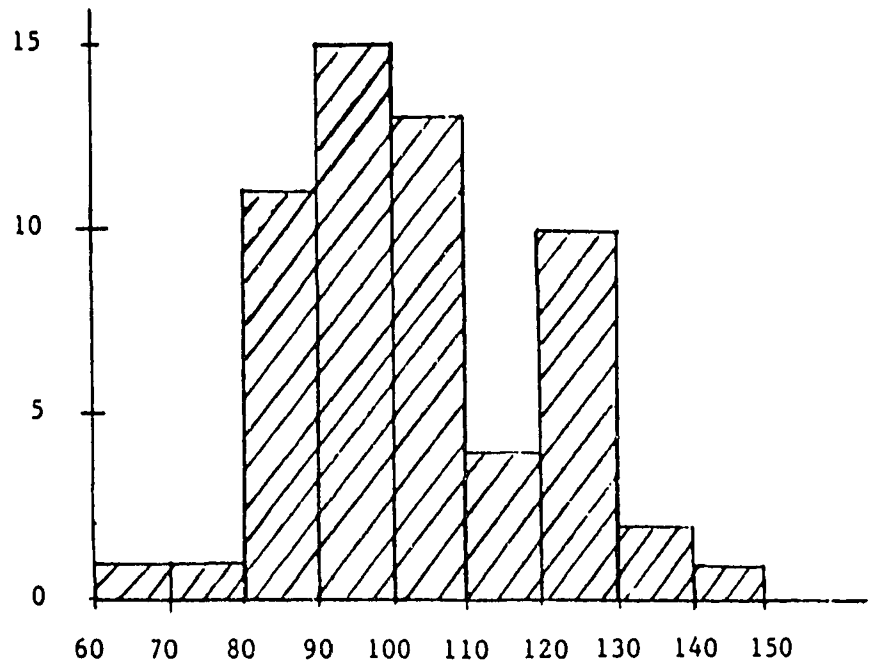

Figure 1. Distribution of SAI Scores for Group 1.

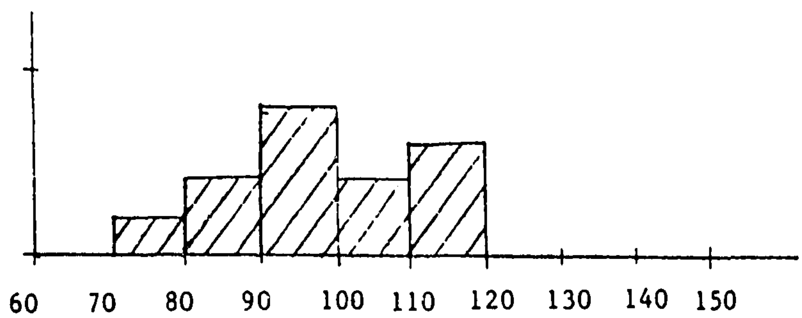

Figure 2. Distribution of SAI Scores for Group 2.

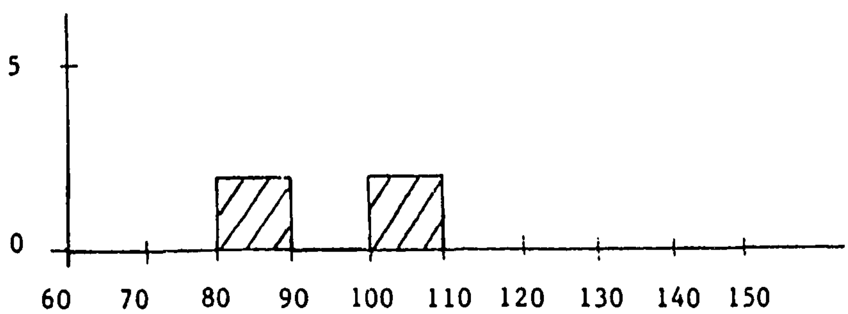

Figure 3. Distribution of SAI Scores for Group 3.

scores greater than 120, whereas no students in Groups 2 and 3 obtained similar scores.

The Kruskal-Wallis test of significance was carried out to determine if the null hypothesis of no difference between Groups 1 and 2, 1 and 3, and 2 and 3 could be rejected. It was found that the value of p was 0.630. This value is larger than 0.05 and therefore, the differences in the means of the SAI in the three groups were not large enough to reject the null hypothesis. Consequently, although there were differences in mean scores of the three groups, these differences were too small to conclude that any one group had a more positive attitude toward science than another group.

Table 11

Mean and Range of the Scientific Attitude Inventory Scores (SAI) for the Three Student Groups

	Mean	Median	Range
Group 1	103.88	101.5	67-145
Group 2	99.67	97.0	80-115
Group 3	107.00	107.0	97-117

Kruskal-Wallis probability value, $p=.630$

Summary

The analyses of this study to compare the science and mathematics experiences, achievement, career interests, and attitudes of high-ability students in a special pull-out program at KAMSC with similar students who did not have these experiences have been presented in this chapter. Four of the seven hypotheses tested produced significant findings. In one result, it was found that students who remained

throughout the KAMSC program took more science and mathematics courses during grades nine, ten, and eleven, compared to students who left KAMSC and those who declined an invitation to attend KAMSC. KAMSC students also took significantly more field trips during their junior year, and scored higher in the mathematics sub-section for the ACT test, compared to the students in the other two groups. More than 50% of KAMSC students also chose mathematics and science in their top three career choices, whereas the percentage is 8% for those who left KAMSC and 25% for students who did not accept the invitation to attend KAMSC.

The other three hypotheses tested did not produce significant findings. In one, there were no significant differences in the median number of hours the three groups of students reportedly spent in the science laboratory during their three years in high school. Also, no significant differences were found for the median number of hours per week the three groups of students reportedly spent studying and doing homework in mathematics and science. Part of the fifth hypothesis which examined student achievement in science did not produce significant findings as well. Analysis of the ACT scores in the science sub-section did not indicate a significant difference for the three groups. Finally, from the results of the Scientific Attitude Inventory (SAI), the hypothesis that there were no differences in the median scores of the SAI could not be rejected. From the analysis of the SAI scores, it appeared that science attitudes for the three groups of students were not different.

CHAPTER V

CONCLUSIONS

The discussions and conclusions that follow in this chapter are based on the observations and the analysis of the data described in Chapter IV. This discussion is divided into three sections: (1) an overview of the study, (2) limitations of the study, and (3) conclusions.

Overview of the Study

The report titled A Nation at Risk: The Imperative for Educational Reform (National Commission on Excellence in Education, 1983) triggered educational reform efforts to remedy the country's declining educational performance, particularly that in science and mathematics. Various research syntheses also examined the literature concerning the effectiveness of hands-on, inquiry-oriented science curricula that were originally developed during the 1960s and early 1970s. Evidence from these studies indicated that students in such programs had enhanced higher-level intellectual skills, as well as a better understanding of scientific concepts (Kyle, 1985). Educators believed that these programs can help to improve the quality of science education in the nation's schools.

In many instances, support programs that linked businesses or industries with schools were established to address these concerns (Holden, 1984). An example of such a program is the Kalamazoo Area Mathematics and Science Center (KAMSC) in Kalamazoo, Michigan. This specialized school offered a pullout program in the sciences, computer science, and mathematics for qualified students in the Kalamazoo

area. Because of the availability of special funding, KAMSC has sophisticated laboratory equipment and is a demonstration site for a major computer company.

Therefore, a specialized school like KAMSC is better equipped and able to provide a variety of advanced courses and electives in mathematics and science compared to those available in regular high schools. Thus, it seems proper to question whether the KAMSC program can achieve certain educational objectives more effectively than regular school programs. In this study, the primary purpose is to compare the science and mathematics experiences, achievement, attitudes, and career interests of similarly qualified students who attended KAMSC (Group 1), with those of students who initially enrolled at KAMSC but later left the program (Group 2), and with those who declined the offer to attend KAMSC (Group 3).

A total of seven research questions were formulated to compare the four different parameters described above. Six of the research questions were tested for significance of median values using the Kruskal-Wallis one-way Anova statistical test. In cases of significant difference between the median values, a multiple comparison procedure was carried out to determine whether all the group median values are different from each other or if the differences exist only for specific groups. The application of the Kruskal-Wallis ANOVA and the multiple comparison test, however, is not suitable for the analysis of students' interests in a career in science and mathematics (Research Question 6). This is because the sixth research question, a comparison of students' interest in careers in science and mathematics, cannot be ranked. Therefore, a direct comparison of the percentage of students in each group was deemed more appropriate.

Science and Mathematics Experiences

Four research hypotheses were formulated to determine how the high-ability KAMSC students compare with similarly qualified students in science and

mathematics curricular experiences. Results from the first hypothesis indicated that during the first three years of high school, students who attended KAMSC took significantly more science and mathematics subjects compared to those who left the program or those who declined an offer to enroll at KAMSC.

Looking at the list of available KAMSC courses discussed in Chapter II, it was clear that KAMSC provided a larger variety of electives in mathematics, computer science, and science courses during the eleventh grade. However, non-KAMSC students did not have a chance to enroll in those electives since their regular high schools do not have as many advanced courses in mathematics and science. Furthermore, a number of KAMSC students also enrolled in mathematics classes at local colleges. Each of these factors allows the KAMSC group to experience a greater number of science and mathematics classes compared to the other two groups of students. Therefore, students who attended KAMSC had more opportunities to select a greater variety of mathematics and science classes.

The second hypothesis tested was to determine whether there was a difference in the number of hours per week students reported doing science activities in the laboratory during the eleventh grade. Results indicate that the average number of hours reported was only slightly higher for KAMSC students, and the difference was not statistically significant compared to the other two Groups. In analyzing these results, it became clear that KAMSC students do enroll in one to three science classes and also one or more mathematics and computer science classes in their junior year. Time spent working on the computer science activities or mathematics problems was not considered laboratory activity but as homework (Hypothesis 4). Thus there was a large variation in the reported number of laboratory hours depending on the specific course elected. Furthermore, these self-reported data may not be totally reliable since they represent a self-assessment which may be unintentionally biased or inflated.

Students who took both Anatomy and Physiology, and Advanced Chemistry experienced about nine hours of laboratory a week, whereas those who took Computer Programming and Calculus would only experience laboratory during their required Physics class. These variations were also observed for both of the groups that did not attend KAMSC. As a result of this large variation, one could not conclude that there was a difference between the number of hours experienced in the science laboratory each week for the three groups.

The third research hypothesis concerned the number of field trips students experienced during their junior year of high school. From the data reported, it was apparent that KAMSC students had many more opportunities for field trips compared to the other two groups of students. Since the curriculum at KAMSC is designed for the development of "vertical" acceleration as well as "horizontal" enrichment, this should not be a surprise. One important way of implementing the horizontal component of enriched experiences in science is by offering relevent field trips.

Students in the computer science and mathematics classes typically do not attend as many field trips. However, the median number of field trips (3.5) is still significantly greater for the group that attended KAMSC. The other two groups both reported a median value of 0.0 for field trips attended in their junior year. Therefore, the conclusion is warranted that the KAMSC program offered students more opportunities for direct contact with professionals in the hospital, laboratory, and college setting.

The fourth research hypothesis concerned the number of hours students spend studying and doing homework in mathematics and science during their junior year. Students who attended KAMSC throughout their high school reported the widest range (3-24 hours). However, the group of students who left KAMSC (Group 2) reported the highest median value of 13.5 hours a week, whereas the KAMSC group

and the group that did not attend KAMSC reported spending 12.0 and 10.5 hours a week, respectively. The Kruskal-Wallis analysis of variance indicated that the difference in the medians is not statistically significant. Therefore, although the median score was highest for Group 2, the value was not large enough and the null hypothesis that the three medians are similar cannot be rejected.

Additionally, about half of the students from all three groups reported that they spent more time studying and doing homework in mathematics and science during the ninth and tenth grades compared to the eleventh grade. It is interesting to note that classes in science and mathematics in those years were apparently more demanding in terms of preparation time and homework load.

Student Achievement in Mathematics and Science

The assessment of student achievement in mathematics and science was determined by a comparison of the scores in the mathematics and science sub-sections of the American Testing Program (ACT). This college entrance standardized examination was chosen for a number of reasons; the validity and reliability of the test is well-established, the test was taken by all participants, and the test provided separate scores for the mathematics and natural science sections.

An analysis of the science scores indicated that KAMSC students obtained a greater range of scores compared to those of Groups 2 and 3. The Kruskal-Wallis analysis of variance, however, failed to find a significant difference between the median scores. This finding meant that there was no statistically significant difference in the median scores of the three groups. Further examination of these results indicate, however, that the national mean (22.0) for the science score is about eight points lower than that of the three groups. Therefore all three groups obtained scores that are significantly higher than the national mean. This finding is not unexpected since all the

subjects in the study were high-ability students.

A similar Kruskal-Wallis analysis for the mathematics sub-section of the ACT indicated a significant difference between the median values of Groups 1 and 2. Therefore, students who attended KAMSC throughout high school performed better in the mathematics sub-section of the ACT test compared to students who left the KAMSC program. This finding is not surprising since KAMSC students undergo a rigorous program in mathematics during the three years. A similar conclusion cannot be drawn in comparing the mathematics achievement of Groups 1 and 3, or Groups 2 and 3 because the multiple comparison procedure did not produce a significant difference between those groups. The national mean on the ACT for mathematics is 19.9. This value is seven points less than the median of Group 2 and nine points less than those of Groups 1 and 3.

Career Interest in Mathematics and Science

The Kalamazoo Area Mathematics and Science Center was established to address wide-spread concern over national problems of declining enrollments in science and technology. One major goal is to increase the number of students interested to continue studies in the major areas of science and mathematics. KAMSC provides an enriched high-school curriculum in science and mathematics that stressed higher-level thinking skills, problem-solving skills, and basic research skills. Furthermore, KAMSC has sophisticated laboratories and computer equipment that are rarely available in traditional high schools. Therefore, it seems appropriate to question whether students who undergo the KAMSC experience would continue to show further interest in programs that involve significant science and mathematics.

In the sixth hypothesis, career interest in science and mathematics was determined from the three career choices participants noted in the job interest survey.

Any change in career interest during the eleventh grade was also compared with career choices made before entering high school. Additional data for KAMSC students allowed for comparison of the solicited career preference with their actual choice of college and study programs upon graduation.

The job interest survey indicated that 95% of KAMSC students chose at least one career choice in mathematics and science whereas more than 50% chose all three careers in the same field. Furthermore, ten students from this group who initially chose non-science careers changed them to those in science and mathematics during the eleventh grade. Additionally, at the close of this study, the data on the students' choice of college programs indicated that about 80% of the class of 1990 at KAMSC enrolled in programs of study involving significant mathematics and science components. From these findings, it can be concluded that student interest in science and mathematics remained high over the tenure of the students at KAMSC and as students prepared for the first year of college.

In their junior year, less than 50% of students from the group that left the KAMSC program indicated interest in at least one of the three possible career choices in science and mathematics. Students in this group (Group 2) had decreased interest in careers related to science and mathematics compared to the time before they enrolled at KAMSC in the ninth grade. From this finding, it can be concluded that about a third of students in this group lost interest and changed their minds about careers related to science and mathematics during the first three years of high school. Related data which offer some information about this loss in interest were available in the answer to the query (in the SME questionnaire) about why these students left the KAMSC program. Two-thirds had reported that they had difficulties in keeping up with the classes and homework assignments at KAMSC. Others wanted to enroll in elective classes available in their home schools during the hours they would need to be at

KAMSC. Therefore, it appears that problems in adjusting to science and mathematics classes and the inability to sample other course options may have led to a loss of interest in mathematics and science careers.

Students in Group 3 reported no changes in career interest during the first three years of high school. All students reported interest in at least one career in mathematics and science. However, no data were available on this group's choice of college programs; thus the conclusions that follow are based only on the Job Interest Survey and the students' response to questions in the SME questionnaire. From the analysis of the results, it is concluded that Group 3 participants had some but not exclusive interest in careers in mathematics and science. This conclusion is supported by the student response to the question of why the group rejected the offer to attend KAMSC. The group reported that they wanted to enroll in non-mathematics and non-science classes in their home schools which they could not attend if they enrolled at KAMSC.

Therefore, the results support the conclusion that the group of students who attended KAMSC not only remained interested in careers in mathematics and science but some who originally showed less interest became more interested as time progressed. This was in contrast to some students in Group 2 who originally indicated career interest in mathematics and science prior to entering high school but who later reported non-mathematics and non-science career interest. This finding as well as responses indicated on the SME questionnaire supported the conclusion that the main reason for leaving KAMSC was reduced student interest in mathematics and science courses.

Student Attitude Toward Mathematics and Science

The Kruskal-Wallis analysis of variance was used to determine whether there was a difference in the median score of the Scientific Attitude Inventory (SAI) for the

three groups. The hypothesis could not be rejected which implied that the difference in the median values were not large enough to be significantly different.

An examination of the SAI score frequency and range indicated that the KAMSC group had scores with the greatest variation. Some students in the KAMSC group had extremely high scores in the SAI which implied a strongly positive attitude towards science, whereas four students had low positive scores (under 85).

Limitations of the Study

The following constraints limit what can be generalized from this study:

1. The study was restricted to in-coming ninth graders who were successful in their application to enroll in the accelerated high school program in science and mathematics at the Kalamazoo Area Mathematics and Science Center (KAMSC) in 1986. Thus, only one pullout program in one state (Michigan) was studied. Generalizations to other pullout programs would necessarily be limited to those that have similar academic programs and recruitment procedures as KAMSC.

2. Group 1 students attend KAMSC for mathematics and science, and return to their home schools for their remaining classes. Therefore, these students spent about the same number of hours at KAMSC as they did at their home schools. Thus, the KAMSC experience cannot be compared with programs at other magnet schools where the total academic program is on site.

3. The study examined the three groups up to their junior year in high school. Thus there is a limitation in that different findings may be obtained if further data were available during the twelfth grade.

4. This study was limited by its inability to discriminate the differences between groups on science achievement. Although the ACT reportedly discriminates well among high-achieving students, it did not do so between the groups in this study and

therefore conclusions concerning science achievement were not possible.

5. Subjects selected three top career choices in the Career Interest Survey, a section of the SME questionnaire. The jobs chosen were categorized into two divisions: mathematics and science-related careers, and non-mathematics and non-science careers. It was difficult to categorize some job choices such as technical writing, psychologist, and college professor, into one or the other of the two groups. Thus there existed some gray areas where categorization was not clear cut and perhaps not definitive.

6. The instrument used to measure student attitude towards science and mathematics was the Scientific Attitude Inventory (SAI). According to Munby (1983b), no one instrument measures all the different sub-scales in attitudes towards science. Therefore the SAI, though the most popular and well-documented attitude instrument, does not measure the entire span of scientific attitudes and may not be sensitive to the range of attitudes for high-ability students.

7. Due to the uneven group size, the most appropriate statistical method to test the hypotheses in this study is the Kruskal-Wallis one-way ANOVA. Though not as powerful as parametric tests, the test can detect if a significant difference exists between group median values. However, a parametric test is more sensitive in that it can detect smaller but significant differences in group means at the same level of significance. This study is limited by the design which necessitates the use of non-parametric techniques.

8. The self-report data on the number of hours spent doing activities in the science laboratory per week and the number of hours of homework in science and mathematics per week lack verification. This study is limited by the ability of the subject to accurately recall and average the data over a one-year period.

Conclusions

The primary purpose of this study was to determine whether a special pull-out program such as that at KAMSC can achieve certain curricular objectives more effectively compared to regular school programs. Since the KAMSC program concentrates significant resources on a special segment of high-school students, it is reasonable to question whether students who attended the Center throughout their high school compared more favorably in the four areas of this study.

One significant finding was that KAMSC students attended more field trips during their junior year. They went to many local hospitals, colleges, and locations that provided exposure to science in the work-place. Such visits provided students with clearer perspectives of actual working conditions faced by scientists. One KAMSC student indicated that his interest to enter the field of medicine was intensified as a result of the field trips. Furthermore, most KAMSC students from the biomedicine course agree that the field trips were well-organized and thus complemented the course objectives well.

In addition, KAMSC students could also select a greater variety of mathematics and science classes compared to the other two groups of students. Therefore, students apparently benefited from the richer and broader experience provided in the pullout program at KAMSC.

From the scores of the mathematics sub-section of the ACT, KAMSC students achieved significantly higher in mathematics compared to the group that left KAMSC. However, no significant difference was observed in science. Since these ACT scores for all three groups were very high (about nine points higher compared to the national average), it was difficult to discriminate between them. All students in the study were high-achievers and performed very well as a group on that standardized test.

In summary, students who attended the pull-out program at KAMSC throughout

their high school performed better in mathematics achievement, chose more careers related to science and mathematics, had a greater choice of science and mathematics courses, and attended significantly more field trips. However, their attitudes towards science were not significantly different from the two other groups. The KAMSC students reported a wide range in the SAI scores, while the other two groups reported more consistent responses. Generally, KAMSC students who chose non-mathematics and non-science careers also had lower scores on the SAI.

Furthermore, the time spent studying and doing homework in science and mathematics, and the number of laboratory hours per week, was also not significantly different for all three groups. KAMSC students reported that they spent about the same time doing their homework as the other groups. KAMSC students also reported approximately the same number of hours (not including field trips) in the laboratory compared to non-KAMSC students.

APPENDICES

Appendix A

List of the National Consortium for Specialized Secondary Schools of Mathematics, Science and Technology

National Consortium for Specialized Secondary Schools
of
Mathematics, Science and Technology

1. Kalamazoo Area Mathematics and Science Center
600 W. Vine St
Suite 400
Kalamazoo, MI 49008
1-616-384-5004

2. Blair Science, Mathematics and Computer Science Magnet
313 Wayne Avenue
Silver Spring, MD 20910
1-301-650-6688

3. Eleanor Roosevelt High School
7601 Hanover Pkwy
Greenbelt, MD 20770
1-301-248-8800

4. North Carolina School for Science and Mathematics
P.O. Box 2418
1219 Broad St.
Durham, N.C. 27705
1-919-286-3366

5. Central Virginia Magnet School for Science and Technology
3020 Wards Ferry Rd.
Lynchburg, VA 24502
1-804-237-7716

6. Mississippi School for Math and Science
P. O. Box W-1627
Columbus, Miss 39701
1-601-329-7360

7. Thomas Jefferson High School for Science & Technology
6560 Braddock Rd
Alexandria. VA 22312
1-703-354-9300

8. Illinois Mathematics and Science Academy
1500 West Sullivan Rd
Aurora, Il 60506-1039
1-312-801-6037

9. Science Academy of Austin
7309 Lazy Creek La
Austin, TX 78724-3299
1-512-928-0380

10. Roanoke Valley's Governor's School of Science and Technology
2104 Grandin Rd., S.W.
Roanoke, VA 24015
1-703-981-2116

11. New Horizons Technical Center
520 Butler Farm Rd.
Hampton, VA 23666
1-804-766-0000

12. Eastern Guilford High School of Science and Mathematics
415 Peeden Dr.
Gibsonville, N. C. 27249
1-919-274-8461

13. Baltimore Polytechnic Institute
1400 W. Cold Spring La
Baltimore, MD 21209
1-301-396-7926

14. Louisiana School for Math, Science and the Arts
715 College Ave.
Natchitoches, LA 71457
1-318-357-3172

15. Texas Academy of Mathematics and Science
University of North Texas
P. O. Box 5307
Denton, TX 76203-9988
1-817-565-3606

16. Stuyvesant High School
345 East 15th St
New York, N. Y. 10003
1-212-673-9030

17. Bronx High School of Science
75 West 205th St
Bronx, N. Y. 10468
1-212-295-0200

18. South Carolina Governor's School for Science and Mathematics
306 East Home Ave
Hartville, S. C. 29550
1-803-383-3900

19. Puloski Governor's School for Science and Technology
P. O. Box 909
Roanoke, Virginia 24015

20. Oklahoma School of Science and Mathematics
2500 North Lincoln Bv
Okalahoma City, OK 74104-1253
1-405-521-4945

21. Center for Advanced Technologies
Lakewood High School
1400 54th Ave., South
St. Petersburg, FL 33705
1-813-867-3161

Appendix B

KAMSC Mission Statement and Goals

MISSION STATEMENT

THE MISSION OF THE KALAMAZOO AREA MATHEMATICS AND SCIENCE CENTER IS TO ENRICH THE QUALITY OF MATHEMATICS AND SCIENCE EDUCATION FOR STUDENTS IN THE KALAMAZOO AREA. THE CENTER IS TO BE A FOCAL POINT FOR GROUPS AND INDIVIDUALS IN THE KALAMAZOO AREA WHO ARE COMMITTED TO THE CONTINUING IMPROVEMENT OF MATHEMATICS AND SCIENCE EDUCATION AND IT IS TO SERVE AS A MODEL FOR EXCELLENCE AND INNOVATION IN THE TEACHING AND LEARNING OF MATHEMATICS AND SCIENCE.

GOALS:

INSTRUCTION

TO DELIVER RIGOROUS EDUCATIONAL OPPORTUNITIES IN MATHEMATICS AND SCIENCE TO ACADEMICALLY TALENTED AND MOTIVATED HIGH SCHOOL STUDENTS.

OUTREACH

TO PROVIDE OPPORTUNITIES FOR THE ENRICHMENT OF EXISTING SCHOOL PROGRAMS THROUGH THE SHARING OF EXPERIENCES AND THROUGH THE DEVELOPMENT AND SHARING OF INNOVATIVE PROCEDURES AND MATERIALS.

STAFF DEVELOPMENT

TO PLAN AND DELIVER PROFESSIONAL DEVELOPMENT PROGRAMS FOR MATHEMATICS AND SCIENCE EDUCATORS, IN CONCERT WITH AREA PROFESSIONALS.

COMMUNITY INVOLVEMENT

TO SERVE AS A CATALYST AND A MEDIUM FOR COMMUNITY INVOLVEMENT, INCLUDING MENTORSHIPS, IN MATHEMATICS AND SCIENCE EDUCATION.

REV. 10/86

Appendix C

List of High Schools Participating in
the KAMSC Program

KALAMAZOO AREA MATHEMATICS
AND SCIENCE CENTER

KALAMAZOO AREA: 16 PUBLIC SCHOOL DISTRICTS, 3 NON-PUBLIC SCHOOL SYSTEMS,18 HIGH SCHOOLS

KVISD (KALAMAZOO VALLEY INTERMEDIATE SCHOOL DISTRICT) AREA HIGH SCHOOLS INVOLVED

Comstock High School
Climax-Scotts High School
First Assembly School
Galesburg-Augusta High School
Gull Lake High School
Hackett Catholic Central High School
Kalamazoo Central High School
Kalamazoo Christian High School
Kalamazoo Norrix High School
Parchment High School
Portage Central High School
Portage Northern High School
Schoolcraft High School
Vicksburg High School

SCHOOLS OUTSIDE OF THE KVISD AREA

Allegan High School
Constantine High School
Delton-Kellogg High School
Plainwell High School

OCTOBER, 1990

Appendix D

The Science and Mathematics Experiences Questionnaire

Name : ________________

Dear Students,
Your participation in the Survey is very important to this study. Please answer all questions completely and accurately.
Circle the most appropriate response in the questions 1 through 7.

1. For each of the science and mathematics subjects named, indicate the grades and the number of semesters in which you took the classes. Circle "12" if you plan to take the subject in the twelfth grade. Circle "nt" for those never taken.

	Subject	Grade when subject was taken					How many Semesters ?	
1.	Biology	9	10	11	12	nt	1	2
2.	Anatomy and Physiology	9	10	11	12	nt	1	2
3.	Chemistry	9	10	11	12	nt	1	2
4.	Organic Chemistry	9	10	11	12	nt	1	2
5.	Physics	9	10	11	12	nt	1	2
6.	Advanced Physics	9	10	11	12	nt	1	2
7.	Earth Science	9	10	11	12	nt	1	2
8.	Astronomy	9	10	11	12	nt	1	2
9.	Integrated Mathematics I	9	10	11	12	nt	1	2
10.	Integrated Mathematics II	9	10	11	12	nt	1	2
11.	Integrated Mathematics III	9	10	11	12	nt	1	2
12.	Pascal Programming	9	10	11	12	nt	1	2
13.	Mathematics Applications	9	10	11	12	nt	1	2
14.	Algebra	9	10	11	12	nt	1	2
15.	Algebra II	9	10	11	12	nt	1	2
16.	Geometry	9	10	11	12	nt	1	2
17.	Trigonometry	9	10	11	12	nt	1	2
18.	Pre-calculus	9	10	11	12	nt	1	2
19.	Advanced Mathematics	9	10	11	12	nt	1	2
	Others (please name)							
20.	________________	9	10	11	12	nt	1	2
21.	________________	9	10	11	12	nt	1	2
22.	________________	9	10	11	12	nt	1	2
23.	________________	9	10	11	12	nt	1	2

2. Approximately how many hours per week did you experience laboratory activities in each of the following science courses (nt=not taken):

Subjects	Number of hours							
Biology	nt	0	1	2	3	4	5	more than 5
Anatomy and Physiology	nt	0	1	2	3	4	5	more than 5
Chemistry	nt	0	1	2	3	4	5	more than 5
Organic Chemistry	nt	0	1	2	3	4	5	more than 5
Physics	nt	0	1	2	3	4	5	more than 5
Astronomy	nt	0	1	2	3	4	5	more than 5
Earth Science	nt	0	1	2	3	4	5	more than 5
Others (please name)								
______________	0	1	2	3	4	5	more than 5	
______________	0	1	2	3	4	5	more than 5	
______________	0	1	2	3	4	5	more than 5	
______________	0	1	2	3	4	5	more than 5	
______________	0	1	2	3	4	5	more than 5	

3. Approximately how many hours per week do you spend studying/ doing homework in science?

   0-3   4-6   7-9   10-12   more than 12

4. Approximately how many hours per week do you spend studying/ doing homework in mathematics?

   0-3   4-6   7-9   10-12   more than 12

5. How many hours outside of regularly scheduled class and laboratory hours do you spend per week in school in order to consult with your science teachers or to finish assigned work in science?

   0   1-2   3-4   5-6   7-8   more than 8

6. Similarly, how many hours outside of regularly scheduled class and laboratory hours do you spend per week in school in order to consult with your mathematics teachers or to finish assigned work in mathematics?

   0   1-2   3-4   5-6   7-8   more than 8

7. Approximately how many field trips in science did you experience? during the 11th grade?

   0 1-2 3-4 5-6 7-8 9-10 more than 10

8. Briefly describe the types and locations of any field trips in science you recall experiencing in Question 7.

9. Describe some positive experiences you had at KAMSC or at your school that you would like to share with other students. (For example, usefulness of the science and computer science labs; the class atmosphere; or other specific experiences).

10. Select <u>three</u> job groups below that you feel BEST DESCRIBES your future job interest. Label your choices 1, 2, and 3 in the order of interest.

Choice:

_____a. Mechanical, Industrial, Construction (electrician, mechanic, repairer, etc.)
_____b. Business, Banking, Sales (Bank manager, Accountant, stockbroker, insurance agent, etc.)
_____c. Artistic (commercial artist, drama, music, writing, television, interior designer, etc.)
_____d. Agricultural and environmental sciences (environmental specialist, agricultural specialist)
_____e. Medicine (physician, veterinarian, specialists in medical fields eg. neurology)
_____f. Computers (computer engineering and programming)
_____g. Mathematics and Statistics
_____h. Life sciences (zoologist, microbiologist, botanist))
_____ i. Earth Sciences (geologist)
_____ j. Engineering (chemical, electrical, mechanical,)
_____ k. Chemistry (polymer scientist, analytical chemist, organic chemist, etc.)
_____ l. Physics and astronomy (electronics, nuclear, solid state physics, etc.)
_____ m. Education (teacher, college professor in the arts or sciences)
_____ n. Social services (lawyer, counselor, social worker)
_____ o. Other (job not listed here) - please indicate job choice(s):

____

____

11. Has there been a change this career interest since you entered the ninth grade? If so, what was your career interest then?

12. Are you presently attending KAMSC? Yes No

If yes, this is the end of the questionnaire. If you wish, you may make any other comments on the back of this form. Thank you for your participation and time in filling out this questionnaire.

If no, please answer the following questions.

13. Did you ever attend KAMSC for any part of a year? Yes No

If no, please go to question 14.

If yes, when did you attend the Center? Mo./ year ________ to Mo./Year ________

Why did you leave the Center?

14. Were you invited to attend KAMSC? Yes No

If yes, why did you decline the invitation?

15. Please make any other comments you wish:

Thank you for your participation in this Survey.

Appendix E

Letter to Superintendents and School Directors

March 1, 1989

Dear Mr.

This letter is going to a number of individuals who are affiliated with schools involved with the activities of the Kalamazoo Area Mathematics and Science Center. Specifically, it refers to plans for the evaluation of some of these activities.

First, let me identify myself and my role with KAMSC. My name is Rozana Abdul Razak. I am a graduate student in the Doctoral Program in Science Education at Western Michigan University, and have been affiliated with KAMSC as a doctoral intern since students first arrived in the Fall of 1986. During that time, I have worked closely with KAMSC students and faculty in a variety of classes and projects.

During my participation at KAMSC, it became apparent to my colleagues and to me that the Center provided unique opportunities in which to compare the achievements, experiences, and attitudes of high-ability students who attended the Center with a comparable group of students who did not attend. Members of my doctoral dissertation committee have reviewed this proposal and believe that this topic should provide worthwhile information in an area in which definitive data are lacking. In order to carry out this study, your support and assistance, as well as those of your colleagues, are essential. Specifically, your cooperation is needed in order to obtain background information regarding students in these categories:

1. Members of the charter class who are currently juniors at KAMSC (class of 1990).
2. Students in the class of 1990 who declined an invitation to attend KAMSC.
3. Students in the class of 1990 who originally attended KAMSC but who have since left the program.
4. Students who were qualified to attend KAMSC but were *not* admitted in 1986 because their applications were incomplete.

Data will be collected, by means of questionnaires and/or interviews, concerning attitudes, achievement, and experiences from students in the above four groups. In addition, we hope to administer a questionnaire to selected members of your faculty, soliciting their opinions of student performance in non-mathematics and non-science courses. The process will involve reviewing student transcripts for the purpose of assessing performance in English, History, and/or Social Science. Please note that only a small number of students at any one school is involved. I assure you that all efforts to minimise time and inconvenience to all involved will be taken. All these data will be treated confidentially and at no time will any person or school be identified. This proposal has been submitted to the Human Subjects Review Committee at WMU and it is scheduled to be approved shortly.

We intend to begin to collect data as soon as possible, hopefully in April and May, 1989. We hope that you will endorse this effort and assist us in making the necessary contacts. Your cooperation will be greatly appreciated. I will provide each of you with a summary of the results, once the data have been collected and analyzed.

If you have any objections, questions or comments, please feel free to contact me at KAMSC (384-5019) during weekday mornings or at home (345-5491) at other times. If I do not hear from you by Tuesday, March 14, I presume that you approve and I may proceed. Thank you.

Sincerely yours,

Rozana Abd Razak

Rozana Abdul Razak
Kalamazoo Area Mathematics and Science Center
600 W. Vine St., Suite 400, Kalamazoo, MI 49008

Appendix F

HSIRB Permission Letter

Human Subjects Institutional Review Board

Kalamazoo, Michigan 49008-3899

WESTERN MICHIGAN UNIVERSITY

TO: Rozana Abdul Razak

FROM: Ellen Page-Robin, Chair EP-R

RE: Research Protocol

DATE: April 6, 1989

This letter will serve as confirmation that your research protocol, "Factors affecting student selection, retention, achievement, and attitude at the Kalamazoo Area Mathematics and Science Center and other area high schools," has been approved at no more than minimal risk after expedited review by the HSIRB.

If you have any further questions, please contact me at 387-2647.

Appendix G

Letter to Parents

April 25, 1989

Dear Parents/ Guardians,

I am conducting a research project which will lead to the comparison and evaluation of some activities at the Kalamazoo Area Mathematics and Science Center (KAMSC) and area high schools. Specifically, the study will involve comparing experiences, achievement, and attitudes in science and mathematics of current high school students in their junior year. The following groups of students have been identified as participants in the study:

1) members of the charter class at KAMSC who are currently Juniors
2) students in the class of 1990 who declined an invitation to attend KAMSC
3) students in the class of 1990 who originally attended KAMSC but who have since left the KAMSC program
4) students who were qualified to attend KAMSC but were *not* admitted because their applications were incomplete

At this time, no evaluation involving the students identified in the four groups above has been attempted. This research should provide useful information for KAMSC and the school systems which support this effort.

The research will involve three components. The first is a survey to elicit student responses to questions concerning their experiences in science and mathematics. A second survey will assess student attitudes towards science. Both these surveys will be in the form of questionnaires requiring a total response time of approximately twenty minutes. They will be given in May either at KAMSC or they will be mailed to your home. The third component involves reviewing the following school records for the purpose of evaluating achievement in science and mathematics: 1) student transcripts 2) scores of standardized tests relating to science and mathematics (eg. subscores of the PSAT) and 3) SCAT (School and College Admission Test) scores. School systems Superintendents have also been advised of this project.

There are, of course, no known hazards, risks, or inconveniences associated with this procedure and it will only take about twenty minutes of one's time. Your child's participation will provide area high schools and KAMSC useful information which will help future planning and decisions.

All information collected will be held in strictest confidence. At no time will your child's name be identified; only group comparisons will be made. In addition, you are free to terminate this consent at any time and withdraw from this project without prejudice. If you have any questions concerning this project or this consent, please feel free to call KAMSC at 384-5019 during weekday mornings or at 345-5491 at other times and ask for Rozana Abdul Razak.

Sincerely,

Rozana Abdul Razak

Rozana Abdul Razak
Center for Science Education
A-428 Ellsworth Hall
Western Michigan University
Kalamazoo, MI 49007

Appendix H

Letter to Students

April 25, 1989

Dear Student,

I am conducting a research project which will lead to the evaluation of some activities at the Kalamazoo Area Mathematics and Science Center (KAMSC) and area high schools. Specifically, the study will involve comparing experiences, achievement, and attitudes in science and mathematics of current high school students in their junior year. The following groups of students have been identified as participants in the study:

1) members of the charter class at KAMSC who are currently Juniors
2) students in the class of 1990 who declined an invitation to attend KAMSC
3) students in the class of 1990 who originally attended KAMSC but who have since left the KAMSC program
4) students who were qualified to attend KAMSC but were *not* admitted because their applications were incomplete

At this time, no evaluation involving students identified in the four groups above has been attempted. This research should provide useful information for KAMSC and the school systems which support this effort.

The research will involve three components. The first is a survey to elicit student responses to questions concerning their experiences in science and mathematics. A second survey will assess student attitudes towards science. Both these surveys will be in the form of questionnaires requiring a total response time of approximately twenty minutes. They will be given in May either at KAMSC or mailed to your home. The third component involves reviewing the following school records for the purpose of evaluating achievement in science and mathematics: 1) student transcripts 2) scores of standardized tests relating to science and mathematics (eg. subscores of the PSAT) and 3) SCAT (School and College Admission Test) scores. School systems Superintendents have also been advised of this project.

There are, of course, no known hazards, risks, or inconveniences associated with this procedure and it will only take about twenty minutes of your time. Your participation will provide area high schools and KAMSC useful information which will help future planning and decisions.

All information collected will be held in strictest confidence. At no time will your name be identified; only group comparisons will be made. In addition, you are free to terminate this consent at any time and withdraw from this project without prejudice. If you have any questions concerning this project or this consent, please feel free to call KAMSC at 384-5019 during weekday mornings or at 345-5491 at other times and ask for Rozana Abdul Razak.

Sincerely,

Rozana ARazak

Rozana Abdul Razak
Center for Science Education
A-428 Ellsworth Hall
Western Michigan University
Kalamazoo, MI 49007

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