An Evaluation of Student Interest, Influence and Motivation in Science and Science Related Courses and Their Relevance to Student Performance, Course Selection and Long-Term Interest in Science.

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Abstract

This study investigates and evaluates the ages that students are most interested in science. Understanding the factors that affect and influences this interest, will allow educators to have a better knowledge of conditions that could motivate school age students to take higher-level science courses. This in turn could promote a society with greater science literacy, and one that is better prepared to meet the future demands of a highly technical workforce and environmentally sensitive world. A survey was given to students who attended a three state science symposium and students from two urban middle schools and two urban high schools. In addition to demographic and background information, students were asked to identify the age and grade they first became interested in science, who or what most influenced their science interest, and then rate an interest level of the various science disciplines. The researchers assume that students will have some interest level in science, and that there is an age when students are more likely to discover their inclination towards science. The study determined that there is a peak interest age for students in the fields of science inquiry and that the factors affecting this interest vary between male and female respondents

CHAPTER ONE

INTRODUCTION

Science education in the United States has entered a new millennium- an exciting time when careful reflection of historically significant themes can be constructively woven into a global educational plan. A plan that motivates, encourages curiosity and promotes a sense of wonder concerning the natural world. Consequently, science curricula will be expected to balance technological advancements and economic forces with environmental, moral and global concerns. To create this new curricula educators will have to examine the needs of a culturally diverse society, and work to eliminate gender related effects (Millar & Osborne, 1998; Carter & Smith, 1998; Farenga & Joyce, 1999).

Problem Statement

The purpose of this study is to gather data to determine the age students are most interested in science and what factors influenced this interest A better understanding of conditions that motivate school age students to take higher-level science courses that in turn will promote science literacy and help meet the future demands of a highly technological workforce is the key to the development of future educational strategies.

Setting and Participants

This study took place in an urban northeastern city with a population of approximately 100,000 residents. This city is composed of a large number of native residents, with a healthy mix of relocated professional and blue-collar workers. The geographic area is impacted economically and recreationally by its climate and diverse seasons. There is broad socioeconomic diversity within the population.

A survey of middle and high school age students within the large urban public school district was conducted The results of the school surveys were combined with an identical survey distributed to students participating in the Minnesota Academy of Science research paper symposium and compared to an identical study conducted forty years ago (Moore, 1962).

Background

Many school districts revise curriculum and purchase new textbooks in hopes of producing science students that are capable of confidently making professional and personal decisions in the ever-changing world. Studies have shown that the “science interest window of opportunity” is thrown open for students between the ages of 10 to 14 (Moore, 1962; Perrodin, 1966; Starch, 1998; Farenga & Joyce, 1999; Ghosh, 2001). Moore's study, done in 1962 at a national science fair, indicated that the window's opening was the greatest around age twelve. If middle school (5th through 9th grade) is the age of opportunity in science, how should educators motivate and create excitement in learning?

Focusing on “how” to motivate interest in science is difficult when the history of “how” keeps changing. The emphasis has oscillated between society’s concern for producing high level technically trained professionals and society’s need to be able to apply general scientific concepts in their daily lives (DeBoer, 2000). The eyes of all United States citizens focused on science and technology in 1957, when Sputnik blasted the world into the “Space Age” (Yager, 1992). Paul Hurd, an Associate Professor of Education at Stanford University, as early as 1958, spoke to the idea that science instruction could no longer be regarded as an intellectual luxury for a select few (Hurd, 1958). Hurd stated that in order to create a science literate society, science education must be incorporated into the first through twelfth grade curriculums. Scientific Literacy was defined as a “desired familiarity with science on the part of the general public” (DeBoer, 2000, p. 582). Through history this definition has fluctuated along with the emphasis between rigidly defined distinct education goals and being considered a broad educational guideline, allowing creative methodologies appropriate to the individual needs of school districts and/or classrooms (DeBoer, 2000).

As a result, the challenge facing classrooms and society is to create methodologies that incorporate rapid technological advancements while considering economic, moral and environmental factors. These challenges were realized as early as 1958, when scientists first started predicting serious technical manpower shortages in the future (Hurd, 1958). In the United States there continues to be a shortage of graduates in science and engineering. In fact, many businesses have to import their highly technical workforce (DeBoer, 2000; Bayer, 1998). Because of this need, the rapidly changing demand on our current workforce and the subsequent worker shortages forces administrators to acknowledge the benefits of culturally diverse and gender equitably trained employees (Millar & Osborne, 1998; DeBoer, 2000).

Studies have shown a significant difference between the number of college bound men and women who intend to enroll in the college of science and engineering (Kahle, 1985). A disparity also is found between the types of classes chosen by boys or girls. In 1999, Farenga and Joyce found that both boys and girls perceive life science as a more appropriate field of study for girls and physical science and technology-related courses as more appropriate for boys. This type of thinking limits the number and availability of a diverse and highly trained technological workforce.

Since there are manpower shortages in science and technology, we live in a time when limiting anyone is not a luxury we can afford (Bayer, 1998). Finding out if gender disparity still exits in science interest and career choices is important. Determining if the window of opportunity to help young people discover their personal inclination for science still occurs during the middle school years, as Moore found in 1962, is valuable information for educators developing future science curriculum and goals.

Background of Researchers and Research Setting

The researchers, Cynthia A. Welsh, Paul H. Sandholm and Tamara Meyer, graduated from the University of Duluth, Minnesota in 1995. All three educators hold Bachelor of Science degrees in middle school science. Welsh also holds degrees in teaching life and earth science, and Meyer has a degree in elementary education. Sandholm holds a Bachelor of Science degree in animal science from Iowa State University. Both Sandholm and Meyer teach in a large urban school district. Sandholm teaches middle school science and Meyer, along with teaching 5th grade, is the school's science specialist Previously, Meyer worked at a private college for a grant-funded program that promotes the interest and participation of adolescent girls in science. Welsh taught seventh and eighth grade science at the same large urban school district and is currently teaching ninth grade science in a smaller school district with a more rural setting. Welsh is also very involved in promoting individualized student science research through the Minnesota Academy of Science.

Limitations and Assumptions

The scope of this study is limited to a specialized group of students who have chosen to participate in the Minnesota Academy of Science Symposium and students from a large urban Minnesota school district and a smaller rural one. The reliability of the results is limited to the participants' honesty while answering the survey.

The researchers share assumptions that this study's students will have an interest in science and that there is an age when students are more likely to discover a personal inclination for science. They also assume that there will be a diversity of student age, gender and cultural background within the study group.

Conclusion

Because of the call to define science literacy and its impact on the ever-changing global demand for professionals in science and technology, this study will look at factors that motivate students to hear this call. Themes touched on in this introduction, (the history of science literacy and teaching, gender influences and the relationship between education and the demands of a rapidly changing technological workforce) will be discussed in greater depth in the following literature review.

CHAPTER TWO

LITERATURE REVIEW

This literature review is looking into the history of science education philosophy and its impact on the relationship between the education and business worlds, including diversity issues and the effects these educational practices have on student motivation across all ages and genders.

Intellectual Heritage of Science Education

To develop future educational strategies our "intellectual heritage" (Hurd, 1958, p. 13) needs to be taken into account. In 1958, Richard C. McCurdy addressed consideration of this "intellectual heritage," while speaking at Cornell University on the history of science education in the United States. McCurdy's account began prior to World War I, when the studies of science, philosophy and the arts were tracked along a purely intellectual pathway, void of any practical application. Concurrently, the general public obtained exclusively a broad liberal education, including basic reading, writing, social studies and arithmetic. Further, it was felt that the strength of the United States' democracy was reinforced with the pillars of public education (reading, writing and arithmetic) along with the average citizen's everyday life experiences. The study of natural science was viewed as an "intellectual luxury."

During the 19th century science education was promoted in liberal colleges primarily by scientists and not the general public (DeBoer, 2000). In 1893, Charles Eliot, President of Harvard University and Chair of the National Education Association (NEA), summarized the goal of science education this way:

> Effective power in action is the true end of education, rather than storing up of information.... The main object of education, nowadays, is to give the pupil the power of doing himself [sic] an endless variety of things, which, uneducated, he could not do. An education which does not produce in the pupil the power of applying theory, or putting acquisitions into practice, and of personally using for productive ends his disciplined faculties, is an education which missed its main aim. (Eliot, 1898, p. 323-324; DeBoer, 2000, p. 583)

John Dewey also felt science instruction should be a part of a liberal education because of the power it gave individuals to act independently (DeBoer, 2000). These men were soon to see their visions become a reality and a necessity.

Under the guidance of these scientists and driven by the consequences of their discoveries, the study of science soon veered from a meandering, purely “intellectual pathway”, to a high-speed expressway of change. In 1926, Robert H. Goddard made the first successful launch of a liquid-fueled rocket. In 1927, the first television was demonstrated, and eleven years later the prototype is completed for the first digital computer (Chronology of Scientific Developments, 2002). In 1944, the Japanese attacked Pearl Harbor and brought the United

States into World War II Nuclear fission contributed to the development, in 1945, of the atomic bomb and its subsequent use on Japan to end World War II The world jumped head first into the age of atomic energy, while looking to the sky with wonder and fear as the Soviet Union launches Sputnik, man's first artificial satellite (Chronology of Scientific Developments, 2002; Technology Timeline: 1752-1900,2002). Nuclear power, plastics, pesticides, detergents, automation and vaccines increased leisure time, health and life span (Hurd, 1958; Technology Timeline: 1752-1900). Technology gave science a "piggy back ride" into public education (McCurdy, 1958; DeBoer, 2000). Technological developments began to play a key role in United States national defense. In 1947, the President's Scientific Research Board commented on the importance of science education to national security:

> The security and prosperity of the United States depends today as never before, upon the rapid extension of scientific knowledge. So important, in fact, has this extension become to our country that it may reasonably be said to be a major factor in national survival. (President's Scientific Research Board, 1947, Vol. 4, p. 113; cited in DeBoer, 2000, p.585)

It was felt ordinary citizens needed to be "science literate" to intelligently contribute to society (McCurdy, 1958; DeBoer, 2000). Suddenly science mattered!

Even with the added interest in science, in the late 1950's no time was set aside for science education during the elementary years. Junior high schools rarely offered full year science programs, and often students could graduate from high school after taking only one general science course (Hurd, 1958). Educators worried curriculum was not being developed to prepare the next generation to keep up with the accelerated momentum of science and technology. The general public, while enjoying the benefits of scientific achievement and fearing the implications of "Sputnik," demanded curriculum changes (Hurd, 1958; McCurdy, 1958). In June of 1958, the *Rockefeller Report* (McCurdy, 1958; DeBoer, 2000) on education was published. The report stated... "Just as we must insist that every scientist be broadly educated, so must we see to it that every educated person be literate in science" (Rockefeller Report, 1958 p. 369; cited in DeBoer, 2000, p. 586).

Educators realized they must find a way to close the gap between scientific advancements and the non-existent science literacy of the general population. Debates ensued as to whether the public schools should attempt to include the entire vast body of scientific knowledge in their curriculum or simply educate the students just enough to make them able to meet the challenges of a "scientific age" (Hurd, 1958; DeBoer, 2000). Many scientists felt that science curriculum should veer away from educating students solely about the history and accomplishments of science and move towards a direct hands on inquiry approach (Hurd, 1958). In an effort to increase the number of advanced students interested in science, many schools developed programs to enhance learning for the gifted and talented students (McCurdy, 1958).

According to Hurd in 1958, if science literacy was to increase for American students, the education of teachers could not be ignored. The National Science Foundation stepped in to aid in the science education of thousands of secondary teachers. Fellowship money was made available for summer instruction. Over two hundred colleges and universities developed special science courses for teachers (Hurd, 1958).

Even after "Sputnik," the continued study of quantitative science was viewed through skeptical eyes. If future scientific research was going to be funded, no longer could scientists be isolated or feared by the general population. Previously, the general public viewed scientists from afar as "eggheads," "geeks" and "Dr. Frankensteins" (McCurdy, 1958; Woods, 1999). To change this attitude and promote the importance of research, universities developed curriculum for public schools that advertised and promoted the importance of scientific research. It was felt that if scientific advancements were to continue at the current rate, propaganda to this end was important (McCurdy, 1958; Heiss, 1958). Citizens needed to be thoughtful and informed if asked to make intelligent decisions concerning continued scientific research (DeBoer, 2000).

Even with science research propaganda, in the mid-twentieth century science was viewed as a “body of knowledge” with value-free objectives (Millar & Osborne, 1998). The average student still found it difficult to see how this scientific knowledge was relevant to their future career needs. Consequently, the registration numbers in higher-level science courses in high school and colleges did not increase at the desired rate (DeBoer, 2000).

By the 1960’s the movement to emphasize scientific literacy and promote the process of individualized inquiry-based research in science classrooms grew. This reformation, however, did not spill over into the curriculum content (Millar & Osborne, 1998). The push was to improve existing curriculum and programs with new materials. These materials were developed by scientists and science educators to be “teacher proof” (Yager, 1992, p. 905). It was felt that even teachers with weak science backgrounds would be able to teach science. To support these new materials the National Science Foundation (NSF) created “Course Content Improvement Projects” (Yager, 1992, p. 905).

In the early 1960’s many science educators defined the science literate student as one with scientific content knowledge from a wide range of disciplines. Only a few educators were concerned with the relationship between science and society (DeBoer, 2000). Practical application using inquiry and the relationship between science and society was not a part of the definition (DeBoer, 2000; Yager, 1992). Many colleges and educators began to be concerned about the shortage of technically trained personal (DeBoer, 2000). This concern only increased as science education entered the 1970's.

During the 1970's the rapid advancements in science and technology without the moral guidance of society led to the tarnishing of the scientific image (Millar & Osborne, 1998). Before society had a chance to understand the effect of these advancements, rapid environmental degradation was occurring. News headlines included topics such as: the use of DDT, Chernobyl, CFC's and the depletion of the ozone layer. The scientific community was also experimenting with genetic manipulations and considering the possibility of cloning (Millar & Osborne, 1998). The importance of the relationship, between science, society and technology, could no longer be ignored by science educators (DeBoer, 2000).

In the seventies educators valued both process skills and the relationship between science, society and technology. This was shown to be true by the National Science Teachers Association (NSTA) stated in a paper titled *School Science Education for the 70's,* that a scientifically literate person is one who, "uses science concepts, process skills, and values in making everyday decisions as he interacts with other people and his environment" and "understands the interrelationships between science, technology and other facets of society, including social and economic development" (NSTA, 1971, p. 47-48). From these philosophies a science-technology-society (STS) curriculum evolved. One of STS education's major goals was to promote social action. These goals were controversial because they suggested that social issues were more important than disciplinary content when developing curriculum (DeBoer, 2000).

As science educators debated over if science education should be centered on content or social issues, the National Commission on Excellence in Education (1983) issued a report called, *A Nation at Risk* The report told of embarrassingly low-test scores in science and math for the United States. It was felt the solution to this problem was to create a rigorous curriculum centered again on the core curriculum. The push to increase interest and a positive attitude about science fell by the wayside and the push towards a content-based curriculum again led the way. High standards were developed to define the content base as were new ways of assessment and accountability. In 1989, an article published by the U.S. Department of Education, President George Bush endorsed the idea of establishing "clear national performance goals." Education's main priority became to create students that would be internationally competitive (DeBoer, 2000).

Science education during the 1990's called for science reform. It was felt that the United States was not doing enough to prepare students to compete in the highly technical and scientific, international work force (Science for all Americans, 1989). As a result, in 1996, the U.S. government took an active role in educational reform by publishing the *National Science Education Standards. National Standards* were written so that all students could attain science literacy by mastering a set of content standards.

Looking at articles on the history of science education and how the definition of science literacy has evolved since the 1950's it is evident that we have come full circle. Many articles were written between 1957 and 1962 on the importance of science attitude and interest while still keeping science education anchored to the "three pillars of education": reading, writing and mathematics (Heiss, 1958; Hurd, 1958; McCurdy, 1958). During the 1970's society was concerned about the impact science was having on human and environmental health (National Science Teachers Association, 1971). This led into the 1980's where science education was concerned about keeping up with the rest of the world (National Commission on Excellence in Education, 1983). In turn, a science-technology-society (STS) curriculum was developed (DeBoer, 2000). While calling for science educational reform during the early 1990's, National Standards were written for content, teachers and students. These standards were again based on the “three pillars of education” and called for hands-on, relevant, inquiry based science education that connected what the student was learning to the real world (STS) (DeBoer, 2000; Minnesota’s High Standards, 2000; Zemelman, Daniels & Hyde, 1998)

Student Interest & Performance in Science and its Connection to the Workforce

Student interest in science and the perception of a scientific career have changed little over time. Today’s students still do not have a positive image of scientists and the Industrial or Information Technology (IT) worker. Ninth grade students who were asked to draw pictures of today’s IT worker drew the geek image of “Bob,” balding with taped glasses, pocket protectors, bow tie and suspenders (Woods, 1999). Woods, in his article on U.S. workforce needs, quotes the former Department of Commerce Secretary William Daley on this stereotypical image of a scientists and its effect on meeting future high tech work force needs: “If this is what kids think people look like who study math and science, no wonder we have a problem” (Daley, 1999, p. 2)

At the root of, or compounding this problem, is the lack of science educators. This shortage of science teachers in the United States is well documented, and the shortage is increasingly significant considering our dependence on science and technology and the need for a science literate society (Oliver & Anderson, 1986).

Students today do not perceive teaching as a viable or rewarding career. In July of 2002, in an interview on National Public Radio (NPR), Mildred Hudson, the executive director for the company *Recruiting New Teachers* stated that 2.2 to 2.7 million new teachers will be needed in the next decade. She also stated that 25 percent of all qualified teachers do not go into the profession and 50 percent leave the profession within three to five years (Hudson, 2002). This teacher shortage problem will be compounded due to the fact that there are fewer students entering the education "pipeline" at the collegiate level (Hudson, 2002). They find the profession to be lacking in pay, possessing bad or long hours with poor working conditions, and topping their list was the fact that they felt teaching and teaching science was not an enjoyable career option (Oliver & Anderson, 1986).

The ninth grade student perceptions concerning science teaching and science careers held true when the National Science Foundation's Division of Science Resources Studies monitored the supply of scientific and technical workers meeting the teaching and industrial employment needs of our nation. In 1990 about 5 percent of the 22-year old population received a degree in science and/or engineering, which was down slightly from a high of 5.2 percent in 1987 (Braddock, 1992). They found that college enrollment rates in science and engineering proportionally had not changed much. However, there was concern if this trend continued, combined with a declining population of 22-year old college students, the needs of a future economic structure increasingly dependent on science and technology would not be met (Braddock, 1992).

These issues and concerns in the early 1990's have become a reality in the new millennium. The current problem facing the United States is that it is not producing enough highly trained graduates in science and engineering to meet industry and economic workforce demands (DeBoer, 2000; Bayer, 1998; McCarter, 2000). Consequently, U.S. businesses, colleges and universities are importing their technical and skilled work force. In 2000, the U.S. Congress legislated a high tech guest worker policy, allowing as many as one million would-be new and permanent immigrants, on top of an existing population of 500,000 temporary visas over the next three years (McCarter, 2000).

Alexis D. Gutzman, an e-commerce technology consultant and author, commented in October of 2000 on the state of the United States education system and its effect on the technological workforce and the American economy: " It's no secret that the best minds around the world have been rushing to emigrate to the U.S., or at least live and work in the U. S., for at least a generation" (Gutzman, 2000, p. 1).

Gutzman implies that the U.S. educational system is failing by not challenging students to take the difficult classes and in some cases not even offering the "hard stuff" in technological skill development and cultivation (Gutzman, 2000; Gomolski, 2001.) This has led to the situation where the United States has become dependent on an imported technological work force (DeBoer, 2000; Bayer, 1998; Gutzman, 2000; McCarter, 2000).

The Digital Economic Opportunity Committee (DEOC) formed from the National Policy Association (NPA) stated that in the United States there is a "skill shortage, not a worker shortage" (DEOC, 2001, p. 10). Elaine L. Chow, U. S. Secretary of Labor, describes America's 21st Century labor problem as one in which the skills of yesterday will not fuel the economy of tomorrow (DEOC, 2001). One of the goals developed by the DEOC recommends that technical workers become involved in the local school systems to teach, mentor and work with students (DEOC, 2001). Most scientists agree that there is a need for science education reform, which would include a hands on inquiry based science education to improve skill development, critical thinking and problem solving (Bayer, 1998).

Two studies, one by the Massachusetts Institute for a New Common Wealth and a national study by the American Management Association published in January, 2001, found that more than one-third of all job applicants lacked basic skills in reading, writing, math and analytical ability needed for science and technology literacy in today's modem workplace (DEOC, 2001).

The Third International Mathematics and Science Study (TIMSS) report validates the growing concern over diminished science literacy skills in United States students. TIMSS reported in 1998 that United States students in the fourth and eighth grades performed above the international average in the science assessments. This level of performance was not maintained, as made evident from the results of the twelfth grade assessments, which indicated a significant drop in general science knowledge (McCann, 1998; SciMath, 1999).

This was later supported by national results, congressionally mandated and collected by the National Assessment of Educational Progress (NAEP), which showed no change in science achievement levels at the fourth grade level; yet some improvement did occur with the highest performing eighth grade students. However, this same study showed that males out-scored females in both fourth and eighth grade and that the gap widened by eighth grade. Again a significant decline in twelfth grade science performance was observed (National Center for Educational Statistics [NCES], 2000). With these reports and the constant bombardment of reports that have followed, which all indicate that student performance is declining, it is important that science educators be aware of student interest and stereotypical attitudes and how course and career selections are affected (Farenga & Joyce, 1999).

In which fields of science will these new technological skills need to be applied? Douglas J. Braddock, an economist in the Office of Employment Projections for the Bureau of Labor Statistics, tried to answer this question by summarizing a Bureau of Labor Statistics study on employment prospects through 2005, using a moderate economic growth projection. The need for engineers is projected to increase at a rate of 1.6 percent a year, with an overall increase of 26 percent, translating to a need for two million engineers by 2005. The projected employment growth in the field of life science is predicted to be 32-33 percent by 2005. This growth will be highly attributed to research and advancements in the fields of medicine, biotechnology and activities related to environmental protection. In the fields of physical science, the projected employment growth is around 21 percent by 2005. Predicted growth in these fields was restricted because of diminished needs in industry such as chemical, oil and gas explorations as well as predicted reduction in defense expenditures at that time. The fields of computers, mathematical and technical research sciences are expected to grow faster than all other fields of science and engineering, increasing up to 73 percent by 2005. The fields of science technicians are the most numerous of all scientific occupation groups. Growth in this field is predicted to be 32 percent with a projected population of up to 3.5 million workers (Braddock, 1992).

Male and female scientists agree that the pace and impact of scientific discoveries on society will be greater in the twenty first century (Bayer, 1998). Citizens worldwide will need to be scientifically literate to utilize scientific concepts at work, regardless of the industry, while making decisions that may shape civic policies (Bayer, 1998; Millar & Osborne, 1998). At the same time, the literature is conclusive that this need for a highly technological work force needs to be balanced with society's responsibility to a democratic society.

Age and Gender

The balancing act society must face between science literacy and the need for a culturally diverse, gender equitable, highly-trained workforce (Millar & Osborne, 1998; DeBoer, 2000) has resulted in many studies concerning gender issues and the target ages for promoting and developing student interest in math and science. A 1958 study of science fair participants by McCurdy disclosed that almost 70 percent of the winners had an interest in science by age 13. Moore (1962) and Perrodin (1966) indicate that the critical ages for developing an interest in science are between the ages of 10 and 14, which includes the middle school science curriculum. Children in this study considered science to be an important school subject, which to many fourth and sixth graders was more important than play. The Bayer Facts of Science Education in 1997 surveyed

1400 scientists, and 61 percent indicated that they became interested in science around the age of 10 (Farenga & Joyce, 1999).

An early study (Mau, 1912) suggested different interests toward science exist between boys and girls early in childhood. Girls, at an early age, indicated a preference for participation in more biological science activities, while their male counterparts favored physical science activities. Many studies have indicated that girls are more likely than boys are to lose interest in math and science by the time they enter high school (Mason & Kahle, 1988; Oakes, 1990; Rosser; 1990; AAUW, 1992). The greatest gender-related differences in attraction to the study of science begin during the middle school years when young adolescent girls are concerned with their own feminine development and societal expectations. This premise has been the focus of research in an effort to pinpoint causative factors (Farenga & Joyce, 1999).

A 1992 AAUW report revealed that some common teaching methods used in elementary and secondary schools were a likely a source contributing to girls' disinterest in math and science. This, in turn, spawned the creation of some all-girl classes. In 1997 education researchers met to discuss results related to single-sex education and its impact on girls. These researchers agreed that there is no evidence showing that single-sex education is generally better or worse for girls than coeducation. Rather, it appears that when certain elements of good schools are present, girls and boys do equally well. Elements include: small classes and small schools, equitable teaching practices and focused academic curriculum. Among the positive results of some single-sex programs in the report are: a heightened regard by girls for math and science; and increases in girls' risk-taking; and a gain in girls' confidence from academic competence (AAUW, 2000; Women's Connection, 1997). However, there is debate among researchers whether these benefits derive from factors unique to single-sex programs or factors that promote good education such as small classes and schools, intensive academic curriculum and a controlled and disciplined environment (AAUW, 2000; Women's Connection, 1997).

A number of other factors have been thought to contribute to these differences in science achievement including: course selection, family background and school characteristics. School characteristics that affect science achievement include: tracking, teachers' judgments about ability, number and quality of science and mathematics courses offered, access to qualified teachers, access to resources, and curricula emphases (AAUW, 1992; George, 1994).

Matyas (1987) developed criteria for equitable and effective mathematics and science teaching to be used as general guidelines for the classroom and school, in order to increase the participation of females and more meaningfully engage <u>all</u> students in scientific learning: Using hands-on activities; developing problem-solving skills; fostering cooperative learning; showing enthusiasm and having high expectations for all; utilizing gender-balanced oral and written instructions and materials; employing activities and resources that are familiar within the cultures of a wide variety of students; and including female role models in instruction (George, 1994). Researchers have suggested the use of less competitive models to teach and practice science, as well as discussions of the practical uses to which scientific discoveries are put forward to help students see science in a more "social context" (Haley-Oliphant & Buttler-Kahle, 1985; Rosser, 1990). The introduction and implementation of such "female-friendly" pedagogical techniques applied to the practice of science indicate our society's concern for a more holistic, global approach to science while helping young women to succeed in science, and ultimately help *all* students succeed. (Rosser, 1990; Haley-Oliphant & Buttler-Kahle, 1985)

In terms of course selection, an NSF report in 1996 indicates that women and minorities take fewer high-level mathematics and science courses in high school and earn fewer bachelors, masters and doctoral degrees in science and engineering. Female students are similar to males in mathematics course taking at all levels according to this report. About 80 percent of males and 72 percent of females had taken geometry, 21 percent of both had taken trigonometry, and 10 percent of both had taken calculus. Female students were also about as likely as males to have taken advanced placement calculus. Male and female 1992 high school graduates did not differ greatly in their science course selection, except in physics. Similar percentages of both male and female high school students had taken biology and chemistry; 92 percent of males and 94 percent of females had taken biology and 54 percent of males and 57 percent of females had taken chemistry. Male students, however, were more likely than females to have taken physics: 28 percent of males and 21 percent of females. Male students were more likely to have taken advance placement physics. Female students have made gains over the last several years, however; in 1982, only 9 percent of women had taken physics in high school (NSF, 1996).

Studies also show that down through history there has been a disparity in the types of science classes and career choices made by men and women (Millar & Osborne, 1998). In terms of achievement in science and math, no notable gender difference appears until age 11 (NCES, 1997). However, recent research indicated that the “gender gap” appears much earlier in science than in mathematics (Hanson, 1996). Lower science scores for girls are evident in grade 7, whereas gender discrepancies in math are not seen until grade 10. Differences in science and mathematics achievement widen in secondary school. The lag in achievement by women may hinder their participation in science and engineering higher education and careers because women have less of a foundation for such pursuits. In the beginning of the 1980s, standardized test scores showed that girls were a bit ahead of boys in reading and writing, but significantly behind in math and science. Results from 1996 national assessment tests show 17 year-old boys lead girls by five points in math and eight points in science (NCES, 1997). Some researchers have debunked the notion that a "gender gap" still exists today and that if it does, the gap has definitely narrowed (Barlow, 1999). Professor J.S. Kleinfeld questions the 1992 AAUW Report, "How Schools Shortchange Girls" and how girls were the victims of "pervasive inequalities" in our schools. She reports that girls get higher grades than boys in school as a whole; do better on standardized tests of reading and writing, and get higher class ranks and more school honors (Kleinfeld, 1998, Barlow, 1999). A 1991 study published by the Department of Education showed women in all majors had an overall GPA of 3.07; men's overall GPA was 2.92. Even in engineering and computer science, the women averaged 3.17 to the men's 2.96 (NSF, 1994).

A review of Westinghouse Talent Search finalists by Kleinfeld, in 1998, showed that from the 1940's through the 1970's, the finalists were overwhelmingly male, with females representing only 26% of the top 40 finalists. In 1995, 46% of the finalists were female, and in 1997, 45% were females. Kleinfeld goes on to point out that a 1996 NCES study revealed that, in 1994, a greater percentage of females than males took algebra I, algebra II, geometry, biology and chemistry. Only in electing physics did the percentage of males exceed the number of females, 27% males to 22% females (Barlow, 1999;Kleinfeld, 1998).

Differences between females and males in their intended preference for degree majors are striking for students planning to enter college. Thirty-one percent of males and 13 percent of females intended to pursue natural science, mathematics, or engineering fields (NSF, 1996). Among first-year science or engineering majors in 1994, women's grades were higher than men's" 47 percent of women and 43 percent of men had average grades of "A" in high school. Women earned a smaller proportion of total science and engineering degrees (45 percent in 1993) than they did of non-science and engineering degrees (58 percent) (NSF, 1996). The proportion of women earning master's degrees and in science and engineering fields reached 36 percent in 1993, having rose steadily from 31 percent a decade earlier. In engineering, one of the fields in which women are least represented, the percentage of master's degrees earned by women increased from 9 to 15 percent between 1983 and 1993 (NSF, 1996). Women also earned 30 percent of the science and engineering doctorates awarded in 1993, up 25 percent from 25 percent in 1983. Their proportions varied considerably by field: 61 percent in psychology, 40 percent in biological sciences, 37 percent in the social sciences, 23 percent in mathematical sciences, 16 percent in computer sciences and 9 percent in engineering (NSF, 1996).

Women constitute 51 percent of the U.S. population, and 46 percent of the U.S. labor force according to 1993 U.S. Bureau of Labor statistics (NSF, 1996). That same report indicates that within the science and engineering fields women are more highly represented in sociology and psychology, buy only 9 percent of physicist and 8 percent of engineers. Among the bachelor of science and engineering graduates, women were less likely to be in the labor force, less likely to be employed full time and less likely to be employed in their field than men (NSF, 1996).

"New technological and workplace demands are increasing the need for workers who have flexible skills, a basic grasp of science and technology, and the ability to solve problems and to think critically." (Kober, 1993, p. 76). The nation's economy is becoming increasingly dependent on the size and quality of a technological workforce at a time when the percentage of the U.S. population involved in science and engineering is decreasing compared with that of Japan, Germany, France, and the United Kingdom (Oakes, 1990). The under representation of women and minorities, the fastest growing population of the workforce, in science, mathematics, and technology undermines the country's ability to function effectively in a technology-based economy (Oakes, 1990).

Conclusion

As a result of the themes, which the literature review focused on, the following questions will form the basis for this study. They will be worded in the form of null hypotheses.

Hypotheses

1. There has not been a change in initial science interest age over the past forty years.
2. There will be no difference between the age males or females first become interested in science.
3. There will be no difference in academic achievement (GPA) between males and females.
4. There will not be a difference in science course interest between males and females.
5. There will not be a gender difference in what influences science interest.
6. There is no difference between interest in biology and academic achievement.

CHAPTER THREE

METHODOLOGY

The Third Intentional Mathematics and Science Study (TIMSS) reported in 1998 that United States students in the fourth and eighth grades performed above the international average in the science assessments, but by twelfth grade this was not maintained (McCann, 1998). Referring to the National Center for Educational Statistics in 2000, the National Assessment of Educational Progress (NAEP) showed that males out-scored females in both fourth and eighth grade and that the gap widened by eighth grade. Again a decline in twelfth grade science performance was observed (Farenga & Joyce, 1999).

The purpose of this study was to address these issues by focusing on factors such as gender and age, and evaluating how student interest, influence and motivation in science and science related courses can influence student performance and long term interest in science. These factors were evaluated to establish their impact on student course selection and potential career choices.

Setting and Participants

Middle school and high school students were selected as a study group because performance and interest appears to wane somewhere between the eighth and twelfth grades (Moore, 1962; Farenga & Joyce, 1999; McCann, 1998; Perrodin, 1966). The group studied was made up of middle school and high school students between the ages of twelve and eighteen. The results of the school surveys were combined with an identical survey distributed to students participating in the Minnesota Academy of Science research paper symposium and compared to an identical study conducted forty years ago (Moore, 1962). The students attended two high schools and two middle schools from a predominantly white, middle class, suburban school district. The thirty-six students that attended the science symposium wrote research papers that were selected from three midwestern states. Letters describing the study, consent forms (Appendix A) and a cover letters were sent out by the Duluth School District (Appendix B) and the Minnesota Academy of Science administrative offices (Appendix C).

To apply for participation in the Symposium students completed an individualized science research investigation and wrote a research paper. Their papers were then sent to regional judges and read. Five papers out of each region were selected and these students moved onto the state competition. At the state competition, two hundred students gave a multimedia presentation of their research to judges who are professional scientists. Only twelve presenters out of the two hundred advance to the three state science symposium. The thirty-six presenters at the symposium were sent surveys in the mail following the symposium; all thirty-six returned their surveys and signed permission slips in the mail.

Instrument

A survey was designed for students (Appendix D). The first page of the student survey was used to gather demographic and educational background information. Questions were asked concerning age, current grade in school, gender, full or half year seventh and eighth grade science, math and science courses completed, academic performance level, interest in higher education, and the critical question, concerning the age respondents first became interested in science.

The second page of the survey collected data on student interest and influences affecting student interest in science. The section on interest in science included subjects such as: astronomy, biochemistry, biology, botany, chemistry computers, ecology, engineering, geology, human behavior, mathematics, physics and zoology. The section on influences affecting interest in science included: parents, teacher, enjoy subject, friends, mentor, books, on-line, TV shows, science fair, magazines, scouting, and science equipment. Participants were asked if science plays an important role in their life, if a strong science background will be important in their future and why. They were also asked to note other activities they participate in.

The survey included a section for only the students at the science fair. They were asked what and/or who motivated them to do a state quality project. The survey also asked participants to identify science classes they have taken and plan to take. A list of class choices were given and they indicated which classes they have taken and which classes they plan to take. Participants were asked to identify motivating factors, which have or could influence them to take future science courses and/or pursue a career in science.

Statistical Analysis

A chi-square analysis was done using a cross tabulation that compares the science interest age of students in 1962 and 2002. A descriptive statistical analysis was done on a nominal cross tabulated chi-square test to establish the strength of the relationship between gender and the onset of science interest age for males and females.

A discriminate function analysis, which is a variant of multiple regression, to predict group membership was used. This analysis was done to predict gender membership (GMP) through a stepwise multiple regression. A regression equation was created that lists the coefficient with the strongest science course predictor first multiplied by the average interest score for that science course.

A Sample Equation:

$$(GMP)=B1(\text{sci course}) + B2(\text{sci course}) + B3(\text{sci course}) \text{ etc....}$$

An independent samples t-test was done using group statistics to determine if there was a significant difference in the mean interest score given for the five strong function predictors used in the discriminate function analysis.

A general linear model was used with descriptive statistics to test for between subject effects. The analysis was to determine if there was a significant difference between what influences the science interest of males vs. females.

A group statistical independent sample t-test was done to analyze the difference between male and female student academic achievement (GPA).

A nonparametric correlation was run to determine if there was a relationship between GPA and an interest in biology.

CHAPTER FOUR

RESULTS AND DISCUSSION

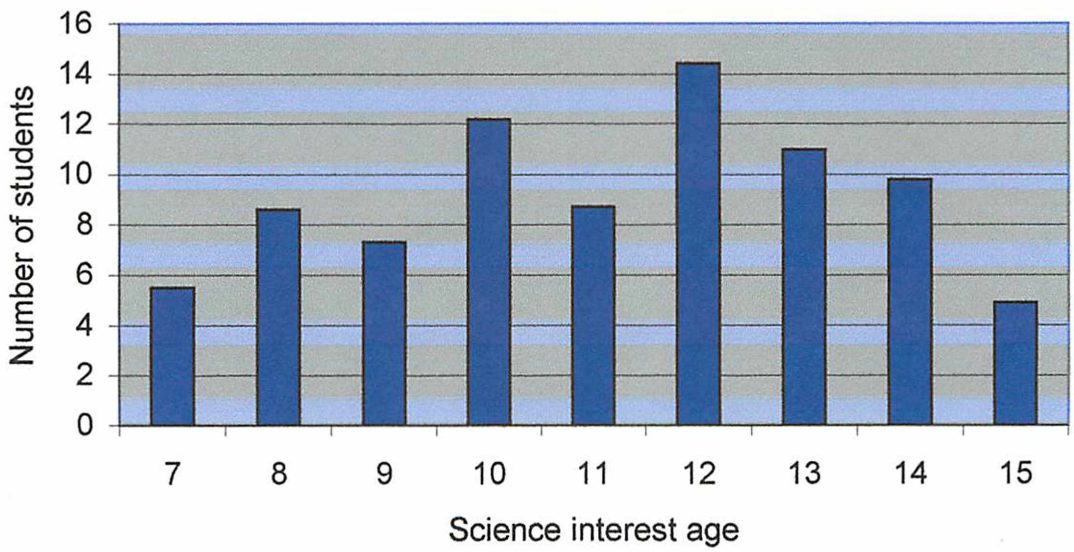
This chapter will discuss the results of a survey given to science students from two high schools, two middle schools and students from a three state high school science symposium (Minnesota, North Dakota, South Dakota). The discussion will focus on three initial questions: At what age are students most interested in science? What science courses are students most interested in and does gender affect this interest? Finally, who and what most influences student interest in science?

Science Interest Age: 1962 vs. 2002

A Science Service study, completed in May of 1962, was performed on students at the 13th National Science Fair-International in Seattle. The results of the 1962 study will be compared to the results of the current study.

Figure 1 shows the age at which students attending the 1962 international science and engineering fair first acquired an interest in science. This histogram depicts the number of students for each science interest age. The interest ages presented in the histogram range from age seven to fifteen. All other science interest ages fell below an "N" (total number) of four students. The science interest age indicated by students in 1962, listed from highest number of students to least was as follows: age 12, age 10, age 13, age 14, age 8, and age 9. The highest age of science interest reported, age 15 and the lowest age 7 had the fewest students reporting initial science interest. In 1962, there appears to be a science interest "window" between ages 8 and 14, or between grades 5 and 9 (the middle school years) (Moore, 1962).

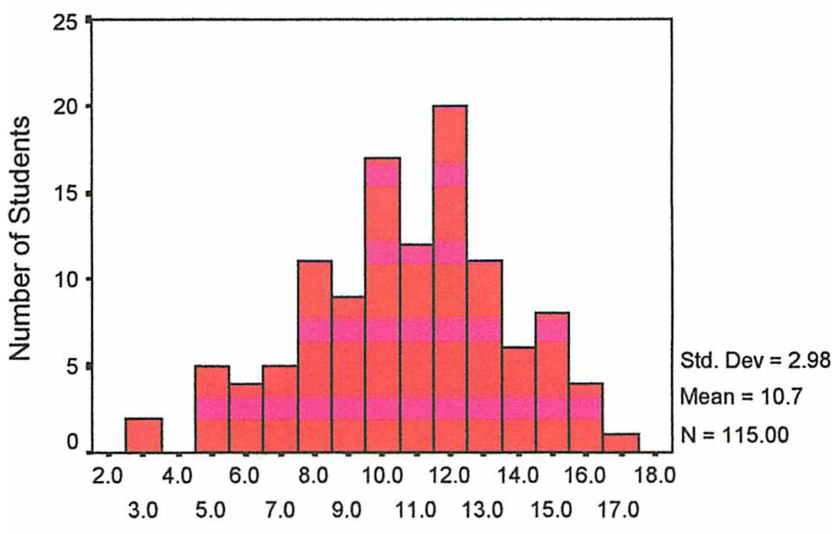
Figure 1: Age at which students in 1962, at an international science fair, first acquired an interest in science (Moore, 1962).



The results of the current study depicted in Figure 2 show the age at which students in 2002 first acquired an interest in science. In 2002, students were surveyed from 2 high schools, 2 middle schools and science fair students who attended a three state science symposium put on by the Minnesota Academy of science. A histogram following the same format as in 1962 (Figure 1) was used. The science interest age indicated by all students in 2002, listed from highest number of students to least was as follows: age 12, age 10, age, age 11, age 13 and age 8.

Figure 2: Science Interest Age in 2002

All Students



Age at which Student Acquired an Interest in Science

Figure 3 is a histogram combining the two previous graphs: science interest age of 2002 students and students who attended the 1962 international science fair. The science interest age follows almost the same exact pattern of interest. Both 1962 and 2002 reveal that the top two science interest ages among the participants were first, 12-years old and second, 10-years olds. In 2002 there also appears to be a science interest "window" between age 8 and 13, or between grades 5 and 9 (the middle school years).

Figure 3: A comparison of science interest age between current students and students in 1962 at an international science fair (Moore, 1962).

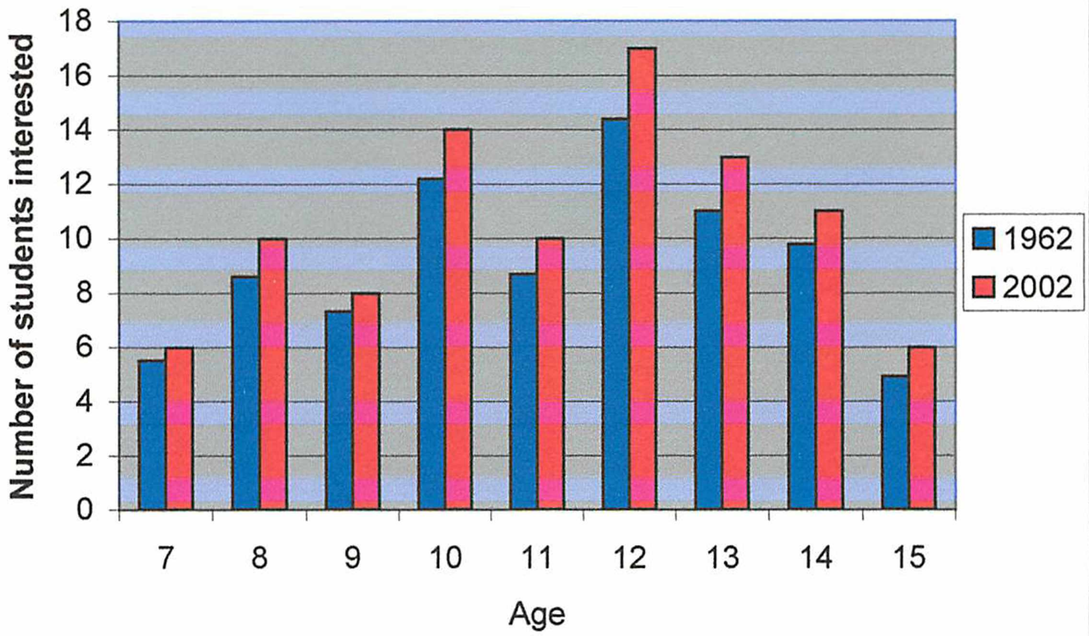


Table 1 is a cross tabulation comparing the age of science interest between 1962 and 2002. The expected values were considered the data from 1962, and the data from 2002 are the observed values for each age (ages 7-15).

Table 1: Frequencies-a cross tabulation that compares science interest Age: all students 1962 vs. 2001

	Science Age	2001	1962	
	Category	Observed N	Expected N	Residual
1	7.0	5	6.3	-1.3
2	8.0	11	10.4	.6
3	9.0	9	8.3	.7
4	10.0	17	14.6	2.4
5	11.0	12	10.4	1.6
6	12.0	20	17.7	2.3
7	13.0	11	13.5	-2.5
8	14.0	6	11.5	-5.5
9	15.0	8	6.3	1.7
Total		99	99	

In Table 2, a chi-square analysis was done comparing the science interest age of students in 1962 and 2002. A chi-square value of 4.839 was calculated with a significance of 0.775. This significance value indicates that there is no difference between 1962 and 2002 in science interest age.

Table 2: Chi-Square Test Statistics-science interest age; is there a difference between 1962 vs. 2002?

	Science Interest Age
Chi-Square	4.839
Df	8
Asymmetrical Significance	0.775

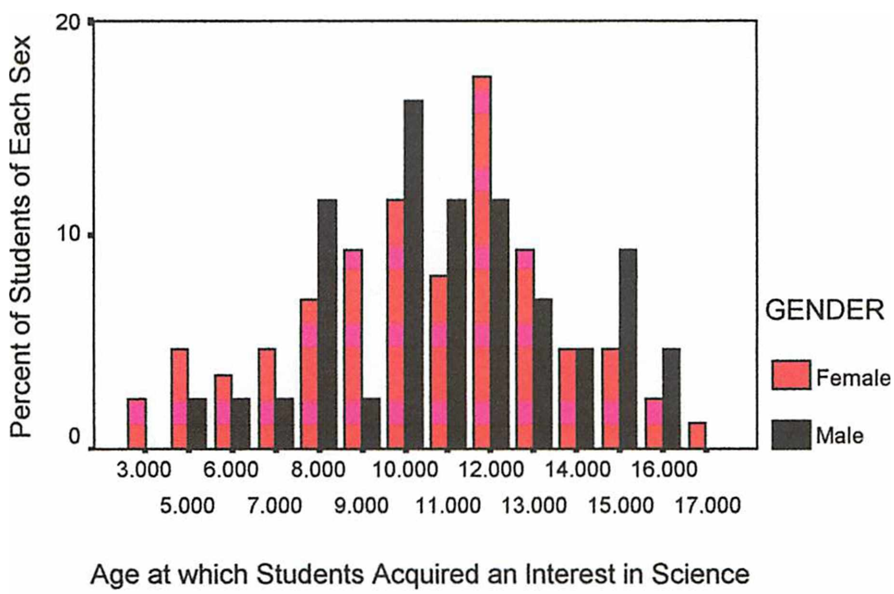
a 0 cells (.0%) have expected frequencies less than 5.
The minimum expected cell frequency is 6.3.

Science Interest Age 2002: Males vs. Females

Figure 4 shows a comparison of science interest age between males and females in a survey done in 2002. Students from two high schools, two middle schools and students who attended a science fair symposium were surveyed. A total of 122 students were surveyed, 81 (66%) female students and 41 (44%) male students. Science interest was recorded as the percentage of students from each gender who chose a certain age they were first interested in science. The highest percentages of males, 19%, were first interested in science when they were 10 years old. Ages 8, 11, and 12 were tied at 14% for the next highest male interest age. The highest percentage of females, 19%, were first interested in science when they were 12 years old followed by 13 % at age 10 and 10% at ages 9 and 13.

Figure 4: Students Interest Age in 2002

Males vs. Females



In Table 3 a descriptive statistical analysis was done on science interest age. A nominal cross tabulation comparing males and females was run. This was preformed to determine if there is a difference between males and females for science interest age.

Table 3: A cross tabulation comparing what age all 2002 males and female students surveyed were first interested in science

Interest Age	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**#**
Gender															
Females	2	4	3	4	6	8	10	7	15	8	4	4	2	1	78
Males	0	1	1	1	5	1	7	5	5	3	2	4	2	0	37
Total	2	5	4	5	11	9	17	12	20	11	6	8	4	1	115

Table 4 represents a cross tabulated chi-square statistical test done to establish the strength of the relationship between gender and onset of interest. A Pearson Chi-Square value of 8.386 and a significance of $p < 0.818$ indicates there is no difference between gender and onset of science interest age.

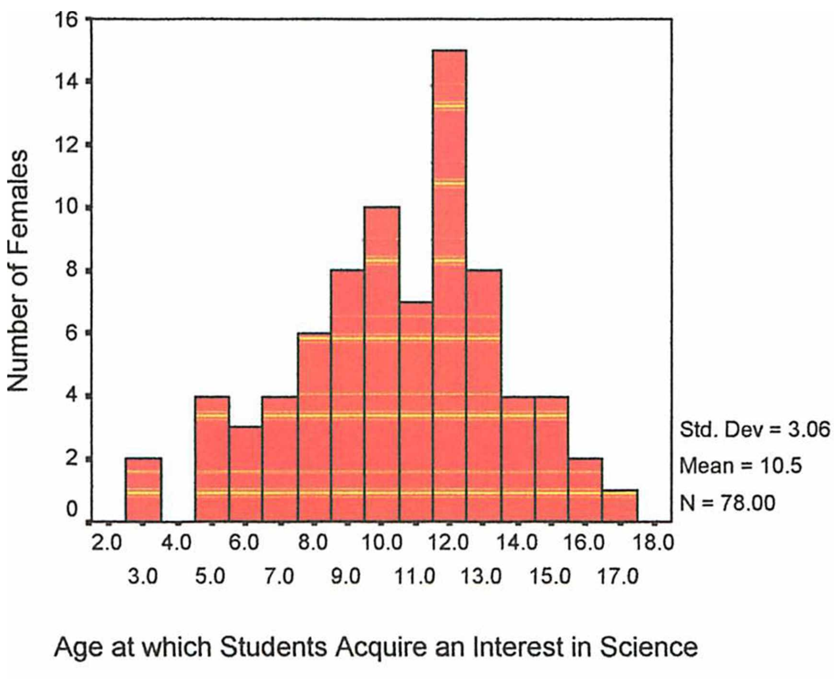
Table 4: Chi-Square Test Statistics-science interest age; is there a difference between males and females for 2002 students?

	Value	**df**	**Asymp.Sig. (2-sided)**
Pearson Chi-Square	8.386*	13	.818
Likelihood Ratio	9.542	13	.731
N of Valid Cases	115		

a. 19 cells (67.9%) have expected frequencies less than 5.
One minimum expected count is 32.

Figures 5 and 6 are histograms, showing the number of students who indicated a certain age they were most interested in science. The chi-square analysis already determined there is no statistical difference between males and females in 2002. These graphs were done to examine trends in science interest age.

Figure 5: Female Student Interest Age in 2002



In Figure 5 females appear to be open to science before age 12, their peak interest age. After age 12 the number of females interested in science declines. Even though more females were interested in science later, at age 12 than males, at age 10, the data suggests that once girls reach their peak interest age of 12 their interest decreases, while male interest increases. Figure 5 shows that 57 percent of the females were first interested before age 12, with 19 percent interested at the peak age 12 and only 24 percent interested after the female peak age of 12. In all, 76 percent of the females were interested before and up to age 12, while only 24 percent after age 12.

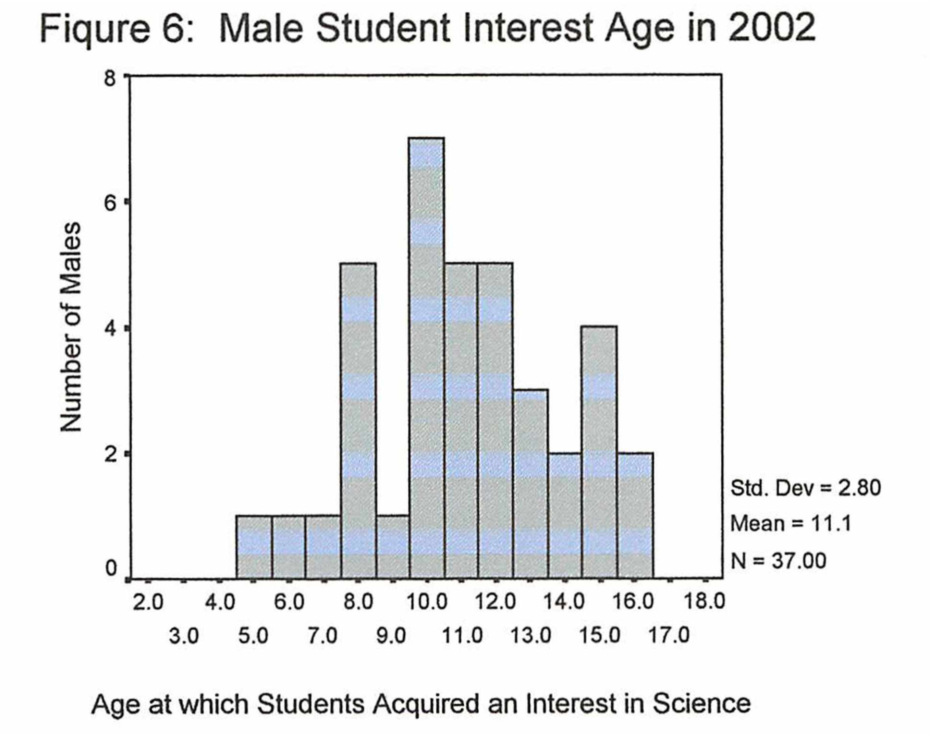


Figure 6 indicates that the greatest number of males were interested in science by age 10. This is younger than the female peak interest age of 12. As stated above, the number of females who first become interested in science decreases after their peak age, but Figure 6 shows that the opposite is true for males. Twenty-four percent of the males were first interested before their peak age of 10, with 19 percent interested at the peak age; and 57 percent of the males were first interested after the peak age of 10. In all, 24 percent of the males were first interested before the peak age and 76 percent of the males were first interested during and after their peak age of 10. These percentages were the opposite of the female percentages with 76 percent before and including the peak age and 24 percent after the peak age. This seems to indicate that females are more open to science at a younger age than males. If a female student has not developed an interest in science by age 12 or 13 (7th or 8th grade-the middle school years) chances are she will not become interested later in high school. Males on the other hand appear to be late bloomers when it comes to an interest in science. If a male is advised as he enters high school in a non-science track because he does not appear to be interested in science he may miss out on a subject that he could develop an interest in and possibly make a career of science.

Gender Effects and the Courses Students are Most Interested In

Tables 5, 6, 7 and 8 make up a discriminate function analysis, which is a variant of multiple regression used to predict group membership. This analysis was done to predict gender membership (GMP) through a stepwise multiple regression. The regression equation lists the coefficient with the strongest science course predictor first multiplied by the average interest score for that science course.

A Sample Equation:

(GMP)= B1(sci course) + B2(sci course) + B3(sci course) etc....

Table 5 is the structure matrix, which lists the course coefficients. Table 6 indicates that high positive function coefficients indicate a strong correlation between a particular science course and being male (1.00). A low negative function coefficient indicates a strong correlation between a particular science course and being female (2.00).

Table 5: All course function coefficients determined from student interest 2002 [(+) = male & (~) = female].

SCIENCE COURSES	Function
Engineering	.727
Mathematics ∂	.349
Behavioral Science	-.341
Physics ∂	.332
Biochemistry	.259
Computer Science ∂	.207
Chemistry ∂	.197
Astronomy	-.183
Zoology ∂	-.121
Botany	-.121
Ecology ∂	-.098
Geology ∂	.048
Biology ∂	.039

Pooled within-groups correlation between discriminating Variables and standard canonical discriminate functions Variables ordered by absolute size of correlation of function ∂. This variable not used in the analysis

Table 6 indicates that five of the science course function coefficients are such strong predictors that only those five courses would be necessary to predict gender membership. A negative function coefficient indicates a strong predictor for being female; botany being the strongest predictor with a function of -.444, next astronomy with a function coefficient of -.427, and the third predictor was behavioral science with a function of -.388. A positive function coefficient indicates a strong predictor for being male. Only two coefficient functions are needed to predict maleness: engineering was the strongest predictor with a coefficient function of .842, biochemistry was the second predictor with a coefficient function of .481.

Table 6: Course function coefficients determined from student interest 2002 [(+) = male & (-) = female]. Only the variables used in analysis ordered by absolute size of correlation of function.

Science Course	Function
Astronomy	-.427
Biochemistry	.481
Botany	-.444
Engineering	.842
Behavioral Science	-.388

Table 7 shows the final results of the discriminate function analysis, a variant of multiple regressions used to predict group (gender) membership. Again 1.00 indicates the gender group (male) and 2.00 indicates the gender group (female). There were 41 males surveyed and 81 females surveyed. Because of the high numbers of females surveyed the resulting percentages are somewhat biased toward females. This analysis shows that 73.2 percent of the time males can be predicted correctly when using only the five science course choices to rate student interest (astronomy, biochemistry, botany, engineering and behavior science). This analysis also shows that 85.2 percent of the time the gender female can be predicted correctly using the same five courses. Course selection appears to be very direction sensitive to gender, so sensitive it is possible to correctly predict gender membership at least 73 percent of the time using only five questions, compared to the fact that peak interest age is not gender dependent as explained in previous discussed data.

Table 7: A discriminate function analysis, which is a variant of multiple regression used to predict gender membership

GNDRNUM		Predicted Group Membership		
		Male (1.0)	Female (2.0)	Total
Count	Male (1.0)	30	11	41
	Female (2.0)	12	69	81
Percentage (%)	Male (1.0)	73.2	26.8	100.0
	Female (2.0)	14.8	85.2	100.0

Table 7 shows the previously discussed discriminate function analysis, a variant of multiple regression that was done to determine if science course selection is so gender sensitive that it could be used to predict gender. Statistically, it was shown that at least 73 percent of the time course selection could be used. Figure 7 and Table 8 show the results of an independent samples t-test which was run using group statistics to determine if there was a significant difference in the mean interest score given for the five strong function predictors used in used in the discriminate function analysis (1=weak interest to 6=strong interest). The only science course choice with a mean interest level significantly different for males or females was behavioral science. Male mean interest score was 3.5 while female average interest was 4.5, $p < .04$. There was a weak difference between male and female interest for the course astronomy. The average female interest score was 4.0 while the average male interest score was 3.5, $p < .07$.

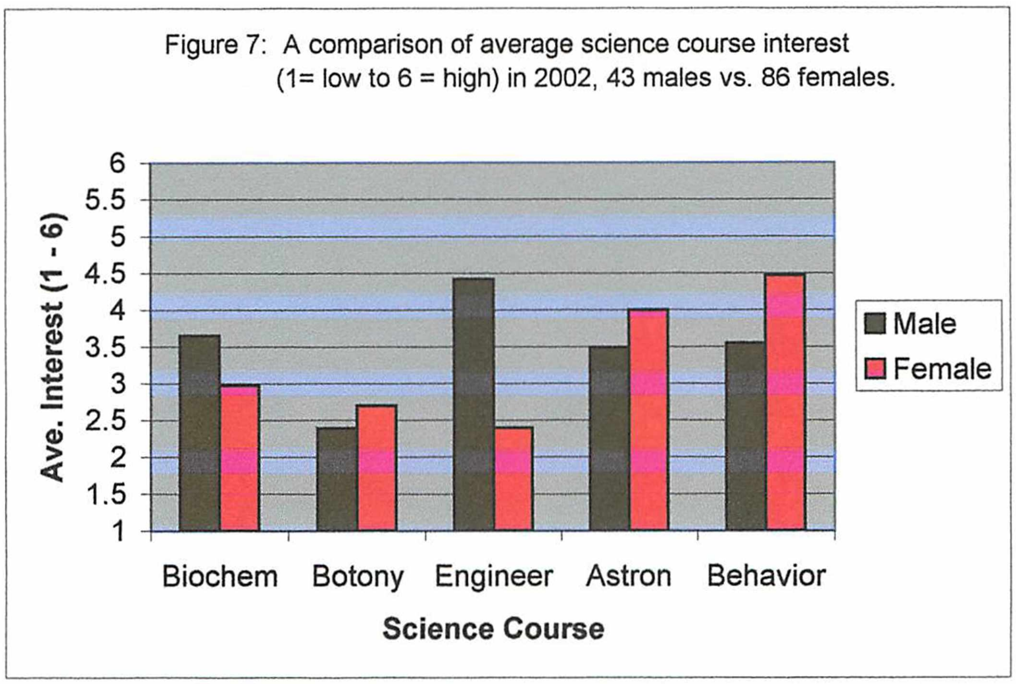


Table 8 Independent samples t-test calculated from the difference in the mean interest score given for the five strong function predictors (1=weak interest to 6=strong interest)

	Gender	N	Mean	Standard Deviation	Std. Error Mean	F	Sig.
Biochem	Male	43	3.65	1.56	.237		
	Female	84	2.98	1.37	.150	1.25	.267
Botany	Male	41	2.39	1.35	.212		
	Female	83	2.70	1.30	.143	0.163	.688
Engineer	Male	43	4.42	1.59	.243		
	Female	84	2.40	1.36	.149	1.127	.291
Astron	Male	43	3.49	1.70	.259		
	Female	86	4.00	1.48	.160	3.367	.069
Behavior	Male	42	3.55	1.77	.273		
	Female	86	4.47	1.51	.163	4.188	.043

Gender Effects and the Influences on Student Science Interest

Figure 8 is a graph of the average influence score (1= low influence to 6 = high influence). The influence score is based on the degree all students in 2002 felt their interest in science was affected by outside variables. The influences on science interest in order from most influence to least was: teacher, enjoy, parents, equipment, books, TV, friends, science fair, online (internet), mentor and scouting.

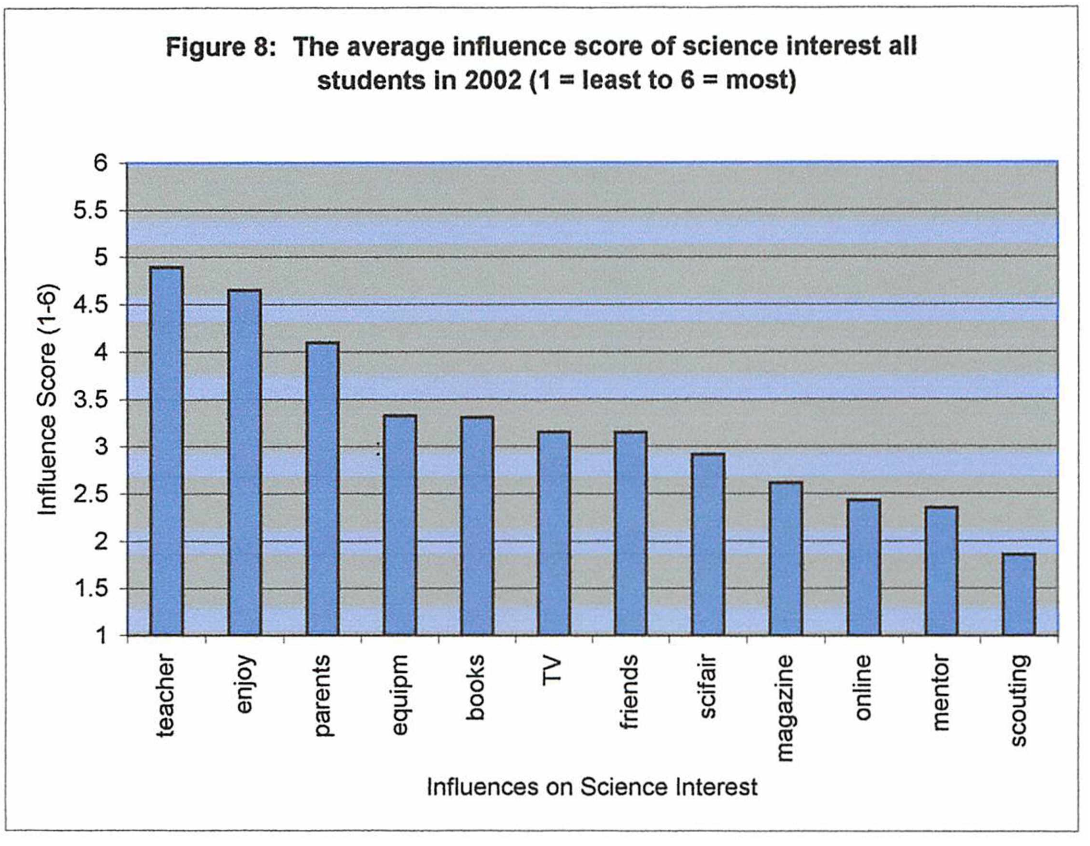


Figure 9 shows the science interest influence variables given to all current 2002 male student survey subjects. The students were asked to rate the influence of each variable on science interest from one to six (1 = low influence to 6 = high influence). The mean influence value for each descriptor is listed in the order of their influence on males. The descriptors that most influence males from most influence to least were: their own enjoyment, teacher, parents, TV, science equipment, books, friends, magazine, online, mentor, science fair and scouting. Forty-three males responded to every question on the influence survey. The descriptors that most influence females from most influence to least were: teacher, their own enjoyment, parents, science equipment, science fair, books, friends, TV, magazines, online, mentor and scouting. Seventy-nine females responded to every question on the influence survey.

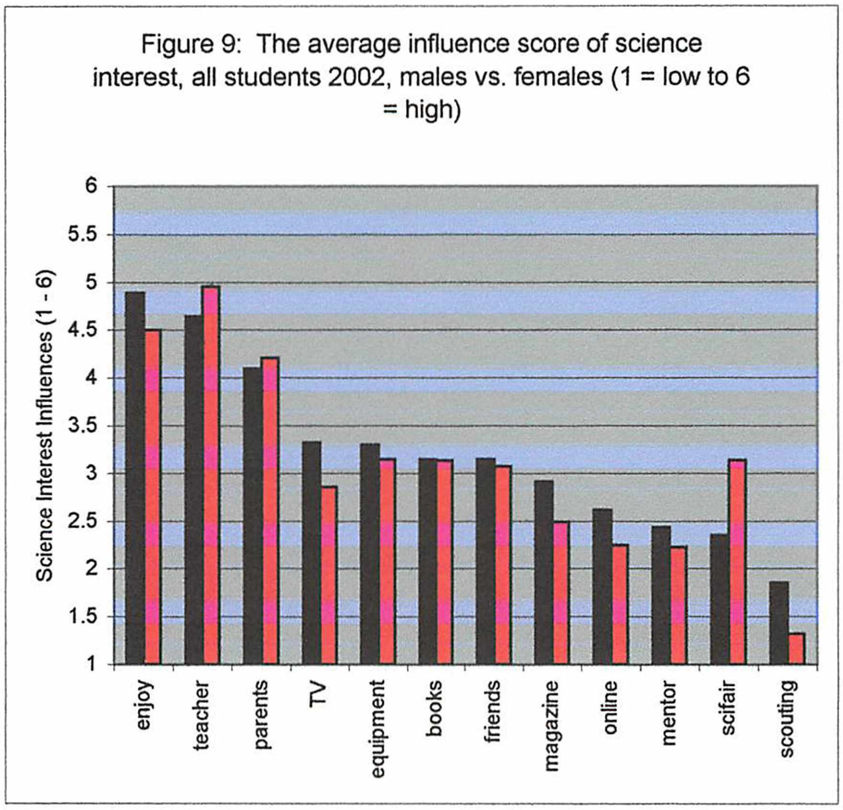


Table 9 shows the results of a general linear model using descriptive statistics to test for between subject effects. The analysis was to determine if there was a significant difference between what influences males verses females. Eight of the most significant descriptive dependent variable influences are listed. The only variable that showed significant difference between males and females in science interest influence was television (TV). The average influence score (1-6, 1=least influenced and 6=most influenced) for males and TV was 3.72, while females influence score was 2.86) Male science interest was more significantly influenced by TV than females, $p < .004$. Online (the internet) and books were only slightly significant when males were compared to females. The average influence score for males and online was 2.79 and for females was 2.25, $p < .060$. The average influence score for males and books was 3.63 and for females it was 3.14, $p<.078$.

Table 9: A general linear model using descriptive statistics testing for between subject effects to determine if there is a significant difference between what influences males verses female.*

Dependent Variables	Type III Sum Of Squares	df	Mean Square	F	Sig.
PARENTS	3.258	1	3.258	1.304	.256
TEACHER	.901	1	.901	.615	.434
ENJOY	5.003	1	5.003	2.270	.135
FRIENDS	1.976	1	1.976	.678	.412
MENTOR	4.268	1	4.268	1.504	.223
BOOKS	8.877	1	8.877	3.163	.078
ONLINE	8.429	1	8.429	3.618	.060
TV	22.461	1	22.461	8.634	.004
SCIFAIR	9.963	1	9.963	2.864	.093
MAGAZINE	4.562	1	4.562	2.083	.152
SCOUTING	1.611	1	1.611	.901	.344
EQUIPMEN	10.469	1	10.469	3.318	.071

*An invariant ANOVA t-test was done using descriptive statistics

<u>A Comparison of Student Academic Achievement (GPA): Males and Females</u>

Table 10 shows a comparison of average academic achievement (GPA) for all males and females surveyed in 2002. The mean GPA for females was slightly higher at 3.79 than males at 3.76 on a scale from 1-4. A group statistical independent sample t-test was done to analyze the difference. Table 11 shows there was not a significant difference between male and female academic achievement, $p < .386$.

Table 10: A comparison of male and female academic achievement (GPA) using a group statistical independent samples t-test.

	Gender	N	Mean GPA	Std. Deviation	Std. Error Mean	F	Significance
GPA	Male	41	3.756	0.4489	0.07001		
	Female	83	3.789	0.3974	0.0430	0.757	0.386

<u>A Comparison of Student Academic Achievement (GPA) and Interest in Biology</u>

Table 11 shows a nonparametric correlation between academic achievement (GPA) and a student's interest in biology. Past research has shown that both males and females reported that biology was the easiest of all science courses and that physics was the most difficult field of study. (Farenga & Joyce, 1999). This analysis was done to see if perceptions of academic rigor might influence interest in biology. There appears to be no significant difference between interest in biology and the 123-survey student's GPA, $p < .594$.

Table 11: A nonparametric correlation determining the relationship between GPA and an interest in biology.

		GPA	BIOLOGY
GPA	Correlation Coefficient	1.000	.048
	Sig. (2-tailed)	.	.594
	N	124	123
BIOLOGY	Correlation Coefficient	.048	1.000
	Sig. (2-tailed)	.594	.
	N	123	128

CHAPTER 5

DISSCUSSION & CONCLUSION

This chapter will first discuss the research in the contents of the literature and compare the outcome to the original hypotheses. Implications of these findings will be discussed as will possible future research. This chapter will conclude with a statement that discusses the scientific “intellectual heritage” and how our pathway through the past, is influencing our pathway to the future.

Science Interest Age: 1962-2002

Currently the national science standards along with many prominent educators promote the implementation of student driven, individualized inquiry science research projects as the best way to teach science, supported by the three pillars of education “reading, writing and mathematics” (Bencze, 2000; Zemelman, Daniels & Hyde, 1998; Minnesota’s High Standards, 2000; National Research Council, 1996; Von Seeker & Lissitz, 1999; Wang, Haertel & Walberg, 1994). In the 1960’s there was an identical movement to emphasize scientific literacy through individualized inquiry-based research projects along with these pillars of education (DeBoer, 2000; McCurdy, 1958; Yagar, 1992). As in 1960, in 2002 science classroom application of this has not occurred nationwide, but in a few classrooms students are doing inquiry based research projects and participating in local, state and international science fairs. (Moore, 1962; Millar & Osborne, 1998; Von Seeker & Lissitz, 1999).

The push during the 1960's was to create a positive attitude (Heiss, 1958), and increase interest in science for students and the general public (McCurdy, 1958; Moore, 1962). It appears from a current literature review that attitude and interest are again being looked at when considering educational programs in science (Minnesota's High Standards, 2000; National Research Council, 1996; Zemelman, Daniels & Hyde, 1998). This study looked at if the age of peak interest has changed in the forty years since Moore's study in 1962. The original null hypothesis was that there would be no difference between 1962 and 2002 in initial science interest age. This null hypothesis was statistically supported using a chi-square analysis, $p < 0.775$.

In 1957 the Russians blasted Sputnik into orbit (Yager, 1992) and the new age of rapid technological developments and scientific discoveries ensued. The scientific world has never been the same, but it is surprising, that the age at which students first become interested in science has not appeared to change.

Educational Implications

Even after 40 years of rapid scientific and technological changes and a renewed effort to instill greater science literacy in the classroom, ages 12 and 10 still appear to be the peak ages for students to first become interested in science.

This suggests that the science interest window may be genetically programmed, just as it has been shown to be for the learning windows of music and language (Begley, 1996; Brain at work, 1999; The Mindlift Foundation, 2001; Stapley, 2001**).**

In a Newsweek article, Sharon Begley concludes from research that there is evidence of "time limits" or "crucial periods" in brain development. Critical periods are "windows of opportunity that nature flings open starting before birth, and then slams shut, one by one with every additional candle on the child's birthday cake" (Begley, 1996, p. 60). Begley writes about three categories of brain development: Language Brain, Music Brain and Logical Brain (math and logic) (Begley, 1996). Further research needs to be done on the "Science Brain" and its "window of opportunity". If elementary teachers avoid teaching science because they feel inadequate or lack the knowledge, the sponge-like neural tissue in the brain necessary to understand science may never be fully activated. The science interest "window" may slam shut before it can every be fully opened (Ghosh, 2001; Begley, 1996).

Science Interest Age: Males vs. Females

During Moore's study in 1962 gender issuers were not assessed. One can only assume that the students who attended the international science fair were predominantly male. Sixty-six percent of the students in this study were females and 33 percent males. A chi-square analysis was done to test the second null hypothesis, that there would be no difference between current males and females in the age they first became interested in science. The null hypothesis was supported; there is no significant difference between the age males or females first become interested in science. This further supports the idea that there may quite possibly be a genetically linked, peak age interest-learning window, and not necessarily a gender linked learning window.

Educational Implications

Ages 10 and 12 appear to be the ages when most female and male students first become interested in science. This finding should indicate that science education during the middle school years (grades 5-9) is of primary importance. If we are concerned about having scientifically literate adults that are productive contributors in a technical society, making intelligent personal and social decisions for the world we live in, capturing and maximizing their science interest during these peak middle school years is paramount.

This further supports the idea that educators should consider enhancing science curriculum in the elementary years. Many elementary teachers do not have a strong science background, and consequently feel uncomfortable with including science on a regular basis (DeBoer, 2000; Millar & Osborne, 1998). This was also a concern during the 1960’s (McCurdy, 1958). There were students in our survey who stated they first became interested in science during kindergarten and early elementary. The peak science interest age could possibly be younger if elementary science specialists were utilized and a more hands on inquiry type approach became an integral part of the elementary curriculum. Further research should be done concerning this issue.

When the data from the male and female science interest ages were visually compared, a unique trend emerges. Seventy-six percent of the females surveyed were interested “before” their peak age of 12. Conversely, 76 percent of the males were interested “after” their peak age of 10. This seems to indicate that science during the elementary years is even more important for female students. If female students do not become interested in science by the time they enter high school, they may never develop an interest in the sciences, and consequently they may also become the least science literate adults. Elementary programs lacking in a strong science curriculum may unknowingly be gender biased against female students. Society faces the prospect of losing many potentially gifted and scientifically inclined female scientists.

Science Course Interest: Males vs. Females

Gender or time does not appear to affect the age of initial interest in science, but the pathway or direction of science interest appears to be gender dependent. This study shows that when a multiple regression equation is calculated to predict gender membership, only interest scores from five of the science courses are needed to predict gender (astronomy, biochemistry, botany, engineering and behavioral science). Astronomy, botany and behavioral science were strong predictors of being female while biochemistry and engineering were strong predictors for males. Research by Farenga and Joyce in 1999, further supports these findings. They found that girls reported a greater interest in sciences associated with plants and animals, while boys related to sciences associated with matter and energy.

The forth-null hypothesis, that there would be no relationship between gender and science course interest was not supported. There appears to be a strong correlation that 82.5 percent of the time females and 73 percent of the time males will be correctly classified based upon their response to five science categories. When the average mean interest score for males and females were compared using an independent samples t-test, Behavioral Science was significantly different along with astronomy, which was slightly significant.

This study showed that female students appear to be more interested in the biological sciences (botany and behavioral science). It was uniquely surprising that interest in astronomy was such a strong predictor of being female. It is possible that the biological sciences and astronomy have a common thread of mystery or wonder that captivates the female science student. The study of biology and astronomy are larger than life. We have little control over the natural living world and the wonders of the universe. Males on the other hand are more interested in engineering and biochemistry. These are fields of study that man can master and control. These factors suggested above could play a part in male class choices (Farenga & Joyce, 1999).

Educational Implications

Farenga and Joyce suggested in 1999 that gender-role socialization processes and environmental influences create the gender disparity in course interest and selection. If this is true, developing intervention strategies as early as Headstart may be warranted. Since there are manpower shortages in science and technology, limiting anyone may not be a luxury we can afford (Bayer, 1998).

The Influences on Science Interest and Gender Effects

Charles Von Seeker and Robert Lissitz did a study in 1999 looking at the impact of instructional practices on student achievement in science. They correlated the relationship between standardized test scores, teacher practices, gender and socioeconomic conditions. What they found was that teacher practices had the greatest affect on student achievement when teachers used student-centered strategies along with an emphasis on laboratory inquiry. It is not surprising that when the 2002 students were asked to rate variables that influence their interest in science, teachers had the highest mean score.

The number one science interest influence for male students was enjoying science and females were most influence by their teacher. This correlates with a research done by Von Seeker & Lissitz in 1999. In their study males benefited the most from student-centered, autonomous critical thinking activities, while females benefited more from teacher-centered and group activities (Von Seeker & Lissitz, 1999). Even though teachers had the highest mean influence overall, it was second for male students, but the highest for female students.

The third highest influence for both males and females were parents. Farenga and Joyce reported that many studies suggest, "...the home is such a powerful influence that no change is possible without its informed support." (Farenga & Joyce, 1999, p. 68).

Past research also found that, "boys more so than girls, have an inclination toward science-like activities that involve the manipulation of external objects in the environment." (Farenga & Joyce, 1999, p. 58). This current study would have expected that male students would be more influenced by science equipment than females. Statistically there was no difference between male students and female students, but female students were slightly more influenced by science equipment than male students and certainly not less.

The null-hypothesis, that there will not be a gender difference in what influences science interest was partially supported. Television did significantly influence male students more than female students. Books only had a slightly higher significant influence on males. For all other influences there was not a significant difference in influence between male students and female students.

Educational Implications

This study reinforces the impact parents and teachers have on influencing learning and interest in science for both male and female students. In fact, the findings from the TIMMS report in 1996 found that the factors behind the United States unimpressive scores in mathematics were "...inadequate teaching skills and an unfocused or nonexistent curriculum" (Today's Science, 1997, p.1). Parents need to understand the influence they have on their child's science interest and overall academic success.

This study does suggest that parents of male students would benefit by making sure their son has access to educational programs on TV and scientific books and literature available. Teachers need to be up-to-date on current research and reflect on the instructional practices they employ in their classroom, for they are affecting student interest and potential success in science.

A Comparison of Student Academic Achievement (GPA): Males and Females

The National Assessment of Educational Progress (NAEP) science assessment reported science scores by gender, "In 2000, the score gaps favoring males over females widened by three points at grade 4 and by five points at grade

8. At grade 12, the apparent narrowing of the gap in 2000 compared to 1996 was not statistically significant" (NEAP, 2000, p. 10). Overall, this study consistently shows that males are out performing females in science. This is further supported by a study done by Voss and Lissitz in 1999. They evaluated the correlation between a standardized test score and gender. They found that males had a 0.288SD higher science achievement than females. These findings are surprising because, the null hypothesis for this study was supported that there would be no difference in academic achievement between male and female students. Females actually had only a microscopically higher mean GPA (3.789) than males (3.756).

Educational Implications

This study shows that for the students we tested there is no difference in GPA between males and females. It would be interesting to compare academic achievement (GPA) to standardized test scores and see if there is a correlation. The results of this study further support the fact that fair testing and assessment are one of the main challenges facing educators today.

Academic Achievement and Course Selection

Farenga and Joyce, in a study done in 1999 found that the student who selects biology have characteristics such as, "one who tends to be more verbal, less mathematical, has the lowest level of school achievement among students selecting science" (Farenga and Joyce, 1999, p. 62). This study did a correlation to determine if there is a relationship between GPA and interest in biology. The null hypothesis that there would not be a correlation between GPA and biology interest was supported. The results of this study did not reinforce Farenga and Joyce's description of a biology student.

Recommendations for Future Research

In a Newsweek article, Sharon Begley concludes from research that there is evidence of "time limits" or "crucial periods" in brain development. Critical periods are "windows of opportunity that nature flings open starting before birth, and then slams shut, one by one with every additional candle on the child's birthday cake" (Begley, 1996, p. 60). Begley writes about three categories of brain development: Language Brain, Music Brain and Logical Brain (math and logic) (Begley, 1996). Possibly further research needs to be done on the "Science Brain" and its "windows of opportunity". If elementary teachers avoid teaching science because of feelings of inadequacy or lack of knowledge the sponge-like neural tissue in the brain necessary to understand science may never be fully activated. The science interest "window" may slam shut before it can ever be fully opened (Ghosh, 2001; Begley, 1996).

Conclusion

When the National Commission on Excellence in Education (1983) issued a report called, *A Nation at Risk* students in the United States were not performing as well as students from the top international countries. This led to massive reforms, and consequently the development of national standards and testing. These same students that were tested in 1983 are now part of the current workforce, in a country that leads the way in scientific research and technology. It is possible that these standardized tests and strict content knowledge are not adequate predictors of future interest and performance in science. A positive attitude and natural interest in science may have more of an impact on producing science literate students who are informed citizens or possibly future scientists.

It is possible that during the early 1900's when they excluded science from the "three pillars of education" and defined it as an "intellectual luxury", grouping it with music, art and philosophy they were not far from the truth of how we should view science education. Science uses the three pillars while adding joy and wonder to our lives as we experience our natural world. The difference today is that you do not have to be an "egghead," "geek" or "Dr. Frankenstein" to enjoy science. You can be a musician, an artist, or a philosopher and find science connections to the world we share.

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Appendix

CONSENT FORM
THE EFFECT OF MIDDLE SCHOOL SCIENCE INSTRUCTION ON FUTURE CAREER CHOICES

You are invited to be in a research study, which will look at the effect of science instruction on future career choices. You were selected as a possible participant because of your participation in a state science fair, or are currently a working scientist, or are secondary student in a science class. We ask that you read this form and ask any questions you may have before agreeing to be in the study.

This study is being conducted by: Cynthia Welsh, Paul Sandholm and Tammera Meyer
They will use the data collected for their masters degree research project while attending the University of Minnesota- Duluth.

Background Information:

The purpose of this study is to gather data to evaluate the effect science instruction has on career choices in science. A better understanding of factors, which could motivate school age students to pursue careers in science, is key to the development of educational strategies that could reduce future professional shortages.

Procedures:

If you agree to be in this study, we would ask you to do the following things:
You will be asked to individually fill out a survey, which will take you approximately ten minutes. You will be asked questions concerning the types of past, present science classes you have taken and possible future classes you will take. You will be asked questions concerning motivating factors in past, present and future science endeavors.

Risks and Benefits of Being in the Study:

The study has several risks: First,____________________ ; Second,___________________ [Risk must be explained, including the likelihood of the risk]

[If there are significant physical or psychological risks to participation, you need to fill out the Social and Behavioral Sciences application as exempt research is for minimal risk research only]

The benefits to participation are:______________________________[If no benefits, state that fact here.]
You will receive payment:__________________ [Include payment or reimbursement information here. Explain when disbursement will occur and conditions of payment]

Confidentiality:

The records of this study will be kept private. In any sort of report we might publish, we will not include any information that will make it possible to identify a subject. Research records will be kept in a locked file; only researchers will have access to the records.

Nature of the Study:

Your decision whether or not to participate will not affect your current or future relations with the University of Minnesota Duluth, or the Minnesota Academy of Science. If you decide to participate, you are free to withdraw at any time without affecting those relationships.

Contacts and Questions:

The researchers conducting this study are Cynthia Welsh, Paul Sandholm and Tamera Meyer. You may ask any questions you have now. If you have questions later, you may contact them either at work (218)733-2046 - (218) - -(218), or home (218) 729-7411. You may also contact Susan Damme, their faculty advisor, at the University of Minnesota________________ .

If you have any questions or concerns regarding the study and would like to talk to someone other than the researchers), contact Research Subjects' Advocate line, D528 Mayo, 420 Delaware Street S.E., Minneapolis, Minnesota 55455; telephone (612) 625-1650.

You will be given a copy of this form to keep for your records.

Statement of Consent:

I have read the above information. I have asked questions and have received answers. I consent to participate in the study.

Signature____ Date

Signature of parent or guardian_________________________________ Date

Signature of Investigator______________________________________ Date

June 25, 2001

Independent School District No. 709
Duluth Public Schools
215 N. 1st Ave. East
Duluth, MN 55102

Dear ISD 709 Students, Parents, and Guardians,

As part of their research requirement for a Masters of Education degree, University of Minnesota-Duluth graduate students Cynthia Welsh, Tamara Meyer, and Paul Sandholm are conducting research studying the effect of science instruction on career choices students make in science. They would like to survey and students, parents/guardians of students, and science professionals to gather information for this study.

As someone that meets those criteria, the Duluth Public Schools would like to encourage your participation in this study. Involvement will include completing a survey, which will take approximately 5-10 minutes. Your participation is voluntary and all responses will be confidential. Regardless of your decision to partake in this study, your decision will not affect any relationship you may have with the Duluth Public Schools.

Please call us at (651) 227-6361 if you have any questions about this research project or the survey, your questions will be answered.

Respectfully,

Bruce Watkins
Director-K-12 School Operations
Duluth Public Schools

October 26, 2001

Minnesota Academy of Science
408 St Peter Street, Suite 410
St Paul, MN 55102

Dear JSHS Participants,

As part of their research requirement for a Masters of Education degree, University of Minnesota-Duluth graduate students Cynthia Welsh, Tamara Meyer, and Paul Sandholm are conducting research studying the effect of science instruction on career choices students make in science. They would like to survey and students, parents/guardians of students, and science professionals to gather information for this study.

As someone that meets those criteria, the Minnesota Academy of Science would like to encourage your participation in this study. Involvement will include completing a survey, which will take approximately 5-10 minutes. Your participation is voluntary and all responses will be confidential. Regardless of your decision to partake in this study, your decision will not affect any relationship you may have with the Academy.

Please call us at (651) 227-6361 or email: contact@mnacadsci.org. If you have any questions about this research project or the survey, your questions will be answered.

Respectfully,

Dezra Helgeson
Executive Director

Student Science Survey

CURRENT (zip code): (_____)

Gender (circle one) Female Male

In 7th grade, did you have a full or half-year science class (circle one) Full Half

In 8th grade, did you have a full or half-year science class (circle one) Full Half

Part 1

1-A Current Grade in School ____________________

1-B How old are you? ____________________

1-C Name of your school ____________________

1-D Which mathematics courses have you completed or are attending in school?
Algebra I ( ) Algebra II ( ) Trigonometry ( ) Pre Calculus ( )
Calculus I ( ) Calculus H( ) Geometry ( ) Basic Math ( )
Others, Please List ____

1-E Which science courses have you complete or are attending in school?
Physical Science ( ) Life Science ( ) Earth Science ( ) Chemistry ( )
Honors Biology ( ) Biology ( ) Physics ( ) Anatomy ( )
Others, Please List ____.

1-F What is your approximate current GPA (optional)
Below 2.0 ( ) 2.1-2.5 ( ) 2.6-3.0 ( ) 3.1-3.5 ( ) 3.6-4.0 ( ) Above 4.0 ( )

1-G Do you plan to attend college? Yes ( ) No ( ) Undecided ( )

1-H What college would you like to attend? Undecided ( )
Please write name and state: ____

1-I Your probable major: Engineering ( ) Science Research ( ) Medicine ( )
Biological Sciences ( ) Chemistry ( ) Physics ( ) Mathematics ( )
Geology ( ) Astronomy ( ) Computer Science ( )
Other (specify area of major if known)____

1-J Is your science fair project a continuation of last year's project? (Circle) yes no

1-K At what age and grade were you first interested in Science?
Age_____________ grade_____________

1-L What or Who motivated you to do a project?

1 -M What or Who helped you decide on your science fair topic?

Part 2- **Circle the number that best describes your interest level in the category noted.**

	Very Interested				**Not Interested**
Astronomy	6	5	4	3	2	1
Biochemistry	6	5	4	3	2	1
Biology	6	5	4	3	2	1
Botany	6	5	4	3	2	1
Chemistry	6	5	4	3	2	1
Computers	6	5	4	3	2	1
Ecology	6	5	4	3	2	1
Engineering	6	5	4	3	2	1
Geology	6	5	4	3	2	1
Human Behavior	6	5	4	3	2	1
Mathematics	6	5	4	3	2	1
Physics	6	5	4	3	2	1
Zoology	6	5	4	3	2	1

What other activities do you participate in (please list)?

Part 3- Circle the number that best describes what most influenced your interest in science.

	Definitely Influenced					**No Influence**
Parents	6	5	4	3	2	1
Teacher	6	5	4	3	2	1
Enjoy Subject	6	5	4	3	2	1
Friends	6	5	4	3	2	1
Mentor	6	5	4	3	2	1
Books	6	5	4	3	2	1
On-line	6	5	4	3	2	1
T. V. Shows	6	5	4	3	2	1
Science Fair	6	5	4	3	2	1
Magazines	6	5	4	3	2	1
Scouting	6	5	4	3	2	1
Science Equipment	6	5	4	3	2	1

3-A In your opinion does science plays an important role in your life? Yes No

3-B Will a strong science background be important to you in the future? Yes No
Why?

If you have a short story to tell concerning what or who interested you in science, please note the story below or on the back of this sheet.