Intentions of Young Students to Enroll in Science Courses in the Future: An Examination of Gender Differences

STEPHEN J. FARENGA, BEVERLY A. JOYCE
School of Education Dowling College, Idle Hour Boulevard, Oakdale, NY 11769-1999

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ABSTRACT: This study examined young students’ perceptions of gender-appropriate science courses. The sample consisted of 427 students in grades 4, 5, and 6, between the ages of 9 and 13. Students completed the Course Selection Sheet (CSS) to choose courses for themselves and members of the opposite gender. A psychosocial framework was offered to explain the differential course selection patterns between young boys and girls. The study reveals a strong gender effect pointing toward stereotypical perceptions of selected science courses for oneself ($p \leq 0.01$). When students selected science courses for the opposite gender, the evidence of gender-role stereotypes was even greater ($p < 0.000$). Course selection profiles imply that a reciprocal relationship exists in the number and kind of courses selected by girls and boys. A detailed analysis suggests that both boys and girls perceive physical science and technology-related courses as appropriate subjects for boys to study and life sciences as appropriate subjects for girls to study. Surprisingly, students’ future science course selections resemble current enrollment data of master’s and doctoral candidates. The students’ perceptions of science are seen years prior to the actual encounter with the science courses listed on the course selection menu. These findings question the auspiciousness of programs designed to ameliorate gender differences in science during junior or senior high school years. Suggestions for school curriculum development and the importance of informal science experiences were examined. © 1999 John Wiley & Sons, Inc. Sci Ed 83:55–75, 1999.

SCIENCE COURSES: YOUNG STUDENTS’ FUTURE PICKS

The literature is replete with accounts of the underachievement of various groups in mainstream education. In the examination of research reported in international studies or government reports (e.g., A Nation at Risk, National Commission on Excellence in Education, 1983; First Lessons, Bennett, 1986; Educating Americans for the 21st Century: A Report to the American People and the National Science Board, National Science Board Commission on Pre-college Education in Mathematics, Science, and Technology, 1983) one might infer that the mainstream in the U.S. culture itself is an underachieving class

Correspondence to: S. J. Farengas; e-mail: farengas@dowling.edu

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when compared with the mainstream of other countries (National Center for Education Statistics [NCES], 1997a, 1997b). With the constant bombardment of reports of educational decline, it is urgent that science educators be aware of the early evidence of stereotypic attitudes regarding courses of study.

Most studies of science enrollment patterns generally begin in high school (Czujko & Bernstein, 1989; Mullins & Jenkins, 1988; NCES, 1997a, 1997b; Nelson, Weiss, & Capper, 1990). The profiles reveal that biology is favored by girls and physics is favored by boys, and these patterns appear to persist through college and graduate school. National statistics indicate that more male college-bound seniors intend to major in physical sciences and computer sciences, whereas females favor biology (College-Bound Seniors, 1997). At the graduate level, male master’s and doctoral candidates are much more likely to pursue degrees in the physical sciences than are female candidates (NCES, 1997b).

In terms of science achievement, no notable gender difference appears until age 11 (NCES, 1997a). Recent research indicates 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 mathematics are not seen until grade 10.

However, in the past, little research has focused on young students’ perceptions of gender-appropriate science courses (Baker, 1990; Farenga, 1995). Research of early interest in science (Brandwein, 1951; Roe, 1952; Walberg, 1991; Zim, 1941), perception of science courses (Baker, 1990; Chambers, 1983; Ormerod, 1975; Walberg, 1967), and gender-role stereotyping (Eccles, 1985; Eccles, Adler, & Kaczala, 1982; Reis & Callahan, 1989; Sadker & Sadker, 1985) have all been cited as influential factors of gender differences in science.

GENDER DIFFERENCES IN PSYCHOSOCIAL DEVELOPMENT

Socialization Process

The early experiences of children have been documented as extremely important to their later development. An example of the importance of early intervention strategies is evidenced by the concept of the Headstart (Soar & Soar, 1972). Headstart was designed to increase achievement of socially disadvantaged children by providing an enriched environment.

The importance of gender-role formation and its influence on educational and vocational choices have been investigated by Bem (1981), Eccles (1985), Fox and Cohn (1980), Hollinger (1991), and Nash (1979). Each of these investigators paid special attention to the way gender-role socialization may affect girls’ educational and occupational choices. The research indicates that certain childhood experiences may have an influence on the formation of future personality traits. In turn, these early experiences foster the development of attributes that are theorized to be better suited to the pursuit of interest and achievement in science.

It has been suggested that, through the interaction of the socialization processes and environmental influences, gender differences in course taking occur in science and mathematics (Eccles, 1985, 1989). This may be the direct result of the gender-role socialization process. Research indicates that differences in the socialization process of young children appear to favor young boys’ achievement, interest, and attitude toward science (Kahle, 1990). Johnston (1984) observed:

Boys and girls enter school science classrooms with different past experiences, interest, different attitudes, and different expectations. This indicates the teachers cannot dismiss
the problems of girls’ under-achieving in science by treating boys and girls identically
... The science classroom and curriculum are designed to build on the foundation of
interest, experiences, and attitudes that is present for one sex but not present for the other.
Treating boys and girls identically in school can only accentuate rather than diminish the
existing differences. (p. 22)

Interaction and Socialization

The importance of examining different patterns of socialization, interaction, and inter-
personal experiences has been cited in numerous studies (Archer & Lloyd, 1982; Bem,
1981; Block, 1983; Culp, Crook, & Housley, 1983; Markus & Oyserman, 1989; Smith &
Lloyd, 1978). All of these studies identify how parents of young children handle and treat
children differently based on the gender of the child. Interestingly, mothers reacted dif-
ferently to the same baby depending upon whether it was presented as a boy or a girl.
Culp et al. (1983) noted that these mothers were not conscious that they handled babies
in the laboratory in a different manner then they reported handling their own babies.

The finding that mothers in the studies are unaware of their actions highlights the im-
portance of the process of unconscious socialization (Nisbett & Wilson, 1977). These early
experiences of boys and girls aid in the construction of the concept of self and result in
different types of thought processes or schemata that are different in content and form for
states, “of all the existing barriers, sex-role socialization’s impact on the child’s developing
self-belief system is the most pervasive and limiting” (p. 136).

Bakker (1990) has shown that certain behaviors stimulate specific areas of the brain,
causing increased acquisition of knowledge. A question that arises is whether certain be-
haviors shape cognitive style and to what degree it is mutable. Is the brain a “dependent
variable,” whereby long-term exposure to a variety of early experiences develops the brain
to be more receptive and to create a positive perception of certain types of learning?

Theories of Gender-Role Identification

Gender-Role Identification. Psychologists and sociologists have proposed various the-
ories to account for how a child learns appropriate gender-roles. These theories stress
differences in the importance of people and objects in the child’s environment. It is evident
that the theorists disagree on the mechanics of the socialization process. However, it is
documented that children associate with their appropriate gender label by age 3 (Hudson,
1983; Kagan, 1969). By preschool, students associate themselves with their appropriate
gender and are aware of the appropriate behavior patterns, play preferences, and psycho-
logical characteristics expected of them (Guttentag & Bray, 1976; Kohlberg, 1966, 1978).
Even though a specific cause has not been determined in the literature, it is clear that, by
age 6 or 7, children can identify specific gender-role definitions. It is also apparent
that the interest and attitudes of young girls and boys begin to diverge dramatically at
this time.

Models of Gender-Role Learning. There are basically three types of models that explain
gender-role learning. The first are psychoanalytical in nature. Freudian-based, they suggest
that a child develops an emotional attachment to, and a desire to be like the same-gender
parent (Chodorow, 1978; Dinnerstein, 1977; Erikson, 1963; Freud, 1925; Winnicott,
1965). The second are those of the social learning theorists. According to social learning
theory, the child learns the appropriate gender role through a system of reinforcements. Significant people in the child’s life reward gender-appropriate behavior and punish for gender-inappropriate behavior (Mischel, 1966). The third are those of the cognitive development theorists. They stress that the child conceptualizes the gender-role category and then tries to mold his or her social behavior to match it (Kohlberg, 1969; Piaget, 1950, 1970).

**Object Relations Account of Personal Development.** The theory of object relations and its account of personal development is psychoanalytic in nature. Object relations theory takes the position of emphasizing the importance of society and culture in personality and development. Object relations theorists explain development as a procession of stages that allow the child to experience and satisfy erotogenic zones as a result of social interactions. Infants are sexual but do not naturally seek the release of tension from physiological drives. Rather, the infant is presumed to manipulate and transform the drive in the course of attaining and retaining relationships with objects in the environment. Thus, satisfaction is achieved through a process of transference and transformation to an object in the environment.

The theory of object relations is used to provide a possible explanation that one’s attitude toward science is the result of the socialization process and its interaction with the environment. Science in our society is predominantly a male-oriented endeavor. The manner in which science is presented is more congruent with the gender-role socialization process of boys. Boys, more so than girls, have an inclination toward science-like activities that involve the manipulation of external objects in the environment.

Klein (1932) suggested the importance of the child’s relationship with objects in the immediate environment as a basis for personality development. Klein explained that objects are representations, created by the individual, which are usually of people, institutions, or things. Klein believed that the personality is formed by the manner in which the individual relates with the objects. Key to the concept of object relations is the process of transference and countertransference, where the individuals transform drives in the process of relating to their internal and external environments.

Science is a construct in the world that is constantly presented to the child. The child is a natural scientist asking questions to seek answers to his or her natural world. The child’s attitude toward science may be affected by the manner in which science is converted to an object and the reality that is created by the child to interpret that object. The child must convert science into an object that he or she then manipulates to gain insight. The nature of the object and the relationship to it will depend on the interaction of the nurturing process and on the forms in which science-related experiences are presented to the child. The research of Winnicott (1965) and Chodorow (1974) refers to earlier work by Klein (1932), but both emerge with a different end goal for the process of personality formation.

**Winnicott’s Theory.** Winnicott (1965) reviewed the work of Klein, but added that it is the goal of the infant to separate out of total dependence on its primary caretaker to become an autonomous adult able to relate to the world. The task of the caretaker is to provide the necessary nourishment, to present the world, and to help the child avoid stress. The last two tasks require a delicate balance that enables separation, but offers adaptive care until the child is able, progressively, to take over functions for himself or herself. The importance of how girls and boys are connected with the world in different ways has been
discussed by Chodorow (1976, 1989), Erikson (1968), and Gilligan (1982). The concept of connectedness that is formed during the socialization process is used to explain why girls perceive science in a different manner than boys do. Harding (1986) applied Chodorow’s explanation for connectedness to explain possible differences in science achievement between genders.

**Chodorow’s Theory.** Chodorow’s (1978) theory of the “Reproduction of Mothering” has been cited in numerous studies to explain gender differences in personality development as a plausible cause of female avoidance of science (e.g., Gilligan, 1982; Harding, 1986). Chodorow suggested that the manner in which child rearing is practiced in the West affects the attributes of both genders. Like Winnicott (1965), Chodorow theorized that it is the primary task of the child to develop autonomy, and that process and its inherent problems are different for males and females.

Key to Chodorow’s theory is the process of identification with the same-gender parent. Although both males and females identify with their mothers as the primary caretaker, males have an easier transition to autonomy. She stressed the differing aspects of development that result from differing patterns of parenting between genders. Men and women foster differing relational capacities and intrapsychic structures caused by their asymmetrical orientations to parenting.

The child’s early experiences from parenting must be internalized and transformed by the child through unconscious processes that come to influence the psychic structures. Internalization does not translate to a direct transmission of what the child is actually experiencing in his or her social world. Social experiences evolve into a variety of psychological meanings depending on the child’s sense of “ease helplessness, dependence, overwhelming love, conflict, and fear” (Chodorow, 1978, p. 50).

Chodorow (1978, 1989) suggested that the concepts of connectedness for girls and separateness for males are developed from the identification process. A girl’s view of connectedness is formed by way of gender similarity to her mother. Boys, being dissimilar to their mothers, sever the close link and begin the task of learning separateness. Differential parenting causes the creation of two worlds—one domestic and the other public—each unequal in value and each dominated by a different gender. Chodorow (1978) explained that the cause is due to the process of mothering:

Women’s mothering is also a crucial link between the contemporary organization of gender and the organization of production. It produces men with personality characteristics and psychic structures appropriate to participation in the capitalist work world . . . Assumptions that the social organization of parenting is natural and proper (that women’s child care is indistinguishable from childbearing, that women are for biological reasons better parents than men, moral arguments that women ought to mother) have continued to serve as grounds for arguments against most changes in the social organizations of gender. (p. 219)

**Connectiveness and Socialization.** For the young female, the socialization processes that occur because of gender similarity to their mothers creates a greater sense of connectedness and relationship to the world. Contrarily, it is at this juncture that boys learn autonomy and separation (Keller, 1986). It has been theorized that autonomy and separation that occur as a result of the socialization process develop the necessary qualities of object reasoning and objectivity (Birke, 1986; Chodorow, 1978; Keller, 1986). However,
unjustified, our society has an image of a scientist separated from the world, unengaged in order to make impartial evaluations. Birke (1986) stated:

. . . that these ideas are important because they locate the origins of women’s exclusion from science in early development, in cultural patterns by which gender identity is learnt within family. The problems related to women in relation to science, then, are not relatively trivial ones such as discrimination, but lie deep in the sexual divisions of society itself. As long as women are responsible for child rearing, girls will grow up with a greater sense of embeddedness than boys, and will thus be more likely to be alienated from the abstractness of science. (pp. 189–190)

Personality Traits of Scientists

Support for the implications that are suggested in the theoretical tenets of Chodorow’s personality theory are maintained by the studies of Chambers (1983), Harding (1986), MacCurdy (1954), McCurdy (1960), Roe (1952), Stein (1956), and Yoder (1894). Each of these studies established personality traits that identified scientists’ preferences for solitary activities, independence of thought, self-acceptance, strong achievement motivation, curiosity about causality in relationship to natural phenomena, and the desire to be participants in activities. Results of past studies (McCurdy, 1960; Roe, 1952; Yoder, 1894) suggested that differences in adult personality traits may be related to early childhood experiences. Harding (1986) reported that:

. . . personality studies of a variety of levels of scientist suggest that a science object which is reliable and immutable which enables control (both tangibly and intellectually) and which may be pursued in a detached, emotionless way is created and used by individuals for whom nurturing has been deficient in emotional support—and these form a majority of the scientist. (p. 165)

Early Interest in Science

Early studies by Zim (1941), Brandwein (1951), and Roe (1952) examined the importance of the relationship between early arousal of interest in science and the selection and training of future scientists. Thompson and McCurdy’s (1957) study of science fair participants revealed that 69% of the winners had an interest in science prior to their 13th birthday. Moore (1962) and Perrodin (1966) identified various ages related to science interest. Reported critical ages of interest were 10, 12, 13, and 14, all centered around adolescence. In support of these findings, a recent survey of 1400 scientists indicated that 61% became interested in science before the age of 10 (Bayer/NSF, 1997).

An early study by Mau (1912) suggested different interests exist between genders toward science, beginning in childhood. Girls report participating in more biological science activities, whereas males definitely prefer to partake in more physical science activities. Biological activities included collecting flowers and bird watching. Physical science activities included experimenting with a chemistry set, working out inventions, using electric kits to build train and race car sets, Lego, and basic tinkering activities. A study by Richardson (1971) indicated a strong presence of gender-differentiated interests. The study suggests that scientific curiosity and interest in mechanical synthesis and analysis are greater in males than females during adolescence.

It is evident that boys’ and girls’ out-of-school science-related experiences are quite
different by the time that they reach school and while in school (Farenga & Joyce, 1997a, 1997b; Kahle & Lakes, 1983). The research indicates that young boys and girls are socialized in ways that foster interest in different science-related activities (Koelsche & Newberry, 1971; Rallinson, 1943). These studies suggest that interest in the physical sciences appears earlier than it does in the other sciences and that it involves activities such as tinkering with objects or investigating physical phenomena.

### Perception of Science Courses

Studies of students’ perceptions of science suggest that males and females have distinct differences in the type of science they choose to experience (Baker, 1990; Farenga, 1995; Shroyer, Powell, & Backe, 1991; Walberg, 1967). Studies of subject preferences of males and females found that certain subjects are perceived as masculine or feminine by elementary school students even as early as kindergarten (Baker, 1990; Farenga, 1995; Ormerod, 1975; Shroyer, Powell, & Backe, 1991). Subjects such as mathematics, physics, and chemistry are considered masculine, whereas subjects such as biology, language, and art are perceived as feminine. A similar finding was identified by Weinreich-Haste (1981), except that boys perceived biology as masculine and girls perceived it as neutral.

Steinkamp and Maehr (1983) found that girls prefer life science and boys prefer physical science. Suchner and Barrington (1980) reported that students have greater knowledge bases of topics in science that follow traditional gender roles. They suggested that girls know more about nutrition, child development, and health-related topics, whereas boys know more about applied sciences. Together, these studies adumbrate the effect of specific interests on one’s cognitive development.

Furthermore, students not only perceive science as a masculine subject, they perceive scientists as predominantly male (Mason, 1986; Mead & Metraux, 1952). Chambers’ (1983) study highlighted the gender-role stereotype young children have of science as a male domain. Chambers selected 4807 students in grades kindergarten through 5 to draw a picture of a scientist. Upon review of the drawings, only 28 were perceived as female scientists, and all were drawn by girls. The perception of science as a masculine endeavor appears to form at a young age. If science is so strongly perceived as stereotypically masculine, the appropriate feminine gender role would be one of avoidance.

The greatest gender-related differences in the study of science begin during the middle school years. This is also the time when a young adolescent girl is most concerned with her feminine development. If feminine values and science are diametrically in opposition, the expected societal roles may cause a swing from science. As a result, the study of science may be eliminated because it does not fit well with one’s gender-role schema (Eccles, 1985).

### Perception of Course Difficulty

Duckworth and Entwistle (1974) examined the perceived difficulty among the subjects of biology, chemistry, and physics. Both girls and boys reported that biology is easier and that the most demanding subject is physics. Hudson (1963) and Stronk (1974) found that students who tend to study physics score higher on intelligence tests and are higher achievers in school.

Research suggests that physics and chemistry are considered among the most challenging school subjects (Edwards & Wilson, 1958; Soy, 1967; Stronk, 1974). It has been suggested that the noted difficulty of high school physics is the cause of falling enrollments
A similar finding reveals that elementary school teachers believe that physical science is a most difficult subject (Behnke, 1959; Ramsay & Howe, 1969; Schirner, 1968). Stronk (1974) reported that, even among high achieving students, physics is perceived to be the most difficult subject, followed closely by chemistry.

Several reasons have been cited for the relative difficulty of the physical sciences: the mismatch of content with students’ cognitive ability (Flowers, 1967); poor psychological ordering of material (Ormerod, 1975); lack of horizontal alignment of mathematics skills and science curriculum (Crofts, 1971); and difficulty due to technical language (Lemke, 1990; Ramsey & Howe, 1969).

Many studies have suggested that the content of physical science is inappropriate for the mental age of the student. It seems that students may not be able to conceptually formulate abstract— theoretical problems (Flowers, 1967; Wells, 1971; Wright, 1974). Gagne and White (1978) argued that the syllabi should conform to the psychological ordering rather than that of adult logic. Gagne’s task analysis provides a scaffold to arrange content horizontally and vertically into a hierarchy of principles, concepts, and skills.

Additional studies indicated that problems in the physical sciences stem from students’ difficulty with mathematics. “Thus the difficulty with mathematics seems to act as an adverse factor in children’s attitude to the study of physical sciences” (Ormerod & Duckworth, 1975, p. 32). Although students perceive the sciences as difficult, gradations of difficulty exist among the disciplines of science.

**Attraction to Biology.** The profile of a student who selects biology is of one who tends to be more verbal, less mathematical, has the lowest level of school achievement among the students selecting science, is more socially concerned, and is more person-oriented (Stronk, 1974).

Research indicates that girls of all ability levels are more person-oriented than boys (Chodorow, 1976; Fox & Denham, 1974; Gilligan, 1982; Harding, 1986; Walberg, 1969). Smithers and Collings (1984) suggested that female scientists are more person-oriented than are males who select to enroll in the arts. Kelly (1988) noted that a girl’s choice to study biology may be a compromise with societal expectations. Some girls possess the ability to do well in the physical sciences, but may select courses with a more relevant social value. Haley-Oliphant (1985) reported that, in a British study, students identified physics, chemistry, and mathematics as masculine endeavors, whereas biology was considered masculine by boys, but perceived as neutral by girls.

The physical sciences involve working with and manipulating objects that are inanimate. The perceived essence of the physical sciences invoke concepts of: “aggressive competitive behavior, remoteness of concern with living things, emotionless employment of the scientific method, and the domination of nature” (Easlea, 1986, pp. 134–143).

In sum, it is the essence of physics that discourages feminine participation. Easlea (1986) stated:

> . . . there also surely exists the attraction of the masculine aura of physics: action in a world largely uncomplicated by women, supposedly hard, rigorous method, the aggressive attitude to nature, the strong connection with industry, above all, physics’ profound association with the military represented most dramatically by the creation of weapons of mass destruction together with their means of delivery. (p. 145)

It appears that activities of this nature are not congruent with feminine values. Feminine
values and interests are better aligned with helping and studying living things. Therefore, the study of biology and related fields become the science of choice for girls.

Gilligan’s (1982) interview of a young girl captures indirectly the girl’s disposition and subsequent attitude toward science. Gilligan asked the girl to describe herself as a person whom she would recognize. The young girl replied:

I want to be some kind of a scientist or something, and I want to do things, and I want to help people. . . . And I want to do something to help other people. . . . I think that everybody should try to help somebody else in some way, and the way I’m choosing is through science. (p. 34)

It is clear from the young girl’s statement that her pursuit of science is embedded in humanistic values. The description of her actions seem to bring her in touch with the world of which she is part. It is suggested by Chodorow (1976) that the feeling of connectedness to the world is ingrained through the socialization process.

**Hypotheses**

1. Males will select significantly more science courses than will females.
2. Males will select significantly more physical science courses than will females.
3. Females will select significantly more life science courses than will males.
4. Males will select significantly more technology courses than will females.
5. When given a choice, females will select significantly more science courses for males than they would for themselves.
6. When given a choice, males will select significantly fewer science courses for females than they would for themselves.

**METHOD**

**Subjects**

The sample selected for the study consisted of 427 students between the ages of 9 and 13. The students attended two elementary schools in a predominantly white, middle class, suburban community. The sample of 203 males and 224 females was selected from 28 classes, grades 4–6. All students in the study were exposed to a laboratory-based science program as part of their regular classroom experience.

**Instrument**

To determine what type of subjects are of interest to boys and girls, the *Course Selection Sheet (CSS)* was administered (see Appendixes A and B).

The CSS required the student to choose five courses he or she would like to study next year. The CSS included 24 possible choices, 12 science and 12 nonscience courses. The students were given a place on the CSS to include the name of any additional course not listed.

The second part of the course selection process was conducted by having the students select courses for members of the opposite gender. Students were requested to select courses that they thought a person other than they would enjoy. The format and course offerings were the same as the courses the students selected for themselves in part one.
Procedure

All of the CSSs were coded, and students were only requested to circle either that they were male or female. The students’ exposure to curricula used in their classrooms and their daily out-of-school experiences were considered as the treatment.

Prior to completing the CSS, the students were informed that they were taking part in an experiment to see what courses young people preferred. Students were instructed not to place any identifying marks on the answer sheets and to answer the questions as accurately as possible.

In all grades, the directions and questions for the CSS were read aloud while students read silently. Time was given between each question to allow students to select their answers. Students were instructed to raise their hands if they were having difficulty, required additional time, or needed any type of clarification.

The CSS had two sections to be completed. The directions for the sections were read aloud for all grades. Students were then given time for questions. The first section required students to select courses for themselves.

The second section required students to select courses for someone other than themselves. The students were instructed that they were going to make additional course selections for a member of the opposite gender. Emphasis was placed on the section of the directions that read, “if you are a girl, select subjects for a boy, and if you are a boy, select subjects for a girl.” Students were requested to select subjects that they thought the person would like. Students in all classes were done within 4 minutes.

Statistical Analysis

Four $t$-tests for independent samples and two paired $t$-tests for nonindependent samples were used in the analysis. The $t$-tests for independent samples analyzed differences between number of courses by gender. The paired $t$-tests analyzed significant differences between number of courses selected for oneself and courses selected for a member of the opposite gender.

The results of each $t$-test were evaluated in terms of effect size ($d$) or the degree to which a phenomenon exists. By converting mean differences into standardized scores, a comparative effect size could be determined (Cohen, 1965).

RESULTS

Hypothesis 1

The data revealed a significant difference by gender for the total number of science courses selected (Table 1). The mean number of science courses selected by males was 3.42 compared to a mean of 2.42 for females ($p \leq 0.000$). The effect size ($d = 0.70$) revealed that a large difference existed between the two means.

Hypothesis 2

The results of the data analysis indicated that there was a significant difference between boys and girls with respect to the type and number of physical science courses selected (Table 2). The mean number of physical science courses selected by males was 1.30 compared with 0.41 for females ($p \leq 0.000$). The effect size ($d = 1.25$) revealed that a large difference existed between the two means.
Hypothesis 3

The t-test of the number of life science courses found that there was a significant difference by gender (Table 3). The mean number of courses selected by females was 1.55, compared to 1.30 for males ($p \leq 0.01$). The effect size ($d = 0.22$) revealed a small difference between the means.

Hypothesis 4

The t-test of the number of technology courses found that there was a significant difference by gender (Table 4). The mean number of courses selected by males was 0.58, compared to 0.24 for males ($p \leq 0.000$). The effect size ($d = 0.60$) revealed a moderate difference between the means.

Hypothesis 5

The data indicate that, when given a choice, females selected significantly more science courses for males than they would for themselves (Table 5). The mean number of courses selected by females for themselves was 2.42, compared to 3.25 selected for males ($p \leq 0.000$). The effect size revealed a moderate difference of nearly 0.7 SD ($d = 0.69$).

Hypothesis 6

The data analysis reveals that, when given a choice, males selected significantly fewer science courses for females than they would for themselves (Table 6). The mean number of courses selected by males for females was 2.02, compared to 3.42 selected for males ($p \leq 0.000$). The effect size revealed a difference exceeding 1 SD ($d = 1.01$).

DISCUSSION

Interpretation and generalization of the findings are offered cautiously. A plethora of reasons has been forwarded to explain why girls do not participate equally with boys in science. If combined, these variables might account for the underachievement of females in science.

The findings of this study suggest the pervasiveness of the gender effect. Together both young boys and girls perceive science as a predominantly male activity. This finding parallels the work of Benbow and Minor (1986) with high school students, as well as recent national studies of college-bound seniors and graduate degree recipients (College-Bound Seniors, 1997; NCES, 1997a, 1997b). In each study, a polarization of the science courses occurred by gender. Life science courses are basically viewed more favorably by females, whereas physical science courses are more appealing to males.

Science Interest Continuum

The gender disparity regarding science interest appears to follow a continuum beginning with elementary students’ perceptions of gender-appropriate coursework and continuing through doctoral candidates’ selected fields of study. Data regarding 1997 college-bound seniors indicate that gender differences are prevalent in students’ plans regarding science course selection and intended majors (College-Bound Seniors, 1997). College students seeking advanced placement in physics (63% male/37% female), chemistry (54%/46%),
## Table 1

### Total Science Courses Selected by Gender

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number of Cases</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Standard Error</th>
<th>t-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>203</td>
<td>3.42</td>
<td>1.49</td>
<td>0.104</td>
<td>7.31a</td>
</tr>
<tr>
<td>Females</td>
<td>224</td>
<td>2.42</td>
<td>1.35</td>
<td>0.090</td>
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</tr>
</tbody>
</table>

* *p ≤ 0.000.*

## Table 2

### Physical Science Courses Selected by Gender

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number of Cases</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Standard Error</th>
<th>t-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>203</td>
<td>1.30</td>
<td>0.961</td>
<td>0.067</td>
<td>11.34a</td>
</tr>
<tr>
<td>Females</td>
<td>224</td>
<td>0.41</td>
<td>0.600</td>
<td>0.040</td>
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</tr>
</tbody>
</table>

* *p ≤ 0.000.*

## Table 3

### Life Science Courses Selected by Gender

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number of Cases</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Standard Error</th>
<th>t-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>203</td>
<td>1.30</td>
<td>1.12</td>
<td>0.079</td>
<td>−2.26a</td>
</tr>
<tr>
<td>Females</td>
<td>224</td>
<td>1.55</td>
<td>1.14</td>
<td>0.076</td>
<td></td>
</tr>
</tbody>
</table>

* *p ≤ 0.01.*

## Table 4

### Technology Courses Selected by Gender

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number of Cases</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Standard Error</th>
<th>t-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>203</td>
<td>0.58</td>
<td>0.65</td>
<td>0.046</td>
<td>5.98a</td>
</tr>
<tr>
<td>Females</td>
<td>224</td>
<td>0.24</td>
<td>0.49</td>
<td>0.033</td>
<td></td>
</tr>
</tbody>
</table>

* *p ≤ 0.000.*

## Table 5

### Differences in Number of Science Courses Selected Self versus Opposite Gender—Female Subjects

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number of Cases</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Standard Error</th>
<th>t-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>For self</td>
<td>224</td>
<td>2.42</td>
<td>1.35</td>
<td>0.090</td>
<td>−8.21a</td>
</tr>
<tr>
<td>For males</td>
<td>224</td>
<td>3.25</td>
<td>1.06</td>
<td>0.071</td>
<td></td>
</tr>
</tbody>
</table>

* *p ≤ 0.000.*

## Table 6

### Differences in Number of Science Courses Selected Self versus Opposite Gender—Male Subjects

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number of Cases</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Standard Error</th>
<th>t-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>For self</td>
<td>203</td>
<td>3.42</td>
<td>1.49</td>
<td>0.104</td>
<td>11.26a</td>
</tr>
<tr>
<td>For females</td>
<td>203</td>
<td>2.02</td>
<td>1.26</td>
<td>0.088</td>
<td></td>
</tr>
</tbody>
</table>

* *p ≤ 0.000.*
or computer science (71%/29%) are more likely to be male. Conversely, requests for advanced placement in biology are more often made by females (57% female/43% male). Gender profiles of students’ intended college majors document that males dominate the physical sciences (62% male/38% female) and computer sciences (76%/24%). In contrast, students planning to major in the biological sciences tend to be female (62% female/38% male). These college-level gender patterns are congruent with those found in the present study.

A review of the science courses selected for oneself indicate that four out of five life science courses favored female participation, whereas all physical science courses favored male participation. The technological courses were selected more frequently by males and were assigned more frequently to males by females.

It was apparent that life science courses were generally more popular. Three out of the five most popular courses were related to the life sciences. The frequencies of selected science courses were: life science, 607; physical science, 356; and technology, 171.

However, there were noticeable preferences of girls selecting the natural sciences, and the boys selecting the physical sciences. This finding is consistent with Benbow and Minor’s (1986) study of 1900 mathematically precocious youths. They found differences favoring gifted girls in biology, but favoring gifted boys in chemistry and physics. Similar findings in the research were also found by Baird, Lazarowitz, and Allman (1984) and Kahle, Parker, Rennie, and Riley (1993). In both studies, girls reported greater interest in sciences associated with plants and animals, and boys with matter and energy.

The five science subjects most preferred by the students in this study were marine biology, robotics, zoology, ecology, and chemistry. Care must be used in making assumptions about the numbers of students enrolled in course and the gender balance of each course. Popularity of the selected courses was polarized along a physical science axis for boys and life science axis for the girls.

The only course that would have a balanced enrollment based on the preferences of boys and girls was marine biology. Zoology and ecology were predominantly selected by girls, whereas chemistry and robotics were predominantly selected by boys. These findings raise some serious concerns for curriculum planners as to the status of the physical sciences in the elementary school. As an example, the enrollment ratio of boys to girls in the robotics class was 6:1. Further, courses in aviation/aerospace, chemistry, and astronomy were all predominantly selected by boys. The enrollment ratio was tenfold greater in favor of boys in aviation/aerospace.

The differences in course selection profiles at the elementary level resemble the percentages of males and females who received doctorates in physical and life sciences. In 1994, 6.1% of women pursuing doctoral studies earned degrees in physical sciences (NCES, 1997a, 1997b). During the same time period, more than twice as many men (13.7%) received doctorates in physical sciences. In contrast, a slightly higher percentage of females (11.1%) pursued doctoral degrees in life sciences as compared to males (10.1%).

The gender disparity is even greater at the master’s level where males (2.3%) receive degrees in physical sciences at a rate three times greater than that of females (0.8%). In life sciences, females (1.4%) and males (1.3%) earned master’s degrees at a similar rate.

Students’ Beliefs

Direct responses to the questionnaire on opposite gender course selections provided the data to assess differences in beliefs between boys and girls. Their opposite gender-based science course selections demonstrate strong stereotypical patterns. Course enrollment pro-
files reveal a reciprocal relationship between selected life science and physical science course by gender.

Among the boys, 69% selected no physical science courses for girls, whereas 59% of the girls selected two or more physical science courses for boys. Further, only 12% of the girls selected no physical science courses for boys, whereas only 5% of the boys selected two or more physical science courses for girls. Among the girls, only 2% selected no life science courses for boys, whereas 52% of the boys selected two or more life science courses for girls. Respectively, among the girls, 76% selected two or more life science courses for boys, whereas, among the boys, 16% selected no life science courses for girls.

When the total number of science courses selected for the opposite gender is included in the analysis, the pervasiveness of stereotypical gender-based patterns is more pronounced. Among the boys, when asked to select courses for young girls, 26% selected one science course compared to 5% of the girls who selected one science course for boys. The examination of four or more science courses selected revealed that 15% of the boys and 44% of the girls assigned science courses to the opposite gender.

These findings are consistent with the research claiming that there is a masculine image of science and science is perceived to be a male domain (Chambers, 1983; Johnson, 1984; Mason, 1986; Mead & Metraux, 1957; Steinkamp & Maehr, 1983; Vockell & Lobonc, 1981). The findings suggest that, in science, stereotypical patterns are in place by age 9. The students in the study appear to have constructed a reality in which particular science courses are better suited to an individual based on gender. What is intriguing is that course selection patterns appear to be complementary with little disagreement by gender. Thus, students’ construction of gender and science with respect to self and others should be carefully studied to avoid fostering stereotypic behaviors.

Informal Science Experience

Studies indicate that students whose at-home experiences parallel the school’s curriculum function productively in school activities (Majoribanks, 1991). Previous studies have suggested that experiential differences affect future learning outcomes in science (Farenga, 1995; Harlen, 1992; Kahle, 1990), and that the home is such a powerful influence that no change is possible without its informed support. The aggregated effect that experience provides can form the foundation to subsequent learning.

The importance of environmental influences outside of school has been the focus of numerous studies (Farenga, 1995; Kahle et al., 1993; Majoribanks, 1991; Mason & Kahle, 1989; Walberg, 1991). The aggregated effect that experience provides can form the foundation to subsequent learning. In response to the research, schools need to identify students’ levels of science-related experience and match instruction to reinforce meaningful learning.

Lamb (1989) and Walberg (1991) suggested that schools foster the continuance of educational inequalities by capitalizing on experiences present in certain segments of the population. Girls and boys come to school with vastly different science-related experiences. Current curriculum topics may promote unfair competition between genders, and young boys may have an unfair experiential advantage. Selected activities, if based on past experiences, may widen the gender gap in science achievement. Walberg (1991) suggested the “Matthew effect” to explain how past science-related achievement can increase future differences.

Inequalities may be related to differing family backgrounds, socioeconomic levels, and gender. Teachers who recognize the disparity in students’ informal science experience can employ constructivist strategies to maximize students’ prior knowledge and interests. Those teachers focus on breaking the mold in teaching to allow for individual differences.
By integrating students’ interests, prior knowledge, and learning activities, teachers can provide an environment in which knowledge can be constructed gradually over time.

 Teachers and administrators must clearly articulate the school curriculum to parents, thus providing the necessary information to coordinate classroom instruction and home activities. When viewed as a two-pronged approach to learning, informal science experiences and classroom science lessons can effectively form a synergistic relationship that may enhance students’ future interest and participation in the field of science. Parents can provide exposure to many informal science-related experiences through books, television programs, zoos, museums, hobbies, clubs, web sites, and family vacations. Collectively, these experiences may provide students with the necessary opportunities to build cognitive schemata needed to interpret and appreciate future learning in science.

 Research has shown that the experiential background of young boys provides them with an *a priori* sense of comfort, curiosity and competence in science — or “science sensibility” — which is not enjoyed by most young girls (Farenga & Joyce, 1997a, 1997b; Kahle et al., 1993; Wang et al., 1993).

**Curriculum Evaluation**

It is evident that interest in specific fields of science appears to form at a very early age (Baker, 1990; Bayer, 1997; Brandwein, 1951; Farenga, 1995; Roe, 1952; Zim, 1941). This was demonstrated in the manner in which children selected their courses.

The findings from the present study have strong implications for science education. The elementary syllabi of many states cover broad curriculum areas involving physical science, life science, and the interaction of the two in the study of ecosystems. Students who lack prior exposure to science experiences may be at risk in developing a positive interest toward learning science. This lack of exposure and limited science experiences may cause girls to perceive science as an inappropriate course of study.

Sociologically, stereotyping has been found to have adverse effects on females’ selection of science courses (Kahle, 1990; Kahle et al., 1993; Shymansky & Kyle, 1988). As a result, females have been found to perceive science as a male domain (Chambers, 1983; Mason, 1986; Mead & Metraux, 1957; Vockell & Lobonc, 1981).

The results of this study suggest that the perception of science as an appropriate or inappropriate field of study is developed at a younger age than 9. The study reveals a strong gender effect pointing toward stereotypic perceptions of selected science courses. The students’ perceptions of science are seen years prior to the actual encounter with the science courses listed on the course selection menu. These findings suggest that declining enrollments in future science courses may be in progress well before high school or college. Young boys and girls have already formed their opinions as to the enjoyment each would find in studying such courses. Equally distressing is that both boys and girls in the study perceive science as more appropriate for boys. It appears that both genders support the stereotype that science is a male domain.

The implication is that, as students progress through the grades, their peers may reinforce gender-role-stereotyped behaviors and preferences. Previous research indicates that, as students continue through school, their stereotypic perceptions of science will increase (Kelly, 1988; Parker, Rennie, & Harding, 1995). The possibility of increased stereotypic influences that can cause negative perceptions of science should create an urgency for the development of science intervention programs prior to middle school.

It is necessary to interest girls in the sciences at an early age. The perception of young girls taking science must be changed, not only by young boys, but by girls themselves.
APPENDIX A

Course Selection Survey (Self)

The purpose of this questionnaire is to help people determine what type of subjects interest young boys and girls. The questionnaire is not a test and there are no wrong or right answers.

Pretend that you can select subjects to study. After reading the list, mark your choices by placing a check mark in the space below. If you would like to suggest additional courses write them in the space below.

________ Botany (the study of Plants)    ________ Chemistry

________ Painting                    ________ Architecture

________ Astronomy (stars & planets) ________ Foreign Language

________ Zoology (study of animals)   ________ Law

________ Sculpture (molding clay)    ________ Aviation/Aerospace

________ Marine Biology (Study of ocean life) ________ Tropical Rain Forest

________ Debating Class               ________ Instrumental Music

________ Geology (study of the earth) ________ Drama Class

________ Computer Math & Engineering ________ Literature

________ Paleontology (dinosaurs/fossils) ________ Writer’s Workshop

________ Computer Graphics           ________ Robotics

________ The Stock Market Game (Business) ________ Ancient Civilization

List additional subjects that you would like to study on the lines below.

____________________________________________________________________________________
____________________________________________________________________________________
____________________________________________________________________________________

APPENDIX B

Course Selection Survey (Opposite)

Pretend that you are asked to select subjects for someone else to study. If you are a girl, select subjects for a boy (a brother, cousin, friend) and if you are a boy, select subjects for a girl (a sister, cousin, friend). Please do your best to select the courses that you think the person would like. After reading the list, mark your choices by placing a check mark in the space below. If you would like to suggest additional courses, write them in the space below.

________ Botany (the study of Plants)    ________ Chemistry

________ Painting                    ________ Architecture

________ Astronomy (stars & planets) ________ Foreign Language

________ Zoology (study of animals)   ________ Law

________ Sculpture (molding clay)    ________ Aviation/Aerospace
REFERENCES


MacCurdy, R. D. (1954). Characteristics of superior students and some factors that were found in their background. Unpublished Ed.D. dissertation. Boston University, Boston, MA.


