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High school student reluctance to major in computer science

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HIGH SCHOOL STUDENT RELUCTANCE TO
MAJOR IN COMPUTER SCIENCE

by

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ABSTRACT

HIGH SCHOOL STUDENT RELUCTANCE TO MAJOR IN COMPUTER SCIENCE

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To understand why American students were exhibiting a reluctance to choose Computer Science as a major in college, the researcher conducted a survey study of students (n=4,127) taking computer courses, in 176 high schools in New York State. One class from each school participated in the study, with an average of 30 students per class. A Likert-type researcher-created instrument was administered to the students that contained 34 items constituting five factors measuring students' attitudes towards computers and computing: (a) enthusiasm towards computing, (b) perceptions of computing ability, (c) apprehension about majoring in computer science, (d) perceptions of the degree of positive instructional influence towards computing received, and (e) perceptions of career and employment opportunities in computing. The major research questions sought to learn the relationship between and among the five factors. In addition, the study sought to determine the effect of various demographic and background characteristics of the students on the five major factors. To answer the questions, the five computer subscales were analyzed using the Pearson product-moment correlation coefficient (Pearson

"r") and multiple regression, and the relationship between the demographic variables and the subscales were analyzed using the Pearson r, t-test for means of independent samples, and analysis of variance (ANOVA).

The results of the study showed that the five subscales were significantly related to one another (p<.001), and that a significant amount of the explained variance, ranging from 19 to 65 percent, was explained for each subscale by the remaining four subscales. The study also found that positive attitudes toward computing were most characteristic of students who were male, attending public schools, had a computer at home, were planning to attend a 4-year college or technical school, concentrating in more mathematically oriented majors where programming was stressed, were in their sophomore year, and lives in residential areas with a population size between 2,501 and 10,000 people.

Recommendations to increase the number of students who will choose to major in Computer Science in college include the following: encouraging high school teachers to stimulate interest in students towards computers, and certifying teachers who teach computer science courses.

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INTRODUCTION

In today's rapidly changing, highly technological world, the United States must have a steady supply of computer professionals, academically trained in computer science, to remain technologically competitive. During the 1970's until around 1983, enrollment was high and steadily increasing in computer science departments around the country, and an increasing percentage of incoming freshmen elected to major in computer science (Horn and Carroll, 1989; Jones et al., 1985). Beginning about 1983-84, however, the percentage of freshmen majoring in computer science began to drop rather precipitously (Archer, Katter, and Price, 1993; Finn, 1989). The results of a 1985 Cooperative Institutional Research Program survey (Computer Careers, 1985), based on a large sample of 192,435 entering freshman from 365 two- and four-year colleges, indicated that only 4.4 percent of fall 1985 freshmen aspired to careers as computer programmers or computer analysts, compared to 6.1 percent in 1984 and 8.8 percent in 1983.

The number of bachelor's degrees awarded in computer science peaked in 1986, with 42,195 degrees conferred (Frenkel, 1990). Two years later in 1988, only 34,896 degrees were awarded, which represented a decline of almost

18 percent in just two years; and in 1990, 21,126 bachelor's degrees in computer science were awarded (Frenkel, 1990). Thus, there was a decrease in bachelor's degrees awarded in computer science of approximately 50 percent between 1986 and 1990.

This statistical picture was supported by the Association for Computing Machinery (ACM). It reported in the "1988 Snowbird Report: A Discipline Matures" (Denning, 1989) that since the mid-1980s there had been a steady decline of incoming freshmen who elected to major in computer science; and that between the mid-1980s and 1988 most computer science programs experienced a 30 to 50 percent decrease in enrollment.

The statistics had made it clear that the allure of computer science as a major had, for some reason, greatly weakened. This signalled a threat to our labor pool of computer scientists (Finn, 1989). The U.S. Department of Labor, in a 1989 study, reported that there was then a persistent shortage of personnel trained in computer science, and predicted that the number of jobs which would require training in computer science would increase during the 1990s and into the next century. This has, in fact, proved to be the case (Fowler, 1993; Lidtke & Moursund, 1993), and the problem of the decline of computer science majors is expected to be compounded in the near future.

According to Blum (1988), inadequate salaries for college faculty could not have been the cause of the decline in computer science majors during the 1980s. Blum reported that the annual survey of college faculty pay showed that the salaries in computer science continued to be higher-than-average--not lower--than for most other disciplines, including such "hard-to hire" disciplines as engineering, accounting, and physics. Vetter reported that the decline of computer science majors was, in fact, to be expected. The major reason was changing demographics, such as fewer college students, but the actual decline had been much more dramatic than expected (Frenkel, 1990). The reasoning behind Vetter's argument is that, traditionally, computer science majors have been white males. Demographic trends, however, suggest a significant decline in the number of white males entering college (Pearl et al., 1990).

The percentage of women electing to major in computer science also has been declining at a rate faster than that for males (Alspach, 1988; Kay et al., 1989; Durndell, 1990; Durndell et al., 1990; Pearl et al., 1990; Pilley, 1985). From 1987 to 1989, for example, there was a 25 percent decline in the number of bachelor's degrees in computer science awarded to females, compared to a 13 percent decline for males during the same period (Pearl, 1990). Since women have been traditionally underrepresented in computer science, this decline in enrollment and professional certification could represent a serious concern for the

United States and the profession of computer science (Frenkel, 1990).

It is interesting to note that the decline of computer science majors has occurred simultaneously with the rapid spread of microcomputers in the public school systems. It appears that exposure to and familiarity with computers far from guarantees interest in or involvement with the technology, unless other factors are also present. According to Lidtke and Moursund (1993), in 1982 there was about one computer per 125 students in K-12 education, "and the ratio now [in 1993] is nearly ten times that number" (1993, 84).

The "slack" in computer science majors has been taken up somewhat of late by the ongoing popularity of computer science among foreign students, especially Asians, studying in the United States, but this increase will not be sufficient to accommodate the projected need for computer professionals (Finn, 1989).

The decline of computer majors that began in the early 1980s did not go without efforts to rectify the problem. For example, in one attempt to combat the early signs of declining enrollment in computer science courses, in 1984, the ACM Educational Board and the IEEE Computer Society Activities Board jointly proposed two curriculums: The first was a course of study in computing for high school students and the second was a course of study leading to high school teacher certification in computer science (Butcher, 1985). Unfortunately, there was little support for implementing either proposal. Since then, there have been many proposals (ACMEMBERNET, 1991; ACM Model, 1993; Babcock, 1990; Kolatis, 1988) for a curriculum change in computer science, but none has become a standard or solved the problem of declining enrollment.

At the present time, many states, including New York, do not have a separate certification for high school Computer Education teachers. Some have even described the situation today in Computer Education as "chaotic." Klein (Frenkel, 1990), while working under the auspices of the Board of Cooperative Educational Services, which is funded by the New York State Department of Education, wrote an article entitled "Female Students' Underachievement in Computer Science," in which she decried the state of computer science education throughout precollege levels. Many schools were described as having no formal carry-over plan for computer education from one grade level to the next, and there were neither goals nor minimum standards to be covered (Frenkel, 1990, 39).

Since there are no certification standards for Computer Education teachers, there is a great variation in instructional backgrounds and levels of competence among such instructors. Denning (1989) stated in his report, "Computing as a Discipline," that the exposure most students receive in high school to computing is poor and inadequate. The poor quality of instruction in computer courses could be negatively affecting students and contributing to the decline in enrollment. This findings from this study could help us better understand the reasons for this decline.

Purpose of the Study

The purpose of this study was to determine why high school students exhibit a reluctance to major in computer science. The study focused on variables that had been ignored or sparsely investigated in the literature. Answers to the following research questions were sought within the study.

1. What factors are related to students' enthusiasm towards computing?

2. What factors are related to students' perceptions of their computing ability?

3. What factors are related to students' apprehension about majoring in computer science?

4. What factors are related to students' perceptions of the degree of positive instructional influence towards computing they have received?

5. What factors are related to students' perceptions of career and employment opportunities in computing?

Based upon the findings from the data analysis, strategies that educational administrators and classroom instructors could employ to encourage students to major in computer science will be discussed.

Procedures

The researcher designed a questionnaire (see Appendix A) to investigate the reasons why high school students were exhibiting reluctance to major in Computer Science. The sample analyzed for the study consisted of 4,127 high school students taking computer courses, including sophomores, juniors, and seniors, in 143 public and 33 parochial high schools in New York State. One class from each school participated in the study, with an average of about 30 students per class. Those pupils who completed the survey instrument did so because their instructors agreed to have their classes participate in the investigation. The sample was believed to have been representative of the total population of students in computer courses in public and parochial high schools in New York State. The investigator therefore generalized findings from the study to all students in New York State with characteristics similar to those studied.

The survey instrument employed in the study was modeled on the Fennema-Sherman (1986) questionnaire (in the area of mathematics) and reflected important issues that had been sparsely studied, based on a review of the literature. Care was taken to conform to established procedures for creating a survey instrument, with respect to such things as phrasing of questions, appropriateness of wording for intended subjects, clarity of questionnaire items, structuring and scoring a Likert-type scale, and pretesting the survey instrument (Fowler, 1984; Hornville & Jowell, 1978; Moser & Kalton, 1972).

The major aspect of the research instrument employed in the study consisted of 34 items regarding attitudes about computing. For each item, the subject was asked to indicate the extent of his or her agreement or disagreement on a 5-point Likert-type scale ranging from "Strongly agree" to "Strongly disagree." The highest score a subject could have attained on the instrument was 170 (34 X 5) and the lowest score a subject could have attained was 34 (34 X 1). The higher the overall score for each subject, the more the interest in or attraction to computing.

The 34 items on the survey instrument composed five separate subscales, as follows: (a) enthusiasm about computing, (b) perception of computing ability, (c) teacher influence on computing, (d) apprehension about computers, and (e) perception of career opportunities in computer science. A Cronbach alpha analysis indicated that the separate items in each subscale could be combined into a single subscale score for purposes of data analysis, thus resulting in five separate subscale scores for each subject in the study, as well as a total instrument score.

The research instrument also asked about background information on the subjects, including their sex, age, city of residence, type of school attended, year in school, what kind of education, if any, they intended to pursue after high school, what their intended major was if they planned on attending college, and whether or not they had a computer at home. Before distributing the questionnaires to the research participants, a preliminary trial was done on a small sample to make sure the wording and intentions of the questions were clearly understood. The pretest revealed that only one item needed minor modification in order for the questionnaire to be totally clear and understood as intended.

The data collection procedure began during November of 1992 when the researcher distributed letters and flyers (see Appendix B) to public and parochial high school teachers attending a computer conference at the Neville Hotel in Ellenville, New York. These materials also were distributed to high school teachers attending professional meetings of Nassau County Mathematics Teachers Association and Suffolk County Mathematics Teachers Association. In addition, the researcher sent a letter and self-addressed stamped envelope to 902 chairpersons of Mathematics Departments in the New York State public and parochial high schools, asking for their cooperation in the study.

Chairpersons and computer instructors who volunteered them for their cooperation (see Appendix C) along with questionnaires for each student in their class, and a self-addressed stamped envelope. A follow-up letter to those who did not initially agree to participate resulted in 12 additional positive responses. Each participating teacher then had the students in his or her computer class complete the questionnaires and return them during that class session. The teachers then returned the completed questionnaires to the investigator. The data collection process was completed during January and February of 1993.

Among the 190 schools that were sent questionnaires by the investigator, 176 schools returned the completed questionnaires, resulting in a total of 4,350 questionnaires received. They were reviewed for usability, and 223 were determined to be unusable, thus making the final total of usable questionnaires analyzed for the study 4,127.

The data on the questionnaires were coded and analyzed by computer using SPSS. To answer the major research questions of the study, the five computer subscales were analyzed in relation to each other using the Pearson product-moment correlation coefficient (Pearson "r") and multiple regression, and the relationship between the demographic variables and the subscales were analyzed using, as appropriate, the Pearson r, t-test for means of independent samples, and analysis of variance (ANOVA). The characteristics of the research participants were described characteristics of the research participants were described using the arithmetic mean, media, mode, standard deviation, range, percentages, and frequencies.

Limitations

The study was limited in several ways. First, the research participants were drawn only from computer classes. Second, the teachers who distributed the research instrument to their students had to agree to participate in the study; thus they did not constitute a random sample. Third, the research participants were drawn from public and parochial schools in only one state, New York.

Educational Significance

The steadily increasing importance of computers throughout America and the world necessitates that we identify factors dissuading students from majoring in Computer Science. To encourage public school students to overcome their resistance to computers and computing, and to encourage them to choose Computer Science as a major in college, it is essential to first understand the sources of their reluctance. By contributing to such understanding, this study hopefully will facilitate the development of pertinent educational strategies that help alleviate these obstacles and, thereby, substantially increase the number of students who major in Computer Science.

II

REVIEW OF THE RELATED LITERATURE

In this section, the literature pertinent to understanding and explaining the history of computer science in public and postsecondary schools is reviewed. Included in this review are works related to (a) enrollment patterns, (b) gender differences in relationship to the computer and computer science, (c) cognitive and experiential factors affecting students' choice of computer science as a college major, (d) teacher factors, especially attitudes towards the computer, that affect students' interest in and commitment to computer science, and (e) the mathematical and technical orientation of computer science courses as a possible deterrent to computer enrollment. The final section of the literature review compares other investigators' recommendations for curriculum change in computer science.

Enrollment Patterns

Enrollment in computer science courses in colleges and the choice of computer science as a major have greatly declined throughout the 1980s and into the present time (Archer, Katter, and Price, 1993; Finn, 1989). In the 1970s and the beginning of the 1980s, the popularity of computer science among students steadily increased. According to

Horn and Carroll (1989), data from a National Longitudinal Study of 1972 and 1980 cohorts of high school seniors indicated that enrollment in computer science programs experienced an overall increase in the proportion of students earning credits from 1972 to 1980, along with enrollment in some other programs: management, business support, marketing and distribution, and communications.

Using the above data set, Jones et al. (1985) reported that college enrollments in computer science, as well as in engineering and business, increased between 1972 and the early 1980s, while enrollments declined in biological and social sciences, humanities and education. Jones also reported that those who declared majors in science and engineering generally had above-average high school achievement records.

An indication of the popularity of computer science as a major in the early 1980s is that computer science was viewed by higher educational institutions as an attractive major for boosting student enrollment. For example, New England College, when faced with an enrollment decline of 36 percent between 1980-83, decided, among other remedies, to offer a major in computer science (Magarrell, 1983).

Beginning around 1983, however, interest in computer science among students began to rapidly and significantly decrease. Archer, Katter, and Price (1993), for example, reported survey data from the University of California at

Los Angeles which showed that freshmen enrollment in computer science programs steadily declined from 8.8 percent of the class in 1982 to 2.7 percent in 1987, and that the number of students who entered the program that went on to graduate also decreased.

The authors also reported data compiled by the National Center for Education Statistics that indicated between 1985 and 1990 the number of baccalaureate degrees in computer and information sciences dropped from nearly 41,000 to 27,434--a decline of over 33 percent (1993, 16).

The results of a 1985 Cooperative Institutional Research Program survey (Computer Careers, 1985), based on a large sample of 192,435 entering college freshman from 365 two- and four-year institutions, indicated that the proportion of new freshmen planning to major in computer science and pursue computing careers dropped 50 percent in two years, since 1983.

In addition, the 1987 Freshman Survey Report (Interest in Teaching, 1987), the 22nd annual survey of entering freshmen in the United States, showed that freshman interest in computing, for both sexes, had fallen off by more than two-thirds since 1982, along with a fall in engineering (of about 25 percent), among other areas. In contrast, business continued to be the most preferred career among freshmen, and interest in teaching careers had increased by about two-thirds since 1982, according to the survey.

While there has been a general and precipitous drop of declared computer majors, beginning around 1983, this trend was not true for foreign students studying in the United States, especially Asians. A survey study by Duggan and Wollitzer (1983), of international student exchange programs in the Bay Area of California found that foreign students made up 27 percent (14,410) of California's total student enrollment in universities, and that among them, computer science attracted the largest numbers of foreign students, along with business and engineering. The popularity of computer science among Asians also was supported by Peng (1985), based on data from a National Longitudinal Study of the 1980 cohort of graduating high school seniors. The data showed that 86 percent of Asian-Americans entered some kind of postsecondary program by February 1982 (with 51% going to four year colleges), and that popular fields of study for the students included computer science (7%), although enrollment in that major was lower than for some others, including business management (20%), engineering (15%), and life sciences (8%). Thus, the defection from computer science as a major in the early 1980s, when the downward trend began, was primarily among white students, especially males. Historically, females have been underrepresented in the field of computer science.

This general trend was supported by Finn's (1989) data. They indicated that while the number of U. S. citizens earning doctorates in science and engineering fields in 1987 was 9,724--about the same yearly number since 1976--this was not enough to replace scientists and engineers who had left their fields due to death or retirement, but that the slack has been somewhat taken up by foreign students who have received doctorates and remained in the U. S. Despite this, Finn claimed, there remained general persistent shortages of personnel in computer science, among other scientific and technical fields. Given this situation, Finn suggested that Federal intervention in the science and engineering job market should be made, and suggested the following ways: fellowships, traineeships, assistantships, loans, precollege programs, and tax incentives, among others.

Gender, Computers, and Computer Science

Many studies have been conducted on the relationship between gender and computers that primarily have attempted to explain the underrepresentation of women in computer science (Alspach, 1988; Kay et al., 1989; Durndell, 1990; Durndell et al., 1990; Pearl et al., 1990; Pilley, 1985). Miura and Hess (1983) presented results on three studies done in the early 1980s that supported then-anecdotal reports of sex differences in computer access, interest, and use in the school-aged population. The first study, on 87 middle and upper income students in grades 5 through 8, showed that more boys than girls owned home microcomputers.

The second study, in which questionnaires were analyzed for 23 directors of summer camps and classes that offered training in programming for microcomputers, who reported on 5,533 students, indicated that enrollment in the camps and classes showed a pattern of three- to-one in favor of boys. In addition, it was found that the ratio of boys to girls increased with level of course difficulty. The third study reported on by Miura and Hess involved 157 middle school students from three school districts in lower, middle, and upper income areas, who were asked to rate a list of 75 software titles for perceived user interest. The results showed that a significantly greater number of the titles, which were randomly selected from a list developed for three major microcomputer manufacturers, were perceived as primarily suited for male audiences.

A study by Alspach (1988) investigated enrollment in two computer classes--an introduction to computers (n=388) and a programming course (n=127)--at a public high school in northern Indiana over a period of four years to see if there was inequity involving, among other things, males and females. Analysis of the data showed, among other things, that each year there were more males than females were in the programming course, and that some inequities in enrollment were found in gender, year in school, and mathematics. Determination of whether these differences posed a problem were, however, according to the author, beyond the scope of their study.

Kwan et al. (1985) conducted a study on students' evaluations of societal influences on their participation in computing. The investigators found gender differences toward three factors--computing as male dominated, the influence of significant others, and negative attitudes associated with computing and career aspirations--and that the students, especially females, were rejecting computing stereotypes. According to Kay et al. (1989) and Durndell (1990) women are disadvantaged in computing courses because of the apparent technology-centeredness of computing, the emphasis given to mathematics, and the undervaluing of broadly-based problem-solving communication skills.

Pearl et al. (1990) suggested that young women have lacked female mentors and role models in the field of computer science, and that this has played a part in their underrepresentation as majors in this field. As the authors explained,

> While young computer scientists can benefit from mentors of either gender, it is desirable for women to be exposed to female role models. A role model can serve as evidence that a successful career in computer science is not only a possibility, but a normal and unremarkable option for women. The existence of role models <u>does</u> matter, and it matters to women at all stages of their careers (1990, 51).

The above findings also have been supported by studies in the United Kingdom (Durndell et al., 1990; Pilley, 1985;

Sutton, 1991). As regards the issue of women lacking role models in the field of computing, Sutton (1991) reported in a review article covering the past decade that in textbooks for computer studies in Britain and Australia the majority of the pictures showed "males making decisions, supervising, controlling robots, and fixing or using computers whereas the females were portrayed passively--for example, handling input and output" (1991, 484). Sutton explained that:

> This research, while simple in nature, does portray the degree of stereotyping of the computer industry in the early and middle 1980s. The new "intelligent" machines were obviously the domain of White males (1991, 484).

Pilley (1985) found, in a study in Great Britain and Scotland, that women were significantly underrepresented in learning about and working with computers. Another study in the United Kingdom by Durndell et al. (1990), which surveyed and interviewed 387 college freshman regarding course selection, especially the low enrollment of females in computing areas, generally found that computing students were motivated by extrinsic awards, and that stereotypes, intimidation fears, lack of role models, and teacher guidance all influenced women who avoided computing and other technological subjects.

Factors Affecting Enrollment in Computer Science Courses

While the above section focused specifically on gender differences in computer enrollment, and some specific factors, such as lack of role models, negatively affecting female enrollment, this section focuses on more general factors that influence both male and female students' interest in and involvement with computer science.

Students' Attitudes and Perceptions

Campbell and Perry (1988) conducted a study of the factors affecting the motivation of high school students to learn to use computers, using the Computer Attitude Scale and Computer Attribution Scale. The participants were 160 students (89 females and 71 males) enrolled in a large urban school, of various ethnic groups: White, Black, Hispanic, Asian, and American Indian. Most of the students had prior computer coursework and other computer-related experience. Based on path analyses of the data, the researchers' major conclusions were that, in order for student motivation to be high, they should be exposed to computers in a high success environment, and that they should perceive that working with computers is enjoyable as well as useful.

Koohang (1986) studied 67 high school students (29 females and 38 males) to explore the levels of anxiety over computer use based on sex, grade level, and prior computer experience. Data were collected on a computer anxiety subscale of 10 items from an instrument created by Loyd and Gressard (1984), which presented positively- and negatively-worded statements about reactions to computer use. The students were asked to respond to the items on a four-category scale ranging from "strongly agree" to "strongly disagree." The results indicated that both computer experience and gender, but not grade level, were related to computer anxiety. Males exhibited less anxiety than females and students with more computer experience had lower anxiety than students with less computer experience.

In another study by Koohang (1989) on the relationship between attitudes towards computers and their acceptance and use, the researcher administered the Computer Attitude Scale (CAS) to 81 undergraduate college students who were enrolled in various computer-based education courses, e.g., introduction to computer based education and instructional applications of microcomputers. The CAS consists of 30 items that are divided into three 10-item subscales that measure, respectively, computer anxiety, computer confidence, and computer liking, with the score determined by a four-level Likert-type scale ranging from "strongly agree" to "strongly disagree."

Among the findings from the study were that subjects with more computer experience expressed more positive attitudes toward computers, and subjects with more knowledge of computer programming had less anxiety about computers and more confidence in their ability to use computers. From the study, Koohang offered the following recommendations that have implications for curriculum development.

> Based on the findings, the researcher recommends that (a) there is no doubt that computer experience is needed to promote positive attitudes; there is a need to provide all students from grades K through 12 with computers, (b) there is a need for teacher training workshops in computers which must be provided in depth, not only as options but also as requirements so that teachers can become educated in how to introduce and implement the use of computers in the classroom, and (c) no further study is needed to find out whether computer experience promotes more positive attitudes because this research supported all previous findings that computer experience does promote positive attitudes (1989, 148).

Campbell (1990) studied 195 college freshman and sophomore students (102 females and 93 males) enrolled at a large university in the midwestern United States. The subjects completed instruments that measured computer attitudes and attributions, using the Computer Attitude Scale and the Computer Attribution Scale. The investigator also collected demographic data on the subjects. The results showed that the following variables in combination were significant predictors of enrollment in computer courses: perceptions of the usefulness of computers in future educational and career plans, self-evaluation of one's own computer proficiency, and the stereotyped view of computers as a male domain.

A study by Kay (1990) sought to determine the factors that influence commitment to use of computers among 383 education students that has implications for the current study, since commitment would appear to be a necessary prerequisite to choosing and staying with a major in college, and, ultimately, choosing a career. Specifically, Kay examined the extent to which attitudes towards computers, as well as computer literacy, computer locus of control, and gender, could be used to predict commitment to the use of computers, which was divided into three subscales: interest, promotion, and actual use.

Based on analysis of the data collected on a battery of questionnaires, the investigator found that positive cognitive attitude, awareness of computers, and application software ability were the best predictors of commitment to the use of computers. "Presumably enthusiasm for the use of computers is important for predicting commitment, but positive cognitions account for considerably more variance" (1990, 306). This conclusion has direct relevance for the current study, which examines the effect of enthusiasm on intention to major in computer science, among other variables.

Kay also found that less effective, though still significant, predictors of commitment to computer use included affective attitude, internal locus of control, and gender, with males showing more commitment than females.

Graham and Cockriel (1990) conducted a study to evaluate the perceived utility of college majors, including the effects of gender, on 53,372 college alumni. The American College Testing (ACT) Alumni Survey was used to collect data between January 1980 and May 1988 at 172 colleges in 42 states, involving 16 major area categories. Among the findings were that the major field of study had a clear impact on the perceived utility of the major, the congruency or "job fit," and the overall assessment of academic career preparation. It was also found that females generally reported a stronger relationship between their careers and academic majors, across a diverse number of academic major fields. Alumni in computer science (along with business, engineering, and education) had consistently higher ratings than majors in other fields in perceived utility of their majors, the academic major and career congruency, and the quality of their educational preparation.

A study by Durndell, Macleod, and Siann (1987) on 982 students at an institution of higher education in Britain sought to determine the extent to which an individual is likely to make use of computers and intelligent technologies (IT) based on his or her attitude toward computers, attitude to technology in general, experience with computers, background discipline, and gender. The subjects were selected for the study if they fell into one of four discipline ares: COMP (computer/electronic studies), SCIENCE (science courses), HI-IT (non-science courses making heavy use of IT) and LOW-IT (non-science courses making relatively low use of IT). Based on analysis of the data, the investigators found that on entry to college, students in the COMP category had more experience with computers than students in other categories, and that across all categories, except HI-IT, males had more experience with computers on entry than females. Students in the COMP category also had significantly more knowledge about computers than other students, and across all categories males had more knowledge than females on entry. In addition, there were no consistent gender differences found on the attitude variables.

A study by Munger and Loyd (1989) of 60 high school students attempted to determine the relationship between performance in mathematics and the students' attitudes toward computers and calculators ("technology"). The investigators also were interested in learning if gender affected this relationship. To collect their data, the investigators used the Computer Attitude Scale (CAS), a practice form of the General Educational Development test to measure mathematics performance, and a four-item instrument prepared by the investigators to measure attitudes towards calculators. Analysis of the data showed that, in general students of both sexes with more positive attitudes towards computers and calculators performed better than students with more negative attitudes. The authors added,

> Contrary to findings of earlier studies which have reported sex-related differences in mathematics performance favoring males, no gender-related differences were demonstrated in this study (1989, 175).

Effects of Teachers' Attitudes Towards Computers on Students

A study by Dick and Rallis (1991) found that teachers, along with parents and other factors, can have an extremely important effect on high school students' career choices. The data for their study were collected in the spring of 1986, by surveying 2,213 seniors (1,089 men and 1,124 women) from a stratified random sample of public high schools in Rhode Island, composing 25 percent of all public high schools in the state and representing both large and small communities with varying socioeconomic levels. Although computer science was not specifically cited in the study, the fields of science and engineering were a major focus of the investigation.

Among the findings from the study were that, for students of both sexes, teachers, as mentioned, may play a particularly important role in influencing career choice, as well as parents, and that both teachers and parents were perceived to be influences on career choices more often for students who chose careers in engineering and science than for students who did not choose such careers. The researchers also found from their study that pay was more important for men than women in influencing career choice, that genuine interest in the career was a more important factor for women not choosing careers in science and engineering than for men in influencing career choice, and that gender differences did not appear among students with extremely strong mathematics and science coursework background, even though there was a great disparity in the proportion of men to women planning careers in engineering or science. A major conclusion the authors drew from their study was that, for both men and women, those who chose engineering or science careers had specific encouragement to do so, especially from parents and teachers.

Given the influence of teachers on students' career choice, it is logical to assume that students will resist majoring in computer science if, among other things, their teachers exhibit fear or "phobia" about the computer and the students thus have negative classroom experiences with their instructors. In short, a source of a negative instructional experience for students can be the instructor's own fear of the computer, which is then transferred to the students. To the extent that this line of reasoning is valid, it suggests that curriculum design in the future do all it can to reduce computer phobia in the schools, if it is desired that more high school students choose computer science as a major in college.

When the computer was first introduced into the public school system, Smith reported "the culture of computing to be a negative one for novices" (1987, p. 480). Many studies have shown, in fact, that public school teachers in the 1980s generally have had negative attitudes towards the existence of computers in the school environment (Lawton, &

Gerschner, 1982; Loyd, & Loyd, 1985; Manarino-Lattett, & Cotton, 1985; Smith, 1987; Stimmel,Connor, McCaskill, & Durrett, 1981).

Lawton and Gerschner (1982) reviewed a variety of articles written between 1976 and 1982 on attitudes of both teachers and students towards computers in schools. Relevant to this study was their point that "computerphobia" affected attitudes, and that this phobia could be reduced under certain conditions, leading to more favorable attitudes towards the computer. Citing Jay (1981), the authors defined computerphobia as: "(a) a resistance to talking about computers or even thinking about computers, (b) fear or anxiety towards computers, and (c) hostile or aggressive thoughts about computers" (Lawton, & Gerschner, 1982, p. 52). One cause of computerphobia was purported to be a failure of the computerphobic person to "keep up" with the technology; a second cause was stated as a failure of the institution (i.e., the school) to take the teacher's job into consideration when planning; and a third cause of computerphobia was cited as a failure of the school to provide incentives for the teacher (or student) to keep up. One would therefore predict that, as these conditions were satisfied, in whole or in part, computerphobia would decrease, to a greater or lesser degree.

Lawton and Gerschner concluded that there was very little agreement on attitudes towards computerized instruction (1982, p. 54). Ultimately citing a low level of computer literacy as the major deterrent to positive attitudes, the authors summarized several suggestions offered to raise the level of computer literacy. Staff development, more planning, and being aware of the computer's impact on people were suggested to make teachers more receptive to computers and encourage the growth of computer literacy (1982, p. 54).

Williams (1983) studied 149 elementary school teachers in a Stockton, Massachusetts school district. Data were collected using a survey developed by the researcher on the following categories of information: (a) years of teaching experience; (b) level of mathematics training, (c) previous computer training and experience; (d) attitude towards computers and their use in education; (e) commitment to learning about computers; and (f) perceived importance of potential computer literacy topics.

Two hypotheses were tested, namely, that the number of college mathematics courses taken would be related to attitudes towards computers, and that years of teaching experience would be correlated with attitudes towards computers. Statistical analysis using Spearman's rho revealed a significant positive correlation between attitude towards computers and number of college mathematics courses taken, and a significant negative correlation between attitude towards computers and number of years of teaching.

In other words, the more mathematics courses the teachers took in college, the more positive was their attitude towards computers, and the more years the teachers had taught, the less positive was their attitude toward computers.

According to Valesky (1984), in the early 1980's, many educators were urging the implementation of computer-based instruction to meet the challenge of the "Information Age." Valesky felt that to implement computer-based instruction successfully, the school administrators should know (a) the characteristics of teachers who were more likely to have positive attitudes concerning the implementation of microcomputers in the classroom, and (b) the most appropriate methods of microcomputer implementation. He attempted to provide such information through his study of teachers in 167 private, U.S.-assisted, overseas schools. A total of 385 teachers responded to a survey instrument that requested the following: (a) demographic data, (b) opinions concerning the way in which microcomputers should be implemented in the classroom, and (c) attitudes toward computers. The results of the study indicated that mathematics and science teachers had more positive attitudes toward the implementation of microcomputers than did all other teachers, and that teachers who attended one or more microcomputer in-service programs in the last three years had more positive attitudes than others. Valesky also reported that teacher attitudes toward implementation of microcomputers were not affected by: (a) grade level taught, (b) computer coursework taken in a higher educational facility, (c) the ratio of teachers to microcomputers in the teachers' present school, (d) the citizenship of the teachers, (e) the geographic location of the teachers' present school, (f) age,(g) academic degree, (h) sex, and (i) the number of years taught outside the teachers' home country.

Price (1985), pointed out that the computer education literature suggested computer anxiety was a problem common to classroom teachers without prior computer training. He designed a study to investigate the effectiveness of workshops designed to reduce computer anxiety. Based on a study of 80 teachers in a treatment group and 57 teachers in a quasi-control group, in which data were analyzed with the chi-square test (for descriptive characteristics) and a one-way analysis of variance (for the relationship between test anxiety and achievement), the investigator confirmed an inverse relationship between computer knowledge and computer anxiety, i.e., the greater the knowledge, the less the anxiety.

The Mathematical and Technological Orientation of Computer Courses

A major reason for both the decline in computer enrollment and the disparity between the sexes in computer courses may be that many instructors treat computer courses as math courses. The courses are then experienced by the students to be more difficult than anticipated and devoid of fun (Bernstein, 1990; Chen, 1992).

The rationale for computer science courses definitely being mathematics courses is presented forcefully by Dijkstra (1989):

> Right from the beginning and all through the course, we stress that the programmer's task is not just to write down a program, but that his main task is to give a formal proof that the program he proposes meets the equally formal functional specification. While designing proofs and programs hand in hand, the student gets ample opportunity to perfect his manipulative agility with the predicate calculus. Finally, in order to drive home the message that this introductory programming course is primarily a course in formal mathematics, we see to it that the programming language in question has <u>not</u> been implemented on campus so that students are protected from the temptation to test their programs (1989, 1404; emphasis in original).

Dijkstra admits that students at first often rebel against this mathematical and formal approach to programming, but that "Within a few months, they find their way in a new world with a justified degree of confidence that is radically novel for them" (1989, 1404).

Bernstein criticized Dijkstra's approach, primarily from a feminist viewpoint (Frenkel, 1990, 42-43). She claimed his mathematical emphasis would discourage those students who want to "see, tinker, experiment, and interact with computers in order to understand principles" (1990, 42). Thus Dijkstra's approach was thought to further cause computer science majors to dwindle. Bernstein summarized her argument by saying, "To me, (Dijkstra's approach) means, 'Computer science is getting too easy. Let's keep the riff-raff out'" (1990, 43).

Chen (1992), a recent graduate of Nova High School, in Davie, Florida, provided an anecdotal account of why the technical and mathematics orientation of computer science courses discouraged her and her classmates to think, wonder, and explore, despite her expectation and hope that the courses would be enjoyable, stimulating, and even mind expanding. Describing her early experience with computer courses in elementary school, she says,

> We were asked to study the history of computers, memorize the names of hardware, and master the rules of syntax. We were sixth graders. We weren't about to enter the high-tech world of programming. All we wanted was to see what neat things we could do with the computer....After my sixth grade BASIC experience, I never wanted to take another computer course again (1992, p. 1918).

Chen derides computer science instruction by focusing on the mathematics aspect, which, she says, "turns off" many students who would otherwise be attracted to careers in computers. She reports that in ninth grade, her mathematics class began a course in Logo, and that the students looked forward to the days they would study Logo, "not only because it meant a break from math, but also because working in Logo was a lot of fun, and it was easy." Chen goes on to report, however, that "Unfortunately, that course was 'squeezed out' by the pressure of our math courses over the next three years" (1992, 1919).

Another criticism of the way computer science is taught in schools that focuses on the technological orientation of the courses is presented by Becker (1993). He says that the most striking thing about computer use in secondary school during the 1980s and intc the present time is that

> most computer time has been devoted to teaching students computer skills qua skills, rather than embedding or applying computer capacity in the context of ongoing teaching and learning in other subjects (1993, p. 69).

Becker argued that since 1983 there has been too great an emphasis on learning about computers and programs themselves--especially keyboard instruction, programming, word processing programs, and data base programs--rather than on what the students can do with the computers.

Lips and Temple (1990) conducted a study of 305 undergraduates, both men and women, to test a causal model relating math and attitudes for choice of computer science as a major. The model found that attitudes towards mathematics played a more complex and stronger role for men whereas experience played a stronger, more positive role for women.

Kilpatrick (1988) studied factors that influence choice of a major in college, focusing on the causal relationship between variables related to attitudes toward mathematics, calculus, high school background, and gender. The investigator administered the Fennema-Sherman Mathematics Attitudes subscales and a self-report questionnaire to 300 college seniors, and the data were input into the computer program Gemini, used to analyze structural equations with standard errors and indirect effects. In general the findings showed that the eight predictor variables used in the study accounted for 67.25 percent of the variation in choice of a major. Among the specific findings, the researcher found that calculus ability had a sizeable influence on both the total group and across genders, that mathematics was not perceived as a male domain, and that gender on the choice of a major was minimal.

Despite all the concern about the mathematics orientation in computer courses, not all investigators agree that this orientation dominates the field of computer science today. Litdke and Moursund (1993) pointed out a fundamental division among educators that emerged in the early 1970s, when computer usage was just beginning to proliferate in the public schools. The split was between programming instruction, which was held to be for the mathematically adept, and applications instruction, which was proposed for those not so strong in mathematical aptitude. According to Litdtke and Morisund, however, the mathematics emphasis has not prevailed. "Since the 1980s," they wrote,

> the use of applications software and CAI [Computer Assisted Instruction] packages for microcomputers has grown rapidly. Simultaneously, there has been a considerable decrease in the teaching of computer programming and computer science in K-12 education (1993, 84).

They continued, "Thus, computer applications and CAI are now by far the dominant uses of computers in precollege education" (1993, 85). They added, however, that the teachers of the applications packages often have had little formal preparation in either computer science or programming. This observation has important implications for teachers' attitudes towards the computer and the quality of instruction they can deliver to students, as discussed in the foregoing section, because the nature of instructional quality may be a factor that dissuades precollege students from choosing computer science as a major when entering college.

In order to encourage greater enrollment in computer classes, many researchers, educators, and professional organizations have made proposals for improvements in the computer science curriculum. A representative sample of the major ideas proposed for curriculum change are presented in the works reviewed in this section.

The Association for Computing Machinery's (ACM) Pre-College Education Committee proposed a computer science curriculum for high school students, including both those students planning on computer careers and those planning on other professions (ACMEMBERNET, 1991; ACM Model, 1993). According to the ACM, the program's goal is to instill knowledge and understanding in individuals about "what makes computers work and what lies behind the computer solution" (1991, 1). It is interesting to note that, for the ACM, neither the use of computers as a tool for other disciplines (e.g., word processing for English) nor programming "is computer science, although both comprise aspects of the discipline" (1993, 87). Rather, to the ACM

> The study of computer science is composed of basic universal concepts that transcend the technology and that comprise an essential part of a high school education. It is these concepts that enable the student to understand and participate effectively in our modern world (1993, 87).

The proposed curriculum would cover the following areas: algorithms and data structures, architecture, artificial intelligence and robotics, database and information retrieval, human-computer communication, numerical and symbolic computing, operating systems, programming languages, software methodology and engineering, and social, ethical, and professional issues. This proposed core curriculum is intended for approximately 10th grade students, and "Student preparation should include first-year algebra and some computing experience" (1993, 87).

Kolatis (1988) presented an overview of both the institutional and technological factors that must be considered in designing or updating a computer science curriculum at the community college level. After pointing out that the needs of students, the institution, and the business community should be considered in the planning, Kolatis offered the following conclusions about curriculum design: (a) programs should be designed to be viable for several years, with a two-year time-lag for program development and rapid changes in technology; (b) no one curriculum will satisfy the needs of all students and the community; (c) the associate of science degree program in computer science cannot differ radically from the first two years of four-year college programs; and d) strong mathematics and science backgrounds are advantageous for computer science majors.

Babcock (1990) conducted a survey of 70 school districts in Arizona and of college catalogs in the state to determine the extent of communication between the secondary schools and postsecondary institutions concerning computer education and computer literacy. Babcock focused on the extent of advanced placement courses, computer education services, availability of hardware and software, and computer literacy course offerings available between and among Arizona high schools and postsecondary institutions. The investigator noted that communication between colleges and high schools could result in the development of new computer education curricula, including classes in programming languages, word processing, data processing, and other literacy courses. The new curricula, in turn, could better prepare high school students for college as well as reduce or eliminate some of the pressure on colleges concerning enrollment in introductory computer courses.

Based on survey data, Sproull et al. (1984) described college students' first encounters with computers as a feeling that they are entering into an "alien" culture, and blamed the social context of introductory courses as encouraging such feelings. They recommended an "anthropological approach" to curriculum change rather than a change in course content per se. To counter the alienation students are likely to feel in computer courses, the authors stressed that a cultural perspective must be taken to the problem of introducing novices to computing, and suggested a socialization model composed of three stages: reality shock, confusion, and attempts at control.

Tucker (1985) reported on the work of the Caddo Career Center, a secondary vocational-technical school in Shreveport, Louisiana. The Center began an in-school effort to make computer applications possible in all areas in the 1983-84 school year. The school trained instructors through creative use of funds made available by the local school board, and established a computer lab, which the students used weekly to learn computer and technology literacy or programming; also the program provided for the students to take a field trip to observe current technology in their field of study. According to Tucker, the fundamental assumption guiding the curriculum of Caddo Career Center was that, by providing these opportunities, students would be interested in computers, choose computer careers, and be prepared to enter the work force and accept and conquer the challenges posed by technological changes.

After documenting a decline in baccalaureate degrees given out in computer science in the United States between 1985 and 1990--from nearly 41,000 to 27,434--Archer, Katter, and Price (1993) argued that this trend could be reversed only if business and academia worked together to create a new curriculum that would attract more computer science majors. They suggested that the involved constituencies should join together to discuss the positive and negative aspects of various levels of subject coverage in a model curricula, and then, perhaps, "curricula could be developed that respond to the needs of business/industry and also satisfy the academic requirements of a baccalaureate degree" (1993, 21).

According to Pearl et al. (1990), a crucial component of any successful curriculum change must address the needs and interests of young women, as well as young men. Among their many recommendations for change, with this emphasis in mind, are the following: (a) ensure that young boys and girls have equal access to computers; (b) design software that appeals to both sexes; (c) ensure that high school girls continue with math and science by establishing programs such as science fairs and conferences where women speak about their careers in engineering and science; (d) provide programs that make women computer scientists visible to undergraduates and graduate students, e.g., by inviting women to campuses to give talks or to serve as visiting faculty members; (e) ensure safety procedures on campus by, for example, providing safe access around the clock to public terminal areas and well-lit routes from offices to parking lots; (f) educate male computer science faculty members about self-esteem issues that women computer scientists face; and (g) keep lists of capable women computer scientists to increase the participation of women in influential positions, such as program committees, editorial boards, or policy boards (1990, 55).

Creating a Questionnaire

According to Moser and Kalton (1972), the mail questionnaire is generally cheaper than other methods of data collection, since questionnaires can be sent through the mail. The mail questionnaire is especially useful for collecting data on scattered populations. The questionnaire method is also the best way to collect information on questions that can be answered briefly from among alternative answer-choices and that are intended to be analyzed statistically. Each answer choice can be given a numeric value, say from "1" to "5," if the answer-choices have an inherent order ranging from "less" to "more," or some other order. Such questions are called "pre-coded" or "closed" as opposed to "open" (Fowler, 1984; Hornville & Jowell, 1978, p. 29; Moser & Kalton, 1972, p. 341).

According to Fowler (1984), on the use of closed questions, "if one is going to have a self-administered questionnaire, one must reconcile oneself to closed questions--that is, questions that can be answered by simply checking a box or circling the proper response from a set provided by the researcher" (1984, p. 64). Also, pre-coded questions are best when the researcher is interested in specific, direct answers, and the range of answers can be anticipated or logically delimited. The Likert-type scale, with a range of answers to pre-coded questions, is best for opinion or attitude items (Hornville & Jowell, 1978, pp. 33-37).

As regards the sequence of events that defines the typical mail questionnaire study, "mail surveys usually take two months to complete. A normal sequence involves mailing the questionnaires, waiting for a while, doing some more mailing, some more waiting, and some eventual follow-up" (Fowler, 1984, p. 69).

With respect to the general design of the questionnaire, the first step of a good design "is to define the problem to be tackled by the survey and hence to decide on what questions to ask" (Moser & Kalton, 1972, p. 308). Once these issues are decided, the detailed design work can begin--"formulating precise questions, ordering the questions and sections, listing possible categories of answers..." (Hornville & Jowell, 1978, p. 28). A good questionnaire should be no longer than is absolutely necessary for the purpose.

A second important step of good questionnaire design is that the questions asked should be practicable.

> It is no good asking a person's opinion about something he does not understand; about events too long ago for him to remember accurately; about matters which, although they concern him, he is unlikely to have accurate information on or that are so personal or emotional that valid answers cannot be expected by formal direct questioning (Moser & Kalton, 1972, p. 310).

As regards the language used in the questions or items presented to respondents, it needs to be chosen with the survey population clearly in mind (Hornville & Jowell, 1978). In a self-administered questionnaire, ambiguity, vagueness, and technical expressions are to be avoided. Also, with respect to the wording of questions, the researcher should do the following: (a) ask questions that are sufficiently specific, (b) use simple language, appropriate for the reading and comprehension level of the subjects, (c) avoid asking leading questions, and (d) avoid asking embarrassing questions) (Moser & Kalton, 1972, p. 318-327).

In order to ensure against such problems with wording of the items on the questionnaire, the investigator should consider doing preliminary research or a pilot study. This will enable him to see which, if any, items need improvement in wording (Fowler, 1984).

As regards the issue of ensuring an adequate return rate from a questionnaire study, this is a potentially major problem. "The main problem with mail surveys is that of getting an adequate response rate" (Moser & Kalton, 1972, p. 262). Some things the investigator can do to maximize the response rate are (a) meet with potential respondents personally, (b) include thoughtfully worded cover letters, stating the purpose of the study, (c) direct the questionnaires to a target group of professionals, (d) have authority figures in organizations distribute and collect the questionnaires from the respondents, (e) enclose a self-addressed stamped envelope with a return address, and (f) send a follow-up letter to nonrespondents, again asking for their participation in the study.

In addition, regarding the return rate, the investigator should be aware that the length of the questionnaire affects the response rate (Fowler, 1984;

Hornville & Jowell, 1978). "Length of questionnaire must be presumed to affect the morale of...[the] respondent, and probably also refusal rates and the quality of the data." (Moser & Kalton, 1972, p. 309). Thus, whenever possible, investigators should use instruments that take the least time for the respondents to complete.

As the literature review has shown, enrollment in computer science courses in colleges, and the choice of computer science as a major, has declined by more than 50 percent since the early 1980s. This continuing decline has resulted in an undersupply of computer professionals to meet demand--a problem predicted to increase in the 1990s; and this undersupply of computer professionals, in turn, poses a threat to the ability of the U. S. to remain competitive in the rapidly changing, highly technological world in which we live.

The enrollment of women in computer science courses has been declining even more rapidly than that of men, and women have traditionally been underrepresented in computer science, for a variety of suggested reasons: lack of mentors and role models, lack of computers at home, stereotypes about computers being a male domain, and poor ability in mathematics.

For students of both sexes, studies have shown that an aversion to computers is associated with negative attitudes towards computers and technology in general, negative perceptions about computers and the utility of computer science as a career, lack of experience with computers, performance in mathematics, and teachers' attitudes about computers, among other factors. Research findings on these variables, although not uniform, suggest the strong influence of these factors in determining students' interest in and commitment to computer science as a career.

Since the early 1980s, computer professionals and educational researchers have been aware of the declining enrollment of computer science majors, and many recommendations have been made for curriculum change. Recommendations have focused on changing course content, the "social environment" of the classroom, the ways teachers are trained, the technical and mathematical nature of the subject area, and the male-oriented nature of the discipline that has been blamed for the underrepresentation of women in the field. Despite the recommendations for curriculum change, the problem of declining enrollment remains, and there are even signs that Computer Education, in general, is in a state of disarray.

Given the above, this study was needed to help better understand the reasons for the decline in the choice by entering college freshmen of computer science as a major.

III

PROCEDURES OF THE STUDY

In this chapter, the method used to conduct the study is discussed. Included in the discussion are details regarding (a) the population, (b) the sample, (c) the research instrument, including discussion of questionnaire construction, (d) the types of variables and scales analyzed for the study, and (e) the method of data collection.

The Population and the Sample

The population of the study was composed of the computer classes in the Mathematics Departments of public and parochial high schools in New York State, except for public schools in the five boroughs of New York City. The reason for this omission was that approval of the Central Board was needed for these schools to participate, and that process of approval would have been inconsistent with the time demands of the study.

The sample analyzed for the study consisted of 4,127 high school students taking computer courses, including sophomores, juniors, and seniors, in 143 public and 33 parochial high schools in New York State. One class from each school participated in the study, with an average of about 30 students per class. One-hundred and forty-eight public schools and 19 parochial schools (a total of 167 schools) responded to the investigator's request for participants but did not agree to take part in the study.

Those pupils who completed the questionnaire used in the study did so because their instructors agreed to have their classes participate in the investigation. As indicated by the figures above, the percentage of teachers and their students who participated in the study, out of the total number who could potentially have participated, was relatively high. The sample was thus believed to have been representative of the total population of students in computer courses in public and parochial high schools in New York State. The investigator therefore generalized findings from the study to all students in New York State with characteristics similar to those studied.

Three potential sources of bias in the sampling procedure were noted. One involved the fact that, as mentioned, New York City public high school students were omitted from the study. They conceivably could have had characteristics that would have significantly differentiated them from students who did participate in the study, and thus have affected the results. The second potential source of bias is that teachers who participated in the study agreed to do so voluntarily, and thus could have had characteristics different from teachers who refused to participate that would have had implications for the types of students enrolled in their classes. The third potential source of bias is that about 50 percent of the subjects in the study attended high schools in Western New York State and Long Island, i.e., the subjects in the study were not evenly distributed throughout the state.

Characteristics of the Sample

In this section, the characteristics of the sample analyzed for the study are described using, as appropriate, the arithmetic mean, median, mode, standard deviation, range, frequencies, and percentages.

Gender

The study included 1,980 (48.00%) females and 2,136 (51.80%) males. Eleven (.20%) subjects did not respond.

Age

The mean age of the subjects was 16.50 years (s.d.=.90), the median age=17.00 years, and the modal age=17.00 years (n=1,688). The age range was 10 years, going from a minimum of 11 to a maximum of 21 years.

Population Size of Area of Residence

The subjects were asked to indicate the size of the city in which they lived. The frequency distribution of their answers is shown in Table 1.

Table 1

Population Size of Area of Residence

Population Size	Frequency	Percentage
Under 2,500	1,011	24.50
2,501-10,000	1,175	28.50
10,001-100,000	778	18.90
100,001-500,000	555	13.40
Over 500,000	600	14.50
No Answer	8	.20
TOTALS	4,127	100.00

As Table 1 shows, the subjects were rather uniformly distributed over population areas of various sizes, ranging from "small towns" to "urban centers." Most of the subjects (53%) lived in areas from less than 2,500 to 10,000 people, or "small" population centers. Only 14.5 percent of the subjects lived in a population center of over 500,000 people, or an "urban" area.

<u>Type of School Attended</u>

The subjects were asked to state whether they attended a public or nonpublic school. The great majority (n=3,288, or 79.70%) said they attended a public school, while 829 (20.10%) of the students said they attended a nonpublic school, and 10 (.20%) subjects gave no answer to this question.

Year in School

Table 2 shows the frequency distribution for the grade distribution of the subjects.

Table 2

Frequency Distribution for Year in School

Year In School	Frequency	Percentage
Freshman	5	.10
Sophomore	648	15.70
Junior	1,758	42.60
Senior	1,707	41.40
No Answer	9	.20
TOTALS	4,127	100.00

As Table 2 shows, the great majority of the subjects were juniors and seniors (84.00%), about evenly divided. Freshmen were barely represented (.10%). Thus, the study was essentially conducted on sophomores, juniors, and seniors, especially the latter two grades.

Major

The frequency distribution for the major areas of concentration is shown in Table 3.

Table 3

Frequency Distribution of Majors

Major	Frequency	Percentage
Liberal Arts	394	9.50
Technical	881	21.30
Business	624	15.10
Health Science	460	11.10
Computer Science	181	4.40
Education	250	6.10
Other	474	11.50
Undecided	558	13.50
No Answer	305	7.40
TOTALS	4,127	100.00

Table 3 shows that there were 13 indicated majors among the subjects plus an undecided category and a no answer category. Among the indicated majors, Business was the single most popular (15.10%), followed by Health Science and Nursing (11.10%) and Science (9.40%). Computer Science, it may be noted, was the major of only 4.4 percent (n=181) of the subjects.

Educational Institution Planning to Attend

The subjects were asked to state what type of educational institution they planned, if any, after graduation from high school. There answers are shown in Table 4.

Table 4

Educational Institution planning to Attend

Planning to Attend	Frequency	Percentage
2-Year College	432	10.50
4-Year College	3,347	81.10
None of the Above	163	3.90
No Answer	96	2.30
TOTALS	4,127	100.00

As Table 4 shows, the great majority (81.10%) of the students said they were planning to attend a 4-year college. Only 2.2 percent of the students indicated a "technical or vocational" school as their future choice of educational institution.

Computer at Home

The subjects were asked to state whether or not they had a computer at home. Slightly more than half (n=2,346, or 56.80%) said that they did, and almost all of the remaining students (n=1,776, or 43.00%) said that they did not have a computer at home. Five (.10%) of the subjects did not answer this question.

Summary

The subjects were almost equally represented by gender, with slightly more males than females, and they had an average age of 16.5 years (s.d.=.90), reflecting their status as mainly juniors and seniors. Nearly 80 percent of the students attended public schools and were planning to attend a 4-year college after graduation. Over half of them lived in population centers of under 10,000 people, and almost three-quarters lived in areas of under 100,000 people. The students indicated 13 major areas of concentration, with no single major dominating the field, and only 4.40 percent of the students were Computer Science majors. Slightly more than half of all the students had a computer at home.

Survey Instrument and Use

The questionnaire employed in the study to collect data from the subjects was created by the investigator (Appendix A), based on the literature. The investigator used the

Fennema-Sherman (1986) questionnaire (in the area of mathematics) as a model for the questionnaire; and concern was taken to conform to established procedures for creating a questionnaire, as explained in the literature, with respect to such things as phrasing of questions, appropriateness of wording for intended subjects, clarity of questionnaire items, structuring and scoring a Likert-type scale, and pretesting the survey questionnaire (Fowler, 1984; Hornville & Jowell, 1978; Moser & Kalton, 1972).

The questionnaire employed consisted of two parts. The first part asked about background information on the subjects, including their sex, age, city of residence, type of school attended, year in school, what kind of education, if any, they intended to pursue after high school, what their intended major was if they planned on attending college, and whether or not they had a computer at home. In the coding of these items, it may be noted that "city of residence" was coded in terms of population size categories and then labeled as "small town," "large urban center," etc.

The second part of the research questionnaire consisted of 34 items regarding attitudes about computing. For each item, the subject was supposed to indicate the extent of his or her agreement or disagreement on a 5-point Likert-type scale ranging from "Strongly agree" to "Strongly disagree." As originally coded, a "1" was assigned to "Strongly agree" and a "5" was assigned to "Strongly disagree." For certain items, these scores were interpolated, or reversed, during the data analysis, as now explained.

The highest score a subject could have attained on the questionnaire was 170 (34 X 5) and the lowest score a subject could have attained was 34 (34 X 1). Some items were worded positively, e.g., "I get excited by computer programming problems" (item 1) and some items were worded negatively, e.g., "I dread computer classes" (item 2). For purposes of data analysis, it was decided to have a "1" indicate lowest interest in or attraction to computing and a "5" indicate highest interest in or attraction to computing. Thus answers to positively worded items were reversed, so that the higher the overall score for each subject, the more the interest in or attraction to computing. As may be seen on the questionnaire in Appendix A, the positively worded items were numbers 1, 3, 9, 12, 13, 18, 20, 21, 22, 25, 26, 27, 28, 29, 31, and 32; and the negatively worded items were numbers 2, 4, 5, 6, 7, 8, 10, 11, 14, 15, 16, 17, 19, 23, 24, 30, 33, and 34.

The 34 items under discussion composed five separate subscales, as follows: (a) enthusiasm about computing (items 1, 6, 15, 17, 21, 25), (b) perception of computing ability (items 11, 12, 22, 23, 29, 30, 34), (c) teacher influence on computing (items 3, 5, 10, 19, 27), (d) apprehension about computers (items 2, 13, 14, 16, 20, 24, 26, 32), and perception of career opportunities in computer science (items 4, 7, 8, 9, 18, 28, 31, 33).

A Cronbach alpha analysis indicated that the separate items in each subscale could be combined into a single subscale score for purposes of data analysis, thus resulting in five separate subscale scores for each subject in the study, as well as a total questionnaire score (see chapter IV, "Findings," for more about the Cronbach alpha analysis). Scoring for each subscale followed the procedure discussed above.

Before distributing the questionnaires to the subjects, a preliminary trial was done on a small sample to make sure the wording and intentions of the questions were clearly understood. The pretest revealed that the questionnaire was clear and understood as intended, except for one question regarding homework, which everyone answered "uncertain." The investigator modified the wording of this question, and did some light textual editing on other questions.

Types of Variables and Scales

Each of the 34 items on attitudes towards the computer or computing, as mentioned, received a score of "1" through "5," and the total score a subject could receive for all the items ranged from a low of 34 to a high of 170. These items are thus quantitative and were treated as composing an interval scale for purposes of data analysis. The same is true for each of the five subscales discussed above, which respectively contained anywhere from five to eight items: they produced quantitative scores that composed an interval scale.

The demographic variables differed in terms of scales. Sex, type of school attended, and whether the subject had a computer at home were each analyzed as a dichotomous nominal scale. City of residence (city size/type), year in school, type of school the subject planned on attending after high school, and intended major in college were each analyzed as a nominal scale with three or more categories. Age was analyzed as an interval scale variable.

The number of types of scales analyzed in relation to each other determined the statistical technique that was employed in a given analysis, including the t-test for the difference between means of independent samples, the Pearson product-moment correlation coefficient, multiple regression, and analysis of variance.

Method of Data Collection

The data collection procedure began during November of 1992, when letters and flyers (see Appendix B) were distributed by the investigator to public and parochial high school teachers attending a computer conference which was held at the Neville Hotel in Ellenville, New York. The fliers were also distributed at professional meetings of Nassau County Mathematics Teachers Association and Suffolk

County Mathematics Teachers Association. In addition, a letter was sent out to 902 chairpersons of Mathematics Departments in the New York State public and parochial high schools, excluding New York City public schools, asking for their cooperation in the study. The letter contained a form the respondent could check to indicate whether he or she agreed to participate in the study, along with a self-addressed stamped envelope.

Chairpersons and computer instructors who volunteered to participate in the study were then sent a letter thanking them for their cooperation (see Appendix C) along with questionnaires, one for each student in their class, and a self-addressed stamped envelope. Each participating teacher then had the students in his or her computer class complete the questionnaires.

Addressees in schools who did not respond to the initial mailing were sent a follow-up letter by the investigator, again requesting their participation in the study. This procedure resulted in 12 additional "yes" responses. The data collection process was completed during January and February of 1993.

Among the 190 schools that were sent questionnaires by the investigator, 176 schools returned the completed questionnaires and 14 schools did not return the questionnaires, for two reasons: three teachers found out that it was against school policy to have students participate in a study, and 11 teachers lacked time due to previously canceled classes during school closings caused by inclement weather conditions.

The 4,350 questionnaires received were reviewed for usability, and 223 were determined to be unusable, for the following reasons: the same response choice was circled through the entire questionnaire or a large part of the questionnaire, the questionnaire was not completed, or the responses were considered to be inappropriate. The total number of usable questionnaires analyzed for the study was 4,127.

IV

RESULTS OF THE STUDY

In this chapter, the questions posed in Chapter I are answered and the characteristics of the sample are described, based on the statistical analysis of the data. The answers to the questions of the study were based upon either the Pearson product-moment correlation coefficient (Pearson r), multiple correlation, analysis of variance (ANOVA), or the t-test for the difference between means of independent samples. Results were considered statistically significant at alpha=.05 or less.

The Subscales Analyzed for the Study

The 34 items on the research instrument (see Appendix ?) were grouped into six distinct subscales, for purposes of answering the questions of the study. To see if items about a similar factor, e.g., enthusiasm towards computers, could, in fact, be grouped to compose a subscale, the designated items were assessed using Cronbach Alpha. The results of this analysis are shown in Table 5.

Table 5

Cronbach Alpha Values for the Subscales of the Study

Subscale	Alpha Value
Enthusiasm Towards Computers	.86
Perception of Computing Ability	.74
Influence of Instructor Towards Computing	.57
Apprehension About Majoring in Computer Science	.77
Perceived Career Opportunities in Computing	.76

As Table 5 shows, the alpha values ranged from a high of .86 (enthusiasm towards computing) to a low of .57 (influence of instructor towards computing), with the other three categories having alpha values of, respectively, .74, .76, and .77. Based on this analysis, scores for these five sets of factors were used to answer the research questions.

Research Questions

In this section, the five questions of the study presented in Chapter I are answered, respectively, based on statistical tests of significance.

Enthusiasm Towards Computing

The first question asked, What factors are related to enthusiasm towards computing? One analysis related each of the subscale scores, respectively, to enthusiasm towards computing using the Pearson r. The result is shown in Table 6.

Table 6

Subscales Related to Enthusiasm Towards Computing

Subscale	Pearson r Value
Perception of Computing Ability	.51**
Instructional Influence	.34**
Apprehension About Major in Computers	.62**
Perceived Career Opportunities	.36**

**=p<.001

As Table 6 shows, each of the other subscales was significantly related to enthusiasm towards computing. A multiple regression analysis also was conducted, with enthusiasm towards computing as the dependent factor and the other subscales as the independent factors. The result was statistically significant with R^2=.42 and F=676.74 (p=.00).

<u>Demographic Factors</u>. The t-test for the difference between means showed that the following factors were related to enthusiasm towards computing: gender, type of school attended, and whether the students had a computer at home. The results are shown in tables 7 through 9.

Table 7

Gender and Enthusiasm Towards Computing

Group	N	Mean	S.D.	t-score
Female	1,900	2.86	.75	-7.07^{**}
Male	2,050	3.03	.82	

**=p<.01

Table 8

Type of School Attended and Enthusiasm Towards Computing

Group	N	Mean	S.D.	t-score
Public	3,150	2.97	.80	3.03^{**}
Nonpublic	802	2.88	.76	

**=p<.01

Table 9

Whether Have Computer at Home and Enthusiasm Towards Computing

Group	N	Mean	S.D.	t-score
Yes	2,260	3.01	.83	5.38^{**}
No	1,697	2.87	.74	

**=p<.01

Using ANOVA, the following factors were found to be significantly related to enthusiasm towards computing: the type of school the students were planning to attend after graduation from high school and major in high school. The results are shown, respectively, in tables 10 and 11.

Table 10

Type of School Planning to Attend After High School and Enthusiasm Towards Computing

Source of Variation	D.F.	Sum of Squares	Mean Squares	F Ratio
Between Groups	3	14.58	4.89	7.81**
Within Groups	3,867	2,406.77	.62	
TOTAL	3,870	2,421.35		

**=p<.01

In this analysis, pairs of factors significantly different at the .05 level were 4-year college and, respectively, 2-year college and none of the above; and technical or vocational school and, respectively, 2-year college and none of the above.

Table 11

Major and Enthusiasm Towards Computing

Source of Variation	D.F.	Sum of Squares	Mean Squares	F Ratio
Between Groups	7	166.49	23.78	41.39**
Within Groups	3,664	2,105.32	.57	
TOTAL	3,671	2,271.81		

**=p<.01

In this analysis, pairs of factors significantly different at the .05 level were Computer Science and all other majors plus Undecided; Technical and all other majors plus Undecided; Business and, respectively, Liberal Arts and Education; Health Science and Liberal Arts; and Undecided and Liberal Arts. It may be noted that the mean score of the dependent variable was highest for the Computer Science majors.

Perception of Computing Ability

The second question asked, What factors are related to students' perceptions of their computing ability? The first analysis related each of the subscale scores, respectively, to perception of computing ability using the Pearson r. The result is shown in Table 12.

Table 12

Subscales Related to Perception of Computing Ability

Subscale	Pearson r Value
Enthusiasm Towards Computing	.51**
Instructional Influence	.32**
Apprehension About Major in Computers	.75**
Perceived Career Opportunities	.26**

**=p<.001

As Table 12 shows, each of the other subscales was significantly related to perception of computing ability. A multiple regression analysis also was conducted, with perception of computing ability as the dependent factor and the other subscales as the independent factors. The result was statistically significant with R^2=.56 and F=1,192.43 (p=.00).

<u>Demographic Factors</u>. Age was found to be weakly and inversely related to perception of computing ability, with r=-.05 (p<.01). Using the t-test for the difference between means, the following demographic factors were found to be significantly related to perception of computing ability: gender, type of school attended, and whether the students had a computer at home. The results are shown, respectively, in tables 13 through 15.

Table 13

Gender and Perception of Computing Ability

Group	N	Mean	S.D.	t-score
Female	1,869	3.26	.56	-8.70^{**}
Male	2,032	3.42	.60	

**=p<.01

Table 14

Type of School Attended and Perception of Computing Ability

Group	N	Mean	S.D.	t-score
Public	3,104	3.36	.60	4.11^{**}
Nonpublic	797	3.28	.54	

**=p<.01

Table 15

Whether Have Computer at Home and
Perception of Computing Ability

Group	N	Mean	S.D.	t-score
Yes	2,227	3.41	.59	8.27^{**}
No	1,680	3.26	.60	

**=p<.01

Using ANOVA, the following factors were found to be related significantly to perception of computing ability: the size of residential area, year in school, type of school the students were planning to attend after graduation from high school, and major in high school. The results are shown, respectively, in tables 16 through 19.

Table 16

Size of Residential Area and Perception of Computing Ability

Source of Variation	D.F.	Sum of Squares	Mean Squares	F Ratio
Between Groups	4	5.14	1.29	3.75**
Within Groups	3,898	1,335.19	.34	
TOTAL	3,902	1,340.33		

**=p<.01

In this analysis, pairs of factors significantly different at the .05 level were 2,501-10,000 and, respectively, Over 500,000 and Under 2,500.

Table 17

Year In School and Perception of Computing Ability

Source of Variation	D.F.	Sum of Squares	Mean Squares	F Ratio
Between Groups	2	3.54	1.77	5.16**
Within Groups	3,895	1,334.93	.34	
TOTAL	3,897	1,338.48		

**=p<.01

In this analysis, pairs of factors significantly different at the .05 level were Sophomore and, respectively, Senior and Junior.

Table 18

Type of School Planning to Attend After High School and Perception of Computing Ability

Source of Variation	D.F.	Sum of Squares	Mean Squares	F Ratio
Between Groups	3	12.06	4.02	11.89**
Within Groups	3,819	1,291.39	.34	
TOTAL	3,822	1,303.45		

**=p<.01

In this analysis, pairs of factors significantly different at the .05 level were 4-year college and, respectively, 2-year college and none of the above; and technical or vocational school and, respectively, 2-year college and none of the above.

Table 19

Major and Perception of Computing Ability

Source of Variation	D.F.	Sum of Squares	Mean Squares	F Ratio
Between Groups	7	67.42	9.63	30.08**
Within Groups	3,620	1,159.03	.32	
TOTAL	3,627	1,226.45		

**=p<.01

In this analysis, pairs of factors significantly different at the .05 level were Computer Science and all other majors plus Undecided; Technical and all other majors plus Undecided; Business and, respectively, Liberal Arts and Education; and Other and Liberal Arts. It may be noted that the mean score of the dependent variable was highest for the Computer Science majors.

Apprehension About Majoring in Computer Science

The third question asked, What factors are related to students' apprehension about majoring in computer science? The first analysis related each of the subscale scores, respectively, to apprehension about computer science using the Pearson r. The result is shown in Table 20.

Table 20

Subscales Related to Apprehension About Majoring In Computer Science

Subscale	Pearson r Value
Enthusiasm Towards Computing	.62**
Perception of Computing Ability	.75**
Instructional Influence	.35**
Perceived Career Opportunities	.35**

**=p<.001

As Table 20 shows, each of the other subscales was significantly related to apprehension about majoring in computer science. A multiple regression analysis also was conducted, with apprehension about majoring in computer science as the dependent factor and the other subscales as the independent factors. The result was statistically significant with R^2=.65 and F=1,706.30 (p=.00).

<u>Demographic Factors</u>. Using the t-test for the difference between means, the following demographic factors

were found to be related significantly to apprehension about majoring in computer science: gender, type of school attended, and whether the students had a computer at home. The results are shown, respectively, in tables 21 through 23.

Table 21

Gender and Apprehension About Majoring In Computer Science

Group	N	Mean	S.D.	t-score
Female	1,893	3.20	.59	-9.25^{**}
Male	2,039	3.37	.61	

**=p<.01

Table 22

Type of School Attended and Apprehension About Majoring In Computer Science

Group	N	Mean	S.D.	t-score
Public	3,131	3.30	.60	3.15^{**}
Nonpublic	801	3.23	.56	

**=p<.01

Table 23

Whether Have Computer at Home and
Apprehension About Majoring In Computer Science

Group	N	Mean	S.D.	t-score
Yes	2,251	3.37	.59	9.75^{**}
No	1,687	3.18	.58	

**=p<.01

Using ANOVA, the following factors were found to be related significantly to apprehension about majoring in computer science: the size of residential area, type of school the students were planning to attend after graduation from high school, and major in high school. The results are shown, respectively, in tables 24 through 26.

Table 24

Size of Residential Area and Apprehension About
Majoring In Computer Science

Source of Variation	D.F.	Sum of Squares	Mean Squares	F Ratio
Between Groups	4	3.84	.96	2.73^{*}
Within Groups	3,929	1,379.08	.35	
TOTAL	3,933	1,382.92		

*=p<.05

In this analysis, one pair of factors was significantly different at the .05 level: 2,501-10,000 and Under 2,500.

Table 25

Type of School Planning to Attend After High School and Apprehension About Majoring In Computer Science

Source of Variation	D.F.	Sum of Squares	Mean Squares	F Ratio
Between Groups	3	16.29	5.43	15.79**
Within Groups	3,850	1,323.92	.34	
TOTAL	3,853	1,340.21		

**=p<.01

In this analysis, pairs of factors significantly different at the .05 level were 4-year college and, respectively, 2-year college and none of the above.

Table 26

Major and Apprehension About Majoring In Computer Science

Source of Variation	D.F.	Sum of Squares	Mean Squares	F Ratio
Between Groups	7	115.25	16.46	52.21**
Within Groups	3,655	1,152.03	.32	
TOTAL	3,662	1,267.82		

**=p<.01

In this analysis, pairs of factors significantly different at the .05 level were Computer Science and all other majors plus Undecided; Technical and all other majors plus Undecided; Business and, respectively, Liberal Arts and Education; and Health Sciences and, respectively, Liberal Arts and Education. It may be noted that the mean score of the dependent variable was highest for the Computer Science majors.

<u>Instructional Influence Towards Computing</u>

The fourth question asked, What factors are related to students' perceptions of the degree of positive instructional influence towards computing they have received? The first analysis related each of the subscale scores, respectively, to instructional influence using the Pearson r. The result is shown in Table 27.

Table 27

Subscales Related to Degree of Positive Instructional Influence Towards Computing

Subscale	Pearson r Value
Enthusiasm Towards Computing	.34**
Perception of Computing Ability	.32**
Apprehension About Majoring in Computer Science	.35**
Perceived Career Opportunities	.33**

**=p<.001

As Table 27 shows, each of the other subscales was related significantly to career and employment opportunities in computing. A multiple regression analysis also was conducted, with degree positive instructional influence towards computing as the dependent factor and the other subscales as the independent factors. The result was statistically significant with R^2=.19 and F=215.44 (p=.00).

Demographic Factors. Using the t-test for the difference between means, only one demographic factor was found to be related significantly to instructional influence towards computing: type of school attended. The result is shown in table 28.

Table 28

Type of School Attended and Degree of Positive Instructional Influence Towards Computing

Group	N	Mean	S.D.	t-score
Public	3,125	3.51	.52	6.57^{**}
Nonpublic	805	3.38	.52	

**=p<.01

Using ANOVA, the following factors were found to be related significantly to degree positive instructional influence towards computing: size of residential area, type of school the students were planning to attend after graduation from high school, year in school, and major in school. The results are shown in tables 29 through 32.

Table 29

Size of Residential Area and Degree of Positive Instructional Influence Towards Computing

Source of Variation	D.F.	Sum of Squares	Mean Squares	F Ratio
Between Groups	4	7.72	1.93	7.10**
Within Groups	3,927	1,074.35	.27	
TOTAL	3,931	1,082.08		

*=p<.05

In this analysis, pairs of factors significantly different at the .05 level were 2,501-10,000 and, respectively, Over 500,000, 100,001-500,000, and 10,001-100,000; and Under 2,500 and Over 500,000.

Table 30

Type of School Planning to Attend After High School and Degree of Positive Instructional Influence Towards Computing

Source of Variation	D.F.	Sum of Squares	Mean Squares	F Ratio
Between Groups	3	5.39	1.80	6.58**
Within Groups	3,849	1,050.62	.27	
TOTAL	3,852	1,056.02		

**=p<.01

In this analysis, pairs of factors significantly different at the .05 level were None of the Above and, respectively, Technical or Vocational, 4-Year College, and 2-Year College.

Table 31

Year In School and Degree of Positive
Instructional Influence Towards Computing

Source of Variation	D.F.	Sum of Squares	Mean Squares	F Ratio
Between Groups	2	2.02	1.01	3.67*
Within Groups	3,925	1,079.98	.28	
TOTAL	3,927	1,082.00		

**=p<.01

In this analysis, one pair of factors was significantly different at the .05 level: Senior and Junior.

Table 32

Major and Degree of Positive
Instructional Influence Towards Computing

Source of Variation	D.F.	Sum of Squares	Mean Squares	F Ratio
Between Groups	7	14.14	2.01	7.55**
Within Groups	3,657	975.99	.27	
TOTAL	3,657	990.13		

**=p<.01

For the data analyzed in Table 32, pairs of factors significantly different at the .05 level were Computer Science and all other majors plus Undecided; and Business and Undecided. It may be noted that the mean score of the dependent variable was highest for the Computer Science majors.

<u>Career and Employment Opportunities in Computing</u>

The fifth question asked, What factors are related to students' perceptions of career and employment opportunities in computing? The first analysis related each of the subscale scores, respectively, to perceived career and employment opportunities using the Pearson r: The result is shown in Table 33.

Table 33

Subscales Related to Perceptions of Career and Employment Opportunities in Computing

Subscale	Pearson r Value
Enthusiasm Towards Computing	.36**
Perception of Computing Ability	.26**
Apprehension About Majoring in Computer Science	.33**
Instructional Influence	.35**

**=p<.001

As Table 33 shows, each of the other subscales was significantly related to career and employment opportunities in computing. A multiple regression analysis also was conducted, with degree positive instructional influence towards computing as the dependent factor and the other subscales as the independent factors. The result was statistically significant with R^2=.19 and F=220.29 (p=.00).

Demographic Factors. Based on the Pearson r (r=-.05, p<.01), age was found to be weakly and inversely related to perceived career and employment opportunities in computing. Using the t-test for the difference between means, two demographic factors were found to be significantly related to perceived career and employment opportunities in computing: type of school attended and whether the students had a computer at home. The results are shown in tables 34 and 35.

Table 34

Type of School Attended and Perceived Career and Employment Opportunities in Computing

Group	N	Mean	S.D.	t-score
Public	3,129	3.61	.53	2.30*
Nonpublic	801	3.56	.51	

**=p<.01

Table 35

Whether Have a Computer At Home and Perceived Career and Employment Opportunities in Computing

Group	N	Mean	S.D.	t-score
Yes	2,236	3.63	.53	4.33**
No	1,699	3.56	.52	

**=p<.01

Using ANOVA, the following factors were found to be related significantly to perceived career and employment opportunities in computing: type of school the students were planning to attend after graduation from high school, year in school, and major in high school. The results are shown, respectively, in tables 36 through 38.

Table 36

Type of School Planning to Attend After High School And Perceived Career and Employment Opportunities in Computing

Source of Variation	D.F.	Sum of Squares	Mean Squares	F Ratio
Between Groups	3	7.26	2.42	8.78**
Within Groups	3,847	1,061.24	.28	
TOTAL	3,850	1,068.50		

*=p<.05

In this analysis, pairs of factors significantly different at the .05 level were 4-Year College and, respectively, 2-Year College and None of the Above.

Table 37

Year In School and Perceived Career and Employment Opportunities in Computing

Source of Variation	D.F.	Sum of Squares	Mean Squares	F Ratio
Between Groups	2	1.89	.95	3.40*
Within Groups	3,923	1,093.62	.28	
TOTAL	3,925	1,095.82		

*=p<.05

In this analysis, one pair of factors was significantly different at the .05 level: Sophomore and Senior.

Table 38

Major and Perceived Career and Employment Opportunities in Computing

Source of Variation	D.F.	Sum of Squares	Mean Squares	F Ratio
Between Groups	7	37.06	5.29	20.07**
Within Groups	3,650	962.91	.26	
TOTAL	3,657	999.98		

**=p<.01

In this analysis, pairs of factors significantly different at the .05 level were Computer Science and all other majors plus Undecided; Technical and, respectively, Education and Undecided; and Business and Education. It may be noted that the mean score of the dependent variable was highest for the Computer Science majors.

Summary

The following are the significant factors reported in the chapter for each of the five subscales, respectively:

1. Enthusiasm towards computing was related to, respectively, perception of computing ability, degree of positive instructional influence, apprehension about majoring in computer science, perceived career and employment opportunities, gender, type of school attended,

whether have a computer at home, type of school planning to attend after high school, and major.

2. Perception of computing ability was related to, respectively, enthusiasm towards computing, degree of positive instructional influence, apprehension about majoring in computer science, perceived career and employment opportunities, age, gender, type of school attended, whether have a computer at home, size of residential area, year in school, type of school planning to attend after high school, and major.

3. Apprehension about majoring in computer science was related to, respectively, enthusiasm towards computing, perception of computing ability, degree of positive instructional influence, perceived career and employment opportunities, gender, type of school attended, whether have a computer at home, size of residential area, type of school planning to attend after high school, and major.

4. Degree of positive instructional influence towards computing was related to, respectively, enthusiasm towards computing, perception of computing ability, apprehension about majoring in computer science, perceived career and employment opportunities, gender, type of school attended, size of residential area, type of school planning to attend after high school, year in school, and major.

5. Perceived career and employment opportunities in computer was related to, respectively, enthusiasm towards

computing, perception of computing ability, apprehension about majoring in computer science, perceived degree of positive instructional influence, age, gender, type of school attended, whether have a computer at home, type of school planning to attend after high school, year in school, and major.

V

INTERPRETATION OF THE RESULTS OF THE STUDY

In this section, the results of the study are discussed for each of the five subscales, respectively, including (a) enthusiasm towards computing, (b) perception of ability, (c) apprehension about majoring in computer science, (d) instructional influence, and (e) career and employment opportunities in computing.

Enthusiasm Towards Computing

Forty-two percent of the variance in enthusiasm towards computing was explained by the other subscales ($p<.001$), with the strongest factors being apprehension about majoring in computers ($p<.001$) and perception of computing ability ($p<.001$). Given this, it is important to consider the observation by Campbell and Perry (1988), that the more students are exposed to a high success environment, the more this will improve their attitudes and reduce their apprehension.

It may also be noted that the explained variance of 42 percent, for the multiple regression analysis, means that 58 percent of the variance in enthusiasm towards computing was left unexplained by the four other subscales. This suggests that more research would be of value to identify other factors accounting for enthusiasm.

In addition, with respect to the demographic variables, the major findings were consistent with past research, and revealed a variety of factors significantly related to enthusiasm towards computers. Specifically, the analysis showed that (a) males were more enthusiastic than females, (b) public school students were more enthusiastic than parochial school students, (c) students with a computer at home had more enthusiasm than students without a computer at home, (d) students planning to attend 4-year and technical school had more enthusiasm than students either planning to attend a two-year college or not planning to continue with schooling, and (e) students in more mathematically oriented majors and in majors where programming was stressed had more enthusiasm towards computers than students in less mathematical and computer-oriented majors.

These findings suggest that females could gain greater enthusiasm towards computers if the software were not so male-oriented, and they were encouraged more to use computers at home at any early age. Koohang (1989) has found, for example, that more computer experience reduces anxiety and increases enthusiasm towards computers. Also, the findings suggest that parochial schools need more computer facilities, to put them on a par with public schools, since exposure to a high success environment improves attitudes and reduces apprehension towards computers (Campbell & Perry, 1988).

Third, the fact that students with computers at home had more enthusiasm than those without computers at home suggests that parents influence enthusiasm, and that computers at home provide students with more opportunity to experiment and do "fun things" with computers. This reduces apprehension and increases confidence and enthusiasm. Also, it appears that better students, who are more likely to plan on attending a four-year college or technical school, have had more exposure to computers and more technical and mathematical capabilities than the other students, and thus have more enthusiasm towards computers.

This factor is related partially to the student's major, since those majoring in mathematics were more enthusiastic and also had more computer courses than the other students, and mathematics and science teachers have more positive attitudes towards computers than other types of teachers (Valesky, 1984). Also, business students, who had relatively high enthusiasm, often can see the functionality of using computers. Durndell (1990) has shown that the more experience one has had with computers, and the more utility that one perceives from computers, the more likely one is to want to use computers in the future.

Perception of Ability

Fifty-six percent of the variance in the students' perception of their computing ability was explained by the other subscales ($p<.001$), with the strongest factors being apprehension about majoring in computers ($p<.001$) and enthusiasm towards computing ($p<.001$). The explained variance of 56 percent, for the multiple regression analysis, means that 44 percent of the variance in perception of ability was left unexplained by the four other subscales. Thus, along with Campbell and Perry (1988), it is suggested that further research would increase knowledge of what accounts for students' perceptions of their computing ability.

With respect to the demographic variables, the major findings were similar to those reported above for enthusiasm towards computing, i.e., (a) males had a more positive perception of their ability than did females, (b) public school students had a more positive perception than did parochial school students, (c) students with a computer at home had a more positive perception than students without a computer at home, (d) students planning to attend 4-year and technical school had a more positive perception than students either planning to attend a two-year college or not planning to continue with schooling, and (e) students in more mathematically oriented majors and in majors where programming was stressed had a more positive perception of their computing ability than students in less mathematical and computer-oriented majors.

Generally, the same explanations discussed above for enthusiasm towards computers account for variations in perception of ability, i.e., more positive perception is related to exposure to and familiarity with computers, both at home and in the school environment, including parental support at home and teachers with positive attitudes towards computing in school.

In addition to the above findings, this analysis revealed that students living in areas with population size between 2,501 and 10,000 had a more positive perception of their computing ability than students living in areas with either less than 2,500 people or more than 500,000 people. The reasons for this could be that the smallest areas lack financial resources to buy computer equipment, and, therefore, the students in these areas have less exposure to computers. For the largest areas, such as New York City and Buffalo, financial problems also could be the problem. Because of lack of adequate financial resources, these cities lack up-to-date equipment. Also, the schools in these cities are heavily populated by minority populations, who are less likely to have computers at home and, in general, to have less exposure to computers, than the white male students who have historically gravitated to computer science courses.

It was also found for this analysis that sophomores had a more positive perception of their computing ability than either juniors or seniors. The explanation for this could be that by the second year of high school, students with the most positive perception have continued to take computer courses and are most enthusiastic about their newfound involvement with computers, whereas during their freshman year, fewer students in general have been exposed to computers, and during their senior year, those students who have a lower perception of their computing ability have self-selected out of computer courses.

Apprehension About Majoring in Computer Science

Sixty-five percent of the variance in apprehension about majoring in Computer Science was explained by the other subscales ($p<.001$), with the strongest factors being perception of computing ability ($p<.001$) and enthusiasm towards computing ($p<.001$). According to Durndell (1990), Computer Science students are generally motivated by extrinsic rewards. Fear--related to a poor success rate--tends to cause avoidance of computers. Since a negative attitude towards computers causes students to perform worse (Munger & Loyd, 1989) and the nature of the school contributes to apprehension (Lidtke & Moursand, 1993), it is in the interest of the field of Computer Science to be aware of and seek ways to lower apprehension in students.

The relatively high amount of explained variance, of 65 percent, for the multiple regression analysis, means that 35 percent of the variance in apprehension about majoring in Computer Science was left unexplained by the four other subscales. Thus, future research focusing on additional factors would undoubtedly increase understanding of apprehension.

The results involving the demographic variables were consistent with the findings reported above for the other subscales: (a) males were less apprehensive than females, (b) public school students were less apprehensive than parochial school students, (c) students with a computer at home were less apprehensive than students without a computer at home, (d) students planning to attend 4-year and technical school had less apprehension than students either planning to attend a two-year college or not planning to continue with schooling, and (e) students in more mathematically oriented majors and in majors where programming was stressed had less apprehension than students in less mathematical and computer-oriented majors.

These findings suggest that females might be less apprehensive if, as previously discussed, software were less male-oriented, and if, in general, the field of Computer Science were less dominated by males (Kwan et al., 1985) and females had more mathematics training (Kay et al., 1989). Once again, it is concluded that those students with more exposure to computers--i.e., attending public schools, with a computer at home, in midsize residential areas, and taking mathematical or computer-oriented majors--benefit in the form of less apprehension about majoring Computer Science. As pointed out earlier, Koohang (1989) has found that more computer experience reduces anxiety and increases enthusiasm towards computers; and Williams (1983) reported a positive correlation between attitudes towards computers and mathematics courses taken. It would seem to follow that the more enthusiastic, attitudinally positive, and less anxious one is about computers and computing, the less apprehensive one would be about majoring in Computer Science.

Instructional Influence

Only 19 percent of the variance in apprehension about majoring in Computer Science was explained by the other subscales ($p<.001$), with all of the other factors being related about the same, between $r=.32$ and $r=.35$ ($p<.001$). Of all the subscales investigated for the study, the least related to the others was instructional influence. The relatively low amount of explained variance, of 19 percent, for the multiple regression analysis, means that 81 percent of the variance in instructional influence was left unexplained by the four other subscales. Thus, more than for the other factors investigated in the study, future research focusing on additional factors would increase understanding of apprehension.

The analysis involving the demographic variables showed the following significant results: (a) public school students reported more positive instructional influence than nonpublic school students, (b) students in residential areas with 2,501 to 10,000 people reported more positive instructional influence than students in either small or larger areas, (c) students planning to attend 4-year and technical school reported more positive instructional influence than students either planning to attend a two-year college or not planning to continue with schooling, (d) seniors reported more positive instructional influence than juniors, and (e) students in more mathematically oriented majors and in majors where programming was stressed reported more positive instructional influence than students in less mathematical and computer-oriented majors.

The explanations discussed above for the other factors apply to this factor, instructional influence. With respect to type of school attended, it may be added here that, generally speaking, public schools have better facilities and more highly paid and qualified teachers than do nonpublic schools, since the former compete with industry for highly qualified personnel.

It may also be noted that, for this analysis, males did not report more positive instructional influence than females. This may be because, as Dick and Rallis (1991) pointed out, both men and women are in need of encouragement from teachers. In particular, females need more role models in Computer Science courses, i.e., more women teaching these courses.

The influence of teachers is very important, it must be emphasized, for the future career choice of high school students (Dick & Rallis, 1991). Teachers, more than anyone, must encourage qualified students to major in Computer Science. Once this reality is firmly established, more care will be taken to ensure that those who teach computer courses in the high schools are themselves highly enthusiastic about computers and computing, as well as technically competent.

Career and Employment Opportunities in Computing

As with instructional influence, only 19 percent of the variance in perception of career and employment opportunities in computing was explained by the other subscales ($p<.001$), with each of the other factors being weakly related, between $r=.26$ and $r=.36$ ($p<.001$). The relatively low amount of explained variance, of 19 percent, for the multiple regression analysis, means that 81 percent of the variance in this factor was left unexplained by the four other subscales.

Thus, future research focusing on additional factors would undoubtedly increase understanding of perception of career and employment opportunities in computing. The low amount of explanation confirms the complexity of the phenomenon of perception of careers and opportunities in Computer Science. It is undoubtedly the weak positive perception of careers and opportunities that mainly accounts for the declining enrollment in Computer Science as a major over the past decade.

The analysis involving the demographic variables showed the following significant results: (a) age was inversely related to positive perception of career and employment opportunities in computing, i.e., the younger the students, the more positive the perception, (b) students in public schools had a more positive perception than students in nonpublic schools, (c) students with a computer at home had a more positive perception than students without a computer at home, (d) students planning to attend 4-year and technical school reported a more positive perception than students either planning to attend a two-year college or not planning to continue with schooling, (e) sophomores reported a more positive perception than seniors, and (f) students in more mathematically oriented majors and in majors where programming was stressed reported more positive instructional influence than students in less mathematical and computer-oriented majors.

In general, the explanations discussed above for the other subscales apply to this factor, perception of career and employment opportunities in computing. With respect to type of school attended, it may be added here that public schools generally have greater access to guest speakers than do nonpublic schools, and such speakers may positively influence the students' perception of career opportunities in computing. Also, it may be noted that in homes where students have a computer, it is likely that the parents are more attuned to technology and thus talk about career opportunities in computing more frequently and more positively than is the case in homes where the students do not have a computer.

Finally, it may be noted that students in the more mathematical and computer-oriented majors, and in business majors, where computers are put to powerful practical use, did have the most positive perception of career and employment opportunities in computing. Thus, it would seem to follow that if more students were encouraged to major in these fields in high school, more of them would choose to major in Computer Science in college.

VI

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was to determine why high school students exhibit a reluctance to major in computer science. The study focused on variables that had been ignored or sparsely investigated in the literature. Answers to the following questions were sought within the study.

1. What factors are related to students' enthusiasm towards computing?

2. What factors are related to students' perceptions of their computing ability?

3. What factors are related to students' apprehension about majoring in computer science?

4. What factors are related to students' perceptions of the degree of positive instructional influence towards computing they have received?

5. What factors are related to students' perceptions of career and employment opportunities in computing?

Based upon the data analysis, strategies that educational administrators and classroom instructors could employ to encourage students to major in computer science were discussed.

To answer the questions of the study, an investigator-created instrument was administered to high school students taking computer courses, including sophomores, juniors, and seniors, in 143 public and 33 parochial high schools in New York State. One class from each school participated in the study, with an average of about 30 students per class, for a total sample size of 4,127. Those pupils who completed the survey instrument did so because their instructors agreed to have their classes participate in the investigation. The sample was believed to have been representative of the total population of students in computer courses in public and parochial high schools in New York State.

The survey instrument focused on the following five factors believed to be important in explaining high school students' attitudes towards computing and computer science: (a) enthusiasm towards computing, (b) perceptions of computing ability, (c) apprehension about majoring in computer science, (d) perceptions of the degree of positive instructional influence towards computing received, and (e) perceptions of career and employment opportunities in computing.

In addition, the study sought to determine the effect of various demographic and background characteristics of the students on the five major factors, including (a) age, (b) gender, (c) type of school attended (public or private), (d) population size of residential area, (e) year in school, (f) major in school, (g) type of educational institution the student was planning to attend, and (h) whether or not the student had a computer at home. A descriptive analysis of these demographic and background variables for the 4,137 students analyzed for the study revealed that their dominant characteristics were as follows: 48 percent were female and 52 percent were male, and they had an average age of 16.5 years. Most of them were juniors and seniors, and nearly 80 percent attended public schools. After graduation, most were planning to attend a 4-year college. They were mainly from smaller residential areas, with over 50 percent living in population centers of under 10,000 people, and almost three-quarters living in areas of under 100,000 people. Collectively, the students were majoring in 13 different areas, with no single major dominating the field. Slightly less than 5 percent of them were Computer Science majors, and slightly more than 50 percent had a computer at home.

To collect data from the sample of students, the investigator designed a questionnaire modeled on the Fennema-Sherman (1986) questionnaire (in the area of mathematics). The items reflected important issues that had been sparsely investigated, based on a review of the literature. Care was taken to conform to established procedures for creating a survey instrument, with respect to such things as phrasing of questions, appropriateness of wording for intended subjects, clarity of questionnaire items, structuring and scoring a Likert-type scale, and pretesting the survey instrument (Fowler, 1984; Hornville & Jowell, 1978; Moser & Kalton, 1972).

The questionnaire consisted of 34 items, and for each item the students were asked to indicate the extent of their agreement or disagreement on a 5-point Likert-type scale ranging from "Strongly agree" to "Strongly disagree." Thus the scores potentially could have ranged from 34 (34 X 1) to 170 (34 X 5), with higher scores indicating more interest in or attraction to computing.

The 34 items on the questionnaire composed the following five subscales: (a) enthusiasm about computing, (b) perception of computing ability, (c) teacher influence on computing, (d) apprehension about computers, and (e) perception of career opportunities in computer science. A Cronbach alpha analysis indicated that the separate items in each subscale could be combined into a single subscale score for purposes of data analysis, thus resulting in five separate subscale scores for each subject in the study, as well as a total instrument score.

Before distributing the questionnaires to the participants, a preliminary trial was done on a small sample, and the instrument was found to be clear of wording and intention. The data collection procedure began during November of 1992 when the investigator distributed letters and flyers to public and parochial high school teachers attending a computer conference in Ellenville, New York. In addition, these materials were distributed to high school teachers attending professional meetings of Nassau County Mathematics Teachers Association and Suffolk County Mathematics Teachers Association, and the investigator sent a letter to 902 chairpersons of Mathematics Departments in the New York State public and parochial high schools, asking for their cooperation in the study.

Chairpersons and computer instructors who volunteered to participate in the study were then sent a letter thanking them for their cooperation, along with questionnaires for each student in their class. The participating teachers had their students complete and return the questionnaires during a class session, and then forwarded the filled-in instruments to the investigator. The data collection process was completed during January and February of 1993.

Among the 190 schools that were sent questionnaires by the investigator, 176 returned the completed questionnaires, resulting in a total of 4,350 questionnaires initially received. Of these, 223 were determined to be unusable, resulting in a total of 4,127 usable questionnaires analyzed for the study.

The data on the questionnaires were coded and analyzed by computer using SPSS. To answer the major research questions of the study, the five computer subscales were analyzed using the Pearson product-moment correlation coefficient (Pearson "r") and multiple regression, and the relationship between the demographic variables and the subscales were analyzed using, as appropriate, the Pearson r, t-test for means of independent samples, and analysis of variance (ANOVA).

Conclusions

The study clearly showed that certain student characteristics were more consistently related to the computer subscales than were other characteristics. Most important, the study found that those students who attended public schools, had a computer at home, were planning to attend a four-year college or technical school, and who were in mathematically oriented majors had the most positive attitudes towards computing and computer science. Specifically, these students reported the most enthusiasm towards computing, the most positive perception of their computing ability, the least apprehension about computing, the most positive instructional influence, and the most positive perception of career and employment opportunities in computing. Conversely, those students who attended parochial schools, did not have a computer at home, were not planning to attend a four-year college or technical school, and who were not in mathematically oriented majors reported the least positive attitudes towards computing and computer science.

In considering these differences, certain points may be emphasized. With respect to public versus nonpublic school students, it should be noted that the nonpublic schools in the study were religious and lacked state funding for computer equipment. The students in these schools, therefore, may have had less exposure to computers, and thus a less positive attitude towards computers and computer science. Similarly, those students with a computer at home undoubtedly had a more positive attitude towards computers and computer science than students without a computer at home, because the former group had more time to experiment with the technology, to do exercises, and to benefit from instruction from their parents. With regard to students in mathematically oriented majors, they probably had the most positive attitude towards computing and computer science because they were suited to technical and quantitative tasks. A similar explanation may apply to those students who planned to attend technical school after graduation from high school.

A second major overall conclusion of the study was that males had a more positive attitude than females on three of the computer subscales: enthusiasm towards computing, perception of computing ability, and apprehension about majoring in computer science. Females, in contrast, did not exhibit a more positive attitude towards computing and computer science than males on any of the subscales. This finding may be attributable to the fact that males in

American society are socialized to relate more comfortably to machine technology and quantitative oriented subjects than are females.

Other findings from the study were too inconsistent across subscales to enable any conclusions to be drawn from them. Among these findings, students who were in the sophomore year exhibited a more positive perception of their computing ability and career and employment opportunities in computer science than did students in other grades; students who lived in an area with a population size between 2,501 and 10,000 people had a more positive perception of their computing ability and reported more positive instructional influence than students from smaller and larger geographic areas; and younger students had a more positive perception of career and employment opportunities in computer science than did older students.

Recommendations

Based on the findings from the study, the investigator would like to offer the following recommendations, which hopefully will be considered and implemented by educational administrators, teachers, guidance counselors, government leaders, and future researchers, intended to increase the number of Computer Science majors in the United States.

As regards the local level, one recommendation is that teachers should encourage students to discover computing concepts for themselves, through ingenious use of computer games, exercises, projects, and problem-solving tasks. Second, teachers should emphasize computer projects that are practical--addressed to real-life issues and concerns--rather than those which are mathematical and abstract. Third, teachers should make an effort to eliminate gender bias from projects by seeking out those computer games that are not male-oriented. Teachers and guidance counselors should encourage capable students to major in Computer Science in college. Fourth, teachers and educational administrators should establish mentoring projects with local colleges in which Computer Science majors and faculty visit high-schools and discuss computer science as a profession. Mentors could also come from the business world, and discuss the role of computer professionals in business. Fifth, Teachers, counselors, and educational administrators should encourage parents to support their children's computing endeavors in the home, such as by praising their children for work well done on the computer and assisting them with computer-related problems and tasks.

As regards the state level, it is recommended that a unified computing curriculum be established, in conjunction with professional computer organizations, such as the Association for Computing Machinery, to eliminate disparities that currently exist in various schools and to minimize the chance of such disparities reappearing in the future. Second, In New York State, a computing teacher certification should become a requirement. This would ensure that competent teachers implement a challenging, interesting curriculum, and eliminate or minimize the current practice of teachers certified in other fields, such as Mathematics or Business, teaching Computer Science courses in the high schools. Third, computers should be integrated into all high school courses. This will make more students comfortable and expert at using computers for a wide variety of purposes, and therefore increase the probability that more of them will choose Computer Science as a major in college.

As regards the national level, it is recommended that such professional organizations as the Association for Computing Machinery should formulate a national policy of "computer guidelines and goals," and through such means as public service advertisements, eliminate the negative stereotypes of computer scientists as "nerds" and "hackers," and encourage more students to major in Computer Science. Second, such professional organizations, in conjunction with educational leaders, should pressure computer game manufacturers to create games that are more "unisex," appealing to girls as much as to boys. This will encourage more girls to become familiar with and expert at using the computer at an early age, and thus increase the probability that more female high school students will choose Computer

Science as a major in college. Third, government should increase funding to public and parochial schools so that they can purchase more computer hardware and software.

As regards future research, the following recommendations are offered to researchers, which would add important knowledge to our understanding of factors that inhibit students to major in Computer Science:

First, it is recommended that researchers be aware of, and attempt to safeguard against, a possible problem arising from self-reporting among research participants. With self-reporting, the students may feel the teacher will examine their responses, and thus the students may alter their responses to satisfy the expectations of the teacher. To minimize this possibility, it is recommended that student monitors be used to collect and mail questionnaires.

Second, it is recommended that researchers conduct the following studies: One study could focus on the relationship between the attitudes of high school teachers of computer courses towards computing and the attractiveness of computing as a career choice to students in their classes. A second study could be conducted that focused on the relationship between ethnicity, or race, as a major student variable, and attitudes towards computing and computer science as a career choice. A third study could be conducted on the relationship between parental characteristics of high school students-- such as their attitudes towards computers, age, marital status, and educational level--and the attitudes of the students towards computers, computing, and Computer Science as a major in college. A fourth study could be conducted on the relationship between teacher qualifications and the attractiveness of computer sciences as a career option.

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Appendix A

Computer Survey

This survey deals with your attitudes and experiences toward computing. Do **NOT** put your name on this sheet. Your reply will be kept anonymous.

Please indicate your response by circling or writing in the appropriate answer.

1. I am a female male

2. My age is ________ years.

3. The city I live in is ______________________________________.

4. I attend a ____

   a. public high school
   b. non-public high school

5. I am a:
   a. freshman
   b. sophomore
   c. junior
   d. senior

6. When I graduate from high school, I plan on attending
   a) a two year college
   b) a four year college
   c) a technical or vocational school
   d) none of the above

7. If you plan on attending college, what is your intended major?

   ____

8. Do you have a computer at home?

   a. yes
   b. no

Please circle the response which most matches your feelings to the following statements:

1. I get excited by computer programming problems.

strongly agree	agree	uncertain	disagree	strongly disagree

2. I dread computer classes.

strongly agree	agree	uncertain	disagree	strongly disagree

3. My teachers have encouraged me to study more about computers.

strongly agree	agree	uncertain	disagree	strongly disagree

4. The need for computer programmers will decrease in the future.

strongly agree	agree	uncertain	disagree	strongly disagree

5. I have found it hard to win the respect of computer teachers.

strongly agree	agree	uncertain	disagree	strongly disagree

6. Figuring out computer problems does not thrill me.

strongly agree	agree	uncertain	disagree	strongly disagree

7. Most computer science graduates have trouble finding a job in their field of study.

strongly agree	agree	uncertain	disagree	strongly disagree

8. When they graduate college, computer science majors are only skilled to be programmers.

strongly agree	agree	uncertain	disagree	strongly disagree

9. I want to study computer science because I know it will be professionally rewarding.

strongly agree	agree	uncertain	disagree	strongly disagree

10. Many of my teachers dislike working with computers.

strongly agree	agree	uncertain	disagree	strongly disagree

11. A computer test would scare me because I think I'll get a bad grade.

strongly agree	agree	uncertain	disagree	strongly disagree

12. I believe I'm capable of solving computer problems.

strongly agree	agree	uncertain	disagree	strongly disagree

13. I am confident that I could do advanced work in computer science.

strongly agree	agree	uncertain	disagree	strongly disagree

14. I think I would feel uncomfortable being around computer science majors.

strongly agree	agree	uncertain	disagree	strongly disagree

15. The challenge of computer problems does not excite me.

strongly agree	agree	uncertain	disagree	strongly disagree

16. Computer science majors have too much homework.

strongly agree	agree	uncertain	disagree	strongly disagree

17. Computer problems are boring.

strongly agree	agree	uncertain	disagree	strongly disagree

18. Computer science graduates can find employment in a wide variety of positions.

strongly agree	agree	uncertain	disagree	strongly disagree

19. My teachers think computer courses are a waste of time for me.

strongly agree	agree	uncertain	disagree	strongly disagree

20. I am confident that I can get good grades in computer science courses in college.

strongly agree	agree	uncertain	disagree	strongly disagree

21. Once I start to work on a computer problem, I find it hard to stop.

strongly agree	agree	uncertain	disagree	strongly disagree

22. I usually have been at ease in computer classes because I can easily handle the work.

strongly agree	agree	uncertain	disagree	strongly disagree

23. Even though I study, computing tasks seem unusually hard for me.

strongly agree	agree	uncertain	disagree	strongly disagree

24. I fear doing advanced computing.

strongly agree	agree	uncertain	disagree	strongly disagree

25. When a question is left unanswered in a computer class, I continue to think about it afterward.

strongly agree | agree | uncertain | disagree | strongly disagree

26. I have a lot of self-confidence when it comes to computers.

strongly agree | agree | uncertain | disagree | strongly disagree

27. My computer teachers are interested in my progress in computer courses.

strongly agree | agree | uncertain | disagree | strongly disagree

28. There are many jobs available for computer science majors when they graduate college.

strongly agree | agree | uncertain | disagree | strongly disagree

29. Computer programming is my best subject.

strongly agree | agree | uncertain | disagree | strongly disagree

30. I have to spend more time studying for computer classes than for other classes.

strongly agree | agree | uncertain | disagree | strongly disagree

31. There are a great deal of advancement opportunities for computer science college graduates.

strongly agree | agree | uncertain | disagree | strongly disagree

32. I think I would be comfortable being around computer science majors.

strongly agree | agree | uncertain | disagree | strongly disagree

33. Computer programmers have a dead end job.

strongly agree	agree	uncertain	disagree	strongly disagree

34. I get upset when I try to solve a hard computer problem.

strongly agree	agree	uncertain	disagree	strongly disagree

Appendix B

December 1, 1992

Dear Mathematics Chairperson:

As you know, one of the greatest challenges confronting teachers today is that of trying to interest greater numbers of students in careers in computing. The number of students electing to pursue careers in computer science has declined dramatically over the last several years. If the United States is to remain technologically competitive, this trend needs to be reversed.

I would greatly appreciate your participation in a study to measure student attitudes toward computing. The opinions of your computing students are of great value in the analysis of the reasons for this trend.

Participation in the study is easy. If you agree to participate, you will be mailed a set of anonymous questionnaires to be distributed to the students in one of your computer programming classes. It should take your students approximately 15 minutes to complete the questionnaire. Please be assured that student answers will be held in strictest confidence (this study is part of a doctoral program) and no school will be identified in the study.

In order to participate in this study, please complete the attached information sheet. You may return the form by mail. Enclosed for your convenience is a stamped, self-addressed envelope.

If you have any questions, please feel free to contact me. Your cooperation is greatly appreciated.

Thank you!

Very truly yours,

Richard O'Lander
Assistant Professor of
Computer Science & Mathematics

INFORMATION SHEET

_________ **YES, I would like to paticipate in this study. Number of students:___________**

_______ **Sorry, I do not want to participate in this study.**

Name: ____________________________

Address: ____________________________

____

Telephone: ____________________________

Please return to:

Prof. Richard O'Lander

Appendix C

December 29, 1992

Dear Educator:

Thank you for volunteering to participate in a survey on student attitudes toward computing. Please be assured that no school will be identified in the study.

Encloses please find the number of questionnaires that you requested. Please distribute the questionnaires to your students. The completed questionnaires may then be returned to me no latter than January 30, 1993.

If you should have any questions, please feel free to contact me at your convenience.

Thank you very for your participation in this important survey.

Very truly yours,

Richard O'Lander
Assistant Professor of
Computer Science and Mathematics