THE EFFECTS OF GENDER AND COOPERATIVE LEARNING WITH CAI ON COLLEGE STUDENTS' COMPUTER SCIENCE ACHIEVEMENT AND ATTITUDES TOWARD COMPUTERS

by
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ABSTRACT

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The purpose of this study was to examine the effects of gender and cooperative learning with CAI on college students' computer science achievement and attitudes toward computers, when the effects of computer ownership, prior computer instruction, previous software and programming experience were controlled. The participants were 155 undergraduates enrolled in introductory computer courses at two colleges in North Taiwan during the Fall 1996 semester. Before the treatment period, they were asked to fill out the Background Data Form, instructed with cooperative learning strategy, and trained on cooperative and individual learning with CAI. During the treatment period, they were randomly assigned to the treatment (78 students) or the control group (77 students). The treatment group students used a CAI program on computer numbering, encoding, and hardware systems with their partner throughout all six CAI sessions. The control group students used the same CAI program individually within the six CAI sessions. After the 6-week treatment period, both groups were posttested by a 40-item multiple-choice Computer Science Achievement Test (CSAT) and a 30-item Computer Attitude Scale (CAS). Data for both posttests were collected from 153 students (77 in the treatment, 76 in the control group; 62 males, 91 females) and analyzed by MANCOVA and follow-up univariate hierarchical MRC analyses for ANCOVAs.

Based on the covariate-adjusted CSAT scores, the results indicated that students using CAI cooperatively had a significantly higher mean than those using CAI individually. Neither gender nor interaction effects were found. Regarding the covariate-adjusted CAS scores, the results showed that males had a significantly higher mean than females. No treatment or interaction effects were found.

Due to the higher computer achievement resulted from cooperative learning with CAI, this study suggested that instructors apply cooperative learning strategy in CAI settings in computer courses, and CAI software be designed for group work. Furthermore, because of females' less positive attitudes toward computers, parents, educators, schools, and software developers should help to bridge the gender gap.

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and love

CHAPTER 1

INTRODUCTION

Background

Computer-assisted instruction (CAI) has been used for more than thirty years. During the last three decades, there have been a large number of studies evaluating the effects of CAI. Many of these studies have shown that this method had positive effects on students' achievement, attitudes, and learning time. A meta-analysis of 51 studies on CAI in grades 6-12 was conducted by Kulik, Bangert and Williams (1983). Kulik and his colleagues found that in 39 out of 48 studies with results from final examinations, students using CAI scored higher than did students receiving traditional instruction. In 8 out of 10 studies with results on attitudes toward the subject matter being studied, students' attitudes were more positive in CAI classrooms. Among four studies with results on attitudes toward computers, all of them reported that students using CAI possessed more positive attitudes toward computers.

With the encouraging results of CAI, researchers and theorists have attempted to explore why CAI affects students' learning. As Alessi and Trollip (1991) pointed out, one often praised advantage of CAI is its capability to accommodate individual differences. For example, Haas (1976) claimed that one important feature of CAI is its compatibility with individualized instruction, (i.e., pacing, one-to-one tutoring, and branching techniques). Similarly, Bujea and Voyce (1988) argued that with CAI the pace, duration, and time of instruction can be adjusted to each student. In addition, a well-designed CAI program will provide paths based on each student's needs (Bujea & Voyce, 1988).

Many researchers and theorists attribute the positive effects of CAI to its ability to individualize; therefore, CAI is typically implemented in individualized settings where students work at a computer by themselves. The majority of CAI software is also designed for individual work. However, researchers have been concerned that working individually at the computer may have a negative impact on students' social development (Dede, 1983; Hawkins, Sheingold, Gearhart, & Berger, 1982). Similarly, Johnson and Johnson (1986) have indicated that individualized CAI approach has a number of limitations. For example, when students use CAI alone for extended periods, this approach may create mood states such as loneliness, boredom, and frustration which will decrease students' motivation. Further, this approach cannot provide peer social modeling and denies students the opportunity for discussion with their peers. The approval from the computer is much less reinforcing than compliments from peers. The feedback from the computer is less complex and complete than the feedback and evaluation from peers. In addition, this approach limits student's critical thinking skills (Johnson & Johnson, 1986).

Johnson and Johnson (1986) have argued that the combination of CAI and cooperative learning can overcome many limitations and problems of individualized CAI method. They stated the following:

> The isolation, the lack of oral explanation and elaboration of the information being learned, the lack of social models, the impersonality of the reinforcement and feedback, the lack of creative and divergent thinking, and the lack of peer accountability existing in computer-assisted

individualistic learning activities all are reversed in computer-assisted cooperative learning activities. (p. 18)

In fact, extensive research in non-computer-based instruction has indicated that students working in cooperative learning groups had higher achievement than those working alone (Humphreys, Johnson, & Johnson, 1982; Johnson, Johnson, Johnson, & Anderson, 1976; McClintock & Songuist, 1976; Okebukola & Ogunniyi, 1984; Sherman & Thomas, 1986). In addition to academic achievement, research has shown that cooperative learning produced better social and affective outcomes than traditional instruction (Humphreys et al., 1982; Johnson et al., 1976; Okebukola, 1986; Slavin & Karweit, 1981). Whether cooperative learning with CAI can result in higher achievement and more positive attitudes is a question which needs to be answered.

Gender differences favoring males in mathematics and science achievement have been reported in a number of studies (Carpenter, Lindquist, Mathews, & Silver, 1983; Fleming, & Malone, 1983; Johnson, Johnson, Scott, & Ramolae, 1985; Jones, Burton & Davenport, 1984; Ramist & Arbeiter, 1986; Reyes & Padilla, 1985; Swafford, 1980). Furthermore, males have been found to have lower levels of mathematics anxiety and more positive attitudes toward science or science classes than females (Betz, 1977; Johnson et al. 1985; Llabre & Suarez, 1985; Reyes & Padilla, 1985; Steinkamp, 1982; Tobias, 1978). Similar to males' higher achievement in mathematics and science or males' more positive attitudes toward mathematics and science, males may have better performance in computer science or more positive attitudes toward computers than females. Whether males have higher computer achievement or more positive computer attitudes also needs to be determined.

Purpose of the Study

The purpose of this study was to examine the effects of cooperative versus individual learning with CAI on college students' computer science achievement and attitudes toward. Furthermore, this study sought to investigate whether there exist gender differences in computer science achievement or attitudes toward computers.

Factors such as home computer ownership, having taken a computer course, and previous computer experience have been found to be significantly related to computer literacy achievement (Clarke & Chambers, 1989; Taylor & Mounfield, 1994; Woodrow, 1991) or attitudes toward computers (Colley, Gale, & Harris, 1994; Hunt & Bohlin, 1993; Koohang, 1986, 1989; Loyd & Gressard, 1984b). These computer-related factors, therefore, should be taken into account when investigating gender differences in computer achievement and attitudes toward computers. It was the intention of this study to examine the effects of gender and cooperative learning with CAI on computer science achievement and attitudes toward computers after the effects of four computer-related factors (i.e., computer ownership, prior computer instruction, previous software experience, and previous programming experience) have been controlled.

Research Questions

This study attempted to address the following questions:

1. Does cooperative learning with CAI result in better achievement in computer science or more positive

attitudes toward computers than individual learning with CAI in a college-level computer course?

2. Are there gender differences in computer science achievement or attitudes toward computers in a college-level computer course?

3. Are there interactions between gender and CAI method (cooperative vs. individual learning) with respect to computer science achievement or attitudes toward computers in a college-level computer course?

Hypotheses

Research Hypotheses

Based on the research questions, the following research hypotheses were formulated:

1. The population mean of students who use CAI in two-member cooperative groups is greater than the population mean of students who use CAI individually with respect to computer science achievement, when the effects of computer ownership, prior computer instruction, previous software experience, and previous programming experience are controlled.

2. The population mean of male students is greater than the population mean of female students with respect

to computer science achievement, when the effects of computer ownership, prior computer instruction, previous software experience, and previous programming experience are controlled.

3. There is an interaction between gender and CAI method in the population with respect to computer science achievement, when the effects of computer ownership, prior computer instruction, previous software experience, and previous programming experience are controlled.

4. The population mean of students who use CAI in two-member cooperative groups is greater than the population mean of students who use CAI individually with respect to attitudes toward computers, when the effects of computer ownership, prior computer instruction, previous software experience, and previous programming experience are controlled.

5. The population mean of male students is greater than the population mean of female students with respect to attitudes toward computers, when the effects of computer ownership, prior computer instruction, previous software experience, and previous programming experience are controlled.

6. There is an interaction between gender and CAI method in the population with respect to attitudes toward computers, when the effects of computer ownership, prior computer instruction, previous software experience, and previous programming experience are controlled.

Null Hypotheses

The following null hypotheses were tested in this study:

1. There is no difference between the population mean of students who use CAI in two-member cooperative groups and the population mean of students who use CAI individually with respect to computer science achievement, when the effects of computer ownership, prior computer instruction, previous software experience, and previous programming experience are controlled.

2. There is no difference between the population mean of male students and the population mean of female students with respect to computer science achievement, when the effects of computer ownership, prior computer

instruction, previous software experience, and previous programming experience are controlled.

3. There is no interaction between gender and CAI method in the population with respect to computer science achievement, when the effects of computer ownership, prior computer instruction, previous software experience, and previous programming experience are controlled.

4. There is no difference between the population mean of students who use CAI in two-member cooperative groups and the population mean of students who use CAI individually with respect to attitudes toward computers, when the effects of computer ownership, prior computer instruction, previous software experience, and previous programming experience are controlled.

5. There is no difference between the population mean of male students and the population mean of female students with respect to attitudes toward computers, when the effects of computer ownership, prior computer instruction, previous software experience, and previous programming experience are controlled.

6. There is no interaction between gender and CAI method in the population with respect to attitudes

toward computers, when the effects of computer ownership, prior computer instruction, previous software experience, and previous programming experience are controlled.

Justification of the Study

Piaget (1973) advocated that peer interaction is important for cognitive development. He believed that accommodation, the reorganization of an individual's cognitive structures, is one important process in cognitive development. The "reorganization to higher levels of thinking is not accomplished easily. The child must 'rethink' his or her view of the world. An important step in this process is the experience of cognitive conflict" (Gredler, 1992, p. 225). During peer interactions, students can discuss different propositions which provoke cognitive conflict, and then be ready to modify their ways of thinking.

Constructivists also emphasize the importance of peer interaction. Constructivists view learning as "the acquisition of knowledge by individuals through a process of construction that occurs as sensory data are given meaning in terms of prior knowledge" (Tobin, Kahle, & Fraser, 1990, pp. 6-7). Learners are active agents attempting to make sense of their world (Pines & West, 1986), using their background knowledge as an index of understanding. Through peer interactions, individuals' existing conceptions can be tested, elaborated, and changed on the basis of fresh meanings negotiated with peers.

Cooperative learning is a teaching method which can facilitate peer interactions. In this method, based on Piaget's theory, students can view issues from different perspectives, examine their own thinking, explore other alternatives, and then reorganize their thinking. From a constructivist perspective, this method can provide an environment in which students share multiple perspectives, compare and negotiate meanings, and then construct their own knowledge.

According to Piaget's theory and a constructivist viewpoint, cooperative learning is an important teaching strategy. Much attention, therefore, should be paid to study how this method with CAI affect students' achievement or attitudes. In recent years, researchers have begun to study the effects of cooperative learning with CAI. Studies have examined the effects of cooperative learning with CAI on achievement in various subject fields such as mathematics, biology, geography, chemistry, social studies, and language arts. Little research in this area has focused on achievement in computer science. It is important and necessary to study the effects of cooperative learning with CAI on computer science achievement.

Since the introduction of computers, computers have entered almost all sectors of our society. Many careers involve the use of computers. Gender differences in computer literacy achievement or attitudes toward computers can yield male-female disparities in career selections and/or performance in computer-related fields. Therefore, it is important to study whether there exist gender differences in computer science achievement or attitudes toward computers.

Significance of the Study

The results of this study could provide educators with guidance in structuring a CAI environment so that teachers can adopt an appropriate strategy in CAI settings in computer courses. The findings of this study could also provide information on how gender is related to computer science achievement and attitudes toward computers. Educators, therefore, could better understand the issue of gender. In addition, this study may help increase the knowledge of the factors influencing computer science achievement and attitudes toward computers. Moreover, this study may provide with a base for further studies in computer education, especially for those to be conducted in Taiwan.

Definition of Terms

Computer-assisted Instruction

Computer-assisted instruction (CAI), also called computer-based instruction (CBI) or computer-based training (CBT), is a teaching method which uses the computer to provide instruction through interactions with learners. CAI programs can be generally classified as tutorials, drill and practice, simulations, instructional games, and problem solving.

Cooperative Learning

Cooperative learning is a teaching strategy in which students work together in small groups and help each other learn academic material. There are many different forms of cooperative learning including Learning Together, Jigsaw, Group Investigation, and Student Team Learning. Each of these approaches is described as follows:

1. Learning Together

This approach was developed by David and Roger Johnson at the University of Minnesota (Johnson & Johnson, 1975, 1987). In this approach, students work together on assignment sheets in groups of four or five. Each group completes and hands in a single sheet which represents the group effort. Students receive praise and rewards based on the group product.

2. Jigsaw

Jigsaw was originally developed by Elliot Aronson and his colleagues (1978). In this method, the teacher first divides content material into several sections. Next, students are assigned to three- to six-member heterogeneous groups. Each group member is assigned a section and independently studies his/her portion. Then, members of different groups who have studied the same portion meet in an "expert group" to discuss their portions. Later, each group member returns to his/her group and teaches other members. Last, an exam which assesses the mastery of the overall material will be given to students individually.

3. Group Investigation

This method was developed by Sharan and his colleagues at the University of Tel-Aviv (Sharan & Sharan, 1976). In this method, students are assigned to two- to six-member groups. Each group then selects a topic from an area being studied by the entire class. Each member carries out an investigation and each group summarizes and presents findings to the entire class.

4. Student Team Learning

Student Team Learning (STL) techniques were developed and researched by Slavin and his colleagues at Johns Hopkins University (Slavin, 1981). The most frequently used techniques are Student Team-Achievement Divisions (STAD), Teams-Games-Tournament (TGT), and Jigsaw II.

In STAD (Slavin, 1978), students are assigned to four-member heterogeneous groups. The teacher presents a lesson, and each team member masters the material and helps other members master it. Students then are given weekly quizzes. Points are rewarded when students' scores exceed their past scores. These points are summed to form team scores. Teams that meet certain criteria receive recognition.

In TGT (DeVries & Slavin 1978; Slavin 1986), as in STAD, students are assigned to small heterogeneous groups and the teacher presents academic material. Students then are given worksheets covering the material and study together with their teammates. Team members compete with members of other teams with similar performance. In the tournament, students are assigned to three-person "tournament tables". Teams with high number of points receive certificates or rewards.

Jigsaw II was Slavin's (Slavin, 1986) adaptation of Jigsaw technique. In this approach, students are assigned to four- to five-member groups. All students read a common narrative such as a short story or a book chapter. Then, each student receives a topic. Students with same topics meet in an expert group and discuss their topics. Students then return to their groups and teach their teammates about their topics. Finally, a quiz covering all of the topics is given to each student. Team scores are based on improvement scores of each team member as in STAD. Teams with high team scores earn certificates or rewards.

Cooperative Learning with CAI

Cooperative learning with CAI is a combination of the use of CAI and cooperative learning strategy. It involves assigning a number of students (usually between two to four) to work on a CAI program together. A modified Learning Together model were used as the cooperative learning strategy in the study; hence, cooperative learning with CAI is defined as a teaching method in which two students are assigned to use CAI together, to discuss the material presented by the computer, to help each other learn it, to give feedback to each other, and to complete CAI lessons.

Individual Learning with CAI

Individual learning with CAI is defined as an instructional approach in which students use CAI and complete CAI lessons alone without discussion with other students or getting feedback and assistance from other students.

Computer Science Achievement

Computer science achievement is operationally defined as a student's scores on the Computer Science

Achievement Test (CSAT) developed by the researcher. The CSAT measured the general knowledge of computer numbering systems, encoding systems, and hardware systems.

Attitudes toward Computers

Attitudes toward computers refer to an individual's feeling of working with and learning about computers. Three types of attitudes are included: computer anxiety, computer confidence, and computer liking. Computer anxiety is defined as anxiety toward or fear of computers or learning to use computers. Computer confidence is defined as confidence in the ability to learn about or use computers. Computer liking is defined as enjoyment or liking of computers and using computers. In this study, attitudes toward computers are operationally defined as a student's total scores on the Computer Attitude Scale (CAS), designed by Loyd and Gressard (1984a).

Computer Ownership

Computer ownership is defined as whether or not (yes or no) a student owned a computer at home.

Prior Computer Instruction

Prior computer instruction is defined as whether or not (yes or no) a student had been in a computer course before taking the introductory computer course in this study.

Previous Software Experience

Previous software experience is defined as number of months of experience a student had had with a word processing, spreadsheet, or database software program before taking the introductory computer course in this study.

Previous Programming Experience

Previous programming experience is defined as number of months of experience a student had had in writing a computer program before taking the introductory computer course in this study.

CHAPTER 2

REVIEW OF RELATED LITERATURE

This chapter consists of three main sections. The first section reviews studies comparing the effects of cooperative and individual learning with CAI on students' achievement and attitudes. The second section reviews research on gender differences in computer literacy achievement and attitudes toward computers. The last section is a summary and synthesis of the reviewed studies.

Cooperative versus Individual CAI

A large number of studies on cooperative learning with CAI have been conducted in recent years. Many of these studies have examined the effects of cooperative versus individual learning with CAI on students' achievement, attitudes, social interactions or interpersonal relations. This section contains a review of studies comparing the effects of cooperative and individual learning with CAI on students' achievement and attitudes.

Achievement

Significant Differences

A number of studies have compared students' achievement between these two CAI methods. Many studies at the middle school level (grades 6-8) showed that students using CAI cooperatively in pairs or in small groups had significantly better performance or higher achievement than students using CAI individually. One study by Mevarech, Silber, and Fine (1991) examined the effects of cooperative versus individual CAI on mathematics achievement. Their study involved 149 sixth-grade students in Israel and lasted approximately one semester. Results of ANCOVA indicated that students who used a drill-and-practice CAI program in mathematics in pairs scored significantly higher on both immediate, $F = 4.62$, $p < .05$, and delayed (2 months later) posttests, $F = 8.03$, $p < .001$, than those who used the same CAI program individually.

Dalton, Hannafin, and Hooper (1989) compared the performance between students working on a computer-based sex education lesson in pairs and those working on the same lesson individually. Participants were 60 eighth-grade students from a health class. Results of a three-way ANOVA showed that students who worked cooperatively with a partner scored significantly higher on an achievement posttest (M = 70.42) than those who worked individually (M = 51.36), $F(1, 52) = 19.49$, $p < .0001$. In addition, students who worked cooperatively consistently achieved better across both gender and ability level.

Johnson, Johnson, and Stanne (1985) compared the effects of computer-assisted cooperative, competitive and individualistic instruction on achievement. Participants were 71 eighth-grade students randomly assigned in groups of four (or five) to one of three conditions (i.e., cooperative, competitive, or individualistic conditions) stratifying for sex and ability. Students all used a modification of a CAI simulation called "Geography Search", supplemented with written materials on the fundamentals of maps reading and navigation. Students' achievement was assessed by daily worksheets, a final examination, and their problem-solving performance (the amount of gold accumulated) on the CAI simulation program. The experiment took 10 days.

Results of the LSD post hoc comparisons indicated that students in the cooperative condition completed more and correctly completed more worksheet questions than those in the competitive or individualistic condition ($p < .05$). Students in the cooperative condition scored higher on all types of questions (factual recognition, application, and problem solving) on the final examination than those in the individualistic condition ($p < .05$). Students in the cooperative condition performed better (accumulated more gold) on the CAI simulation program than those in the competitive or individualistic condition ($p < .05$).

Another study by Johnson et al. (1986) also compared the effects of computer-assisted cooperative, competitive and individualistic instruction on achievement. Seventy-four eighth-grade students participated in this study. Results of this study were similar to those of their previous study. Students in the cooperative condition completed more worksheet questions, $F(2, 64) = 5.16$, $p < .01$, and correctly completed more worksheets questions, $F(2, 64) = 3.34$, $p < .05$, than those in the competitive and individualistic conditions. Students in the cooperative condition performed better on the CAI simulation program than those in the other two conditions, $F(2, 64) = 28.72$, $p < .01$.

Several studies at the university level also supported the positive outcomes of cooperative learning with CAI. Park (1993) compared the effects of cooperative and individual learning with CAI on achievement in an introductory undergraduate chemistry class. This study involved 109 college students enrolled in a fundamental chemistry course for science majors. Participants all used a CAI program consisting of five chemistry lessons. Results of a two-way ANOVA showed a significant difference on a chemistry posttest between students who used CAI cooperatively in pairs ($M = 67.45$) and those who used CAI individually ($M = 60.18$), $F(1, 97) = 4.81$, $p = .03$. The Scheffé F-test also showed a significant difference between these two CAI methods, $F = 4.54$, $p < .05$.

Reglin (1990) examined the effects of cooperative versus individualized CAI on mathematics achievement. Participants were 53 prospective minority teachers enrolled in a mathematics remediation seminar for the Education Entrance Examination. They all used a CAI mathematics program in five domains: arithmetical concepts, arithmetical operations, problem solving, measurement, and geometry. The experiment lasted 9 weeks. Results of the study indicated that students who used the CAI mathematics program in pairs scored significantly higher on a mathematics posttest than those who used the same CAI program individually, $F = 8.67$, $p = .005$.

Stephenson (1992) examined the effects of student-instructor interaction (present/absent) and paired/individual study on achievement in a CBT environment. His study involved 84 college business statistics students. Results of a three-way ANOVA showed that students who used a spreadsheet CBT tutorial in pairs performed better on a computer statistics exercise than those who used the same CBT tutorial individually, $F(1, 76) = 6.624$, $p = .012$.

With the positive achievement effects of cooperative learning with CAI, researchers of these studies generally suggested that CAI be structured in group settings. Stephenson (1992) stated that "CBT instructors should insure that a team configuration is used" (p. 25). Johnson et al. (1986) also suggested that "when teachers wish to maximize achievement on computer-assisted learning tasks, they would be well-advised to structure the lesson cooperatively rather than competitively or individually" (p. 391).

In these studies, many researchers attempted to analyze factors that might contribute to the positive achievement outcomes resulted from cooperative learning with CAI. Dalton et al. (1989) and Reglin (1990) noted that students in cooperative CAI settings were given strategies for interacting, discussing answers to questions presented in a CAI lesson, and resolving disagreements. On the other hand, students in individual CAI settings were limited to only the information presented in a CAI lesson, and their own strategies. Mevarech et al. (1991) also claimed that the main reason for the advantages gained by cooperative learning with CAI is considered to be the interaction between students during CAI learning processes. Similarly, Stephenson (1992) pointed out that social functions are important to students' learning. In the traditional classroom, the teacher may provide most of these functions. In individual CBT settings, the computer can not provide these functions. However, in group CBT settings, these functions can be provided by a team partner. In addition, Park (1993) argued that the improvement in achievement produced by cooperative learning with CAI can be the result of peer teaching that goes on with the cooperative CAI settings.

No Differences

Although a number of studies indicated that cooperative learning with CAI had positive effects on students' achievement, a number of studies indicated no significant differences in achievement between these two methods. A study by Mevarech (1993) examined the effects of cooperative versus individualized CAI on mathematics achievement of high and low achieving students. A total of 110 third-grade students in Israel participated in this study. This study lasted approximately one semester and indicated no significant differences in mathematics achievement on both computer-adaptive and paper-administered posttests between students who used a drill-and-practice CAI program individually and those who used the same CAI program in single-sex homogenous pairs.

Shlechter, Pollock, Rude-Parkins, and Wong (1992) compared middle-school students' performance between small group and individual CBI. Participants were 76 seventh-grade students assigned to one of three conditions: homogeneous small group (four students per terminal), homogeneous dyad (two students per terminal), or individual. All students received a 50-minute CBI lesson on tarantulas. Results of this study showed no significant difference on both immediate and delayed (6 weeks later) posttests among these three CBI settings.

Justen, Adams, and Waldrop (1988) compared the effects of group and individual CAI on students' achievement in an introductory special education course. Participants were 64 college students enrolled in two sections of an introductory special education course. A quasi-experimental design was used in the study. Thirty-three students enrolled in the first section used CAI individually for the first half of the course and used CAI in two- or three-member groups for the second half. The order was reversed for the other 31 students enrolled in the second section. An independent *t* test indicated no significant differences in students' achievement between group and individual CAI conditions.

Carrier and Sales (1987) examined the effects of paired versus individual work on the acquisition of new concepts in a CBI lesson. Thirty-six college juniors enrolled in a teacher training program participated in the study. Results of MANOVA showed no significant difference in overall achievement on immediate and delayed (1 week later) computer-based posttests between students who worked with a partner on a computer-based coordinate concept lesson and those who worked individually on the same lesson.

Tanamai (1989) compared the effects of cooperative and individual CAI on achievement of undergraduate Fine Arts students. This study involved 62 freshmen students enrolled in three sections of a Design Basic Studies course. Results of a two-way ANCOVA on a computer achievement posttest indicated no significant difference in computer achievement between students who used CAI tutorials for MacWrite, MacPaint, and MacDraw in three-member heterogeneous groups and those who used the same CAI tutorials individually.

Despite the failure to find the benefits of cooperative learning with CAI, Carrier and Sales (1987) noted that this method did not have a negative impact on students' performance. Justen et al. (1988) suggested that "in times of financial exigency, group CAI may be a realistic alternative for CAI instruction" (p. 52).

Carrier and Sales (1987) analyzed why the positive results of cooperative work in the CBI lesson were not found in their study. They noted that students in cooperative settings in their study were encouraged to work together, to discuss the content of the task, and to help one another; however, positive interdependence, a basic element in cooperative learning defined by Johnson, Johnson and their colleagues, was not emphasized. The lack of this element might have affected their results.

Attitudes

Toward Cooperative Learning

A number of studies have examined the effects of cooperative versus individual learning with CAI on students' attitudes toward cooperative learning. Some of these studies indicated that students who used CAI in pairs or in small groups possessed significantly more positive attitudes toward cooperative learning than those who used CAI individually.

Hooper, Temiyakarn, and Williams (1993) examined the effects of grouping (cooperative or individual learning) and source of control (learner or program control) in a CBI lesson on high- and average-ability students' attitudes toward working with partners. Their study involved 175 fourth-grade students. Results from an attitude survey ($N = 160$) indicated that students working on a CBI lesson cooperatively in pairs had significantly more positive attitudes than students working on the same CBI lesson individually, $F(1, 152) = 47.47$, $p < .001$. They noted that "apparently, students were more positive about the learning experience following group work than were students who worked alone" (p. 15).

Johnson et al. (1985) examined the comparative effects of cooperative, competitive, and individualistic CAI on attitudes toward cooperation. They studied 71 eighth-grade students and found that students in the cooperative condition were more likely to be cooperatively oriented than those in the competitive or individualistic condition ($p < .05$).

In a similar study involving 74 eighth-grade students, Johnson et al. (1986) also found that students in the cooperative CAI condition were more likely to perceive themselves as engaging in collaborative behaviors than those in the competitive and individualistic CAI conditions, $F(2, 64) = 22.29$, $p < .01$.

Mevarech, Stern, and Levita (1987) compared the effects of cooperative and individual learning with CAI on attitudes toward cooperative learning among 115 junior high school students in Israel. They found that students who used a CAI program in Hebrew language arts in homogeneous pairs had significantly more positive attitudes ($M = 12.20$) than those who used the same CAI program individually ($M = 11.20$), $t = 2.17$, $p < .03$.

On the other hand, in a study of 190 elementary students, Orr and Davidson (1993) failed to find significant differences in attitudes toward cooperative or individual instruction between students who used a

CAI program on astronomy in three-member groups and those who used the same CAI program individually.

Interestingly, in a study investigating whether college students prefer group or individual CAI, or have no preference, Justen et al. (1988) found that a significantly greater number of students preferred individual CAI to those that preferred group CAI or who had no preference, $\chi^2(2, N = 68) = 30.12$, $p < .001$. They noted that "perhaps one reason for this is the anonymity of individual CAI. In group CAI the students' ability is 'naked and exposed,' so to speak. Thus, students might be self-conscious when involved in group CAI" (p. 52).

Toward Computers

Several studies have examined the effects of cooperative versus individual learning with CAI on students' attitudes toward computers. One study showed that cooperative learning with CAI resulted in significantly more positive attitudes toward computers than individual learning with CAI. Johnson et al. (1986) studied 74 eighth-grade students and found that students in the cooperative and competitive conditions exhibited more computer liking than those in the individualistic condition, $F(2, 64) = 3.09$, $p < .05$.

However, a few studies indicated no significant differences in attitudes toward computers between these two CAI methods. For example, Park (1993) studied 109 college students in a chemistry class and found no significant differences in attitudes toward computers between students who used CAI in pairs and those who used CAI individually.

Tanamai (1989) studied 62 college Fine Arts students and employed a 32-item attitude scale divided into three factors: the Liking for Computer factor, the Male Domain factor, and the Necessity of Computer factor. Results of ANCOVA on the posttest data indicated no significant differences on any of these three factors between students who used CAI tutorials for MacWrite, MacPaint, and MacDraw in three-member heterogeneous groups and those who used the same CAI tutorials individually.

Toward CAI or Subject Area

A number of studies have compared the effects of cooperative and individual learning with CAI on students' attitudes toward CAI, or subject area being studied. One study showed that cooperative learning with CAI promoted significantly more positive attitudes toward the CAI lesson being studied. Hooper et al. (1993) studied 175 fourth-grade students and found that students in a cooperative CBI setting had significantly more positive attitudes toward the CBI lesson being studied than those in an individual CBI setting, $F(1, 152) = 6.02$, $p = .015$.

On the other hand, a number of studies failed to find significant differences in attitudes toward CAI, or subject area being studied between the two CAI methods. For example, in a study of 60 eighth-grade students, Dalton et al. (1989) found no significant differences in attitudes toward instruction and lesson content between students who used a CAI program on sex education in pairs and those who used the same CAI program individually.

Johnson et al. (1985) studied 71 eighth graders and found no significant differences in attitudes toward CAI or the subject area among cooperative, competitive, and individualistic CAI conditions. Furthermore, they found that the positive attitudes toward CAI seemed to extend to the competitive and individualistic learning situations.

In a study conducted in Israel, Mevarech et al. (1987) studied 115 junior high school students and found no significant differences in attitudes toward CAI between students who used a CAI program in language arts in homogeneous pairs and those who used the same CAI program individually.

In another study conducted in Israel, Mevarech et al. (1991) studied 149 sixth-grade students and found no significant differences in mathematics anxiety between students who used a drill-and-practice CAI program in mathematics in pairs and those who used the same CAI program individually.

Park (1993) studied 109 college students in a chemistry class and found no significant differences in attitudes toward CAI between students who used CAI in pairs and those who used CAI individually.

Reglin (1990) studied 53 prospective minority teachers and found no significant differences in mathematics anxiety between students who used a CAI mathematics program in pairs and those who used the same CAI program individually.

Several other interesting findings emerged from these studies. Dalton et al. (1989) noted that students in the cooperative CAI group had significantly higher achievement in human reproductive system but did not demonstrate more positive attitudes toward instruction and lesson content. Reglin (1990) also noted that the relationship that positive mathematics achievement is usually accompanied by negative mathematics anxiety was not found in his study.

Dalton et al. (1989) found significant interactions between CAI method (cooperative vs. individual) and gender in regard to attitudes toward both the instruction and lesson content, $F(1, 52) = 4.35$, $p < .05$. Females in the cooperative CAI group had higher attitude scores ($M = 54.22$) than those in the individual CAI group ($M = 48.33$), whereas males in the cooperative CAI group ($M = 48.17$) had lower attitude scores than those in the individual CAI group ($M = 50.39$).

Gender Differences

Gender has been an important concern in computer education research in the last 15 years. A large number of researchers have examined gender differences in attitudes toward computers, performance in computer literacy, computer course enrollment, computer camps and workshop participation, computer use and access, and home computer ownership. This section focuses on studies on gender differences in computer literacy performance and computer-related attitudes.

Computer Literacy Achievement

Males Outperformed Females

A number of studies at the high school level have consistently indicated that males outnumbered females in computer courses, especially in computer programming courses. For example, data from the 1980-1982 National Longitudinal Study showed that 59% of the students in high school programming courses were males (Lockheed, 1985). A 1982 nationwide survey of 17-year-old students in the United States indicated that males outnumbered females by two to one in high school programming courses (Kolata, 1984). In a study with a random sample of

1,138 high school students, Chen (1986) found that a higher proportion of males enrolled in programming courses both before and during high school than females. Linn (1985) reported that females comprised 86% of the students in word processing courses but only 37% of the students in programming courses.

Many studies at the elementary or secondary school level also showed that males significantly outperformed females in computer literacy achievement. Hawkins (1985) and others at Center for Children and Technology (CCT) studied LOGO programming learning in two classrooms (i.e., 8-9-year-olds, 11-12-year-olds). They found that for both age groups, boys performed significantly better on all measures of LOGO programming expertise. Within age groups, boys scored significantly higher on all three assessments of LOGO programming knowledge: programming commands, program composition, and program debugging. In addition, younger boys outperformed older girls on all of the three measures.

Fetler (1985) conducted a 1982-1983 statewide assessment of California 6th and 12th graders' knowledge, attitudes, and experiences in computer literacy and computer science. He found that 6th-grade boys had significantly better overall performance (*M* = 29) than did girls (*M* = 25) on a computer literacy test ($p < .001$). Twelfth-grade males also had significantly higher overall scores (*M* = 40) than did females (*M* = 37) on a test in the domains of computer literacy and computer science ($p < .001$).

Lockheed, Nielsen, and Stone (1985) studied the effects of gender, grade level, mathematics course type and level, computer access, and computer use on students' gain in computer literacy. Participants were high school students enrolled in a required introductory computer literacy course. Complete pretest, posttest, and survey data were collected from 313 students. With respect to gender, they found that for all students (grades 9-12), males had significantly higher adjusted gain scores (*M* = 0.37) than did females (*M* = -0.38), $F = 5.94$, $p < .02$. In addition, the multiple regression analysis showed that gender was significantly related to achievement gain in computer literacy ($p < .05$). For 9th and 10th graders only, gender was also found to be significantly related to the achievement gain in computer literacy ($p < .05$).

The same trend was also found in studies outside of the United States. For example, Voogt (1987) examined performance and engagement in computer literacy among 873 Dutch students (454 males and 419 females) with an age range from 12 to 16. Results indicated that boys performed significantly better ($M = 15.07$) than girls ($M = 13.60$) on a computer literacy test, consisting of 25 items on programming and algorithms, software and data processing, computer mystique, and applications ($p < .0001$).

Lockheed et al. (1985) explored the reason why there was a gender difference in computer literacy gain when there was no gender difference in pretest. They noted that the possible explanations for this difference included gender differences in motivation and gender differences in computer access and computer use. Another possible reason was that "girls did not receive as much instruction from student computer 'buffs' as did their male classmates" (p. 93). Similarly, Voogt (1987) claimed that the higher performance of boys may be due to the fact that boys have more experience with computers in comparison with girls. Fetler (1985) attributed one possible reason of girl's lower achievement to their less encouragement to learn about the technology. Therefore, he believed that gender is an important issue when schools provide students with computer literacy skills or provide a solid underpinning in the basic concepts of computer literacy.

Females Outperformed Males

One study showed that females performed significantly better in some specific areas of computer programming. Anderson (1987) used the data from the Minnesota Computer Literacy Assessment (MCLA) to examine whether females outperformed males in the domain of programming/algorithms on tasks requiring skills such as generalization and information analysis. He analyzed the data from nine program/algorithm test items of 3,615 8th graders and 2,535 11th graders tested in the MCLA. Anderson found that for 8th- and 11th-grade students combined ($N = 6,150$), males scored significantly higher than females on the four-item Problem Reading subtest (each $p < .05$) except for one item. However, females scored significantly higher than males on the five-item Problem Analysis subtest (each $p < .05$) with the exception of one item. For 11th-grade students only, males performed significantly better on the Problem Reading subtest (M = 1.07) than females (M = 0.94), $p < .001$, but females performed significantly better on the Problem Analysis subtest (M = 2.73) than males (M = 2.45), $p < .001$.

This study's finding that females was superior to males on problem analysis runs counter to the stereotype that males are better than females at computer-related problem solving. This researcher offered two possible explanations for this: "one is that the Minnesota educational system may offer an advantage for women, and the other is that women in general may acquire special skills with words and structured thinking that provide an advantage for doing information systems analysis" (p. 48).

No Differences

Although significant gender differences in computer literacy achievement were found in a number of studies, a number of studies showed that females performed as well as males in a computer literacy test or in a computer class at middle or high schools. A study, conducted by the Assessing the Cognitive Consequences of Computer Environments for Learning (ACCCEL), examined students' performance in BASIC programming courses at six middle schools (Linn, 1985). A total of 525 students (339 males and 186 females) participated in this study. At all six schools, results indicated no significant gender differences in performance on the Final Programming Assessment.

Two studies by Webb (1985) investigated gender differences in achievement, verbal behavior, and planning and debugging behavior on computer programming learning in small group or individual settings. In the first study, participants were 35 junior high school students (20 males, 15 females) instructed in LOGO programming in three-member mixed-age and mixed-gender groups (one group had two members) in a computer lab. Webb found that boys and girls showed similar performance on all five measures of the LOGO achievement test: knowledge of basic commands, syntax, interpreting programs, generating programs--graphics, and generating programs--logical relations. Moreover, in those three-members groups (two males, one female), no significant differences were found between boys (n = 16) and girls (*n* = 8) on any of the five measures of the achievement test.

In Webb's second study (1985), participants were 55 junior high school students learning BASIC individually or in two-member groups in a computer lab. Similar to Webb's first study, no significant differences were found between boys (*n* = 32) and girls (*n* = 23) on any of the four measures of the BASIC achievement test: knowledge of commands, syntax, program interpreting, and program generating.

Chen (1986) examined gender differences in experiences with and attitudes toward computers among 1,138 students from five high schools in California. Students' grades in the most recent programming class during high school indicated no significant differences between males and females.

Guinan and Stephens (1988) studied whether an aptitude test and factors such as gender, mathematics background, and current high school GPA can predict high school students' performance or aptitude in beginning computer science courses. Participants were 55 high school students (35 males and 20 females) from two beginning computer science courses (Computer Math, which taught FORTRAN, and Data Processing, which taught BASIC). They found that gender had no significant effect on achievement grade in the course or on the aptitude test. In both classes, ANCOVA showed no gender differences in the aptitude test score after adjusting for math background and then after adjusting for high school GPA.

Similarly, a few studies at the postsecondary level also showed that gender was not a factor influencing performance in a computer course. Woodrow (1991) studied the effects of gender and other factors such as age, prior computer knowledge, and prior computer experience on preservice teachers' achievement in computer literacy courses. This study involved 98 undergraduate and graduate students enrolled in an elective computer literacy course, which focused on BASIC. Results of a correlation analysis showed that gender was not significantly correlated to the final grade in the computer literacy course. A hierarchical multiple regression analysis also indicated that gender was not a significant factor on the performance in a computer literacy class.

In an Australian study by Clarke and Chambers (1989), gender differences in computing achievement, intentions for taking further computer courses, and in a set of factors such as previous computing and previous mathematics experience were investigated. Data were collected from 222 university freshmen (110 males and 112 females) enrolled in a compulsory first semester course in Statistics and Computing Concepts. Results concerning computing achievement revealed no significant differences in the final grade for computing between males and females. Furthermore, a regression analysis showed that gender was not a significant predictor of computer performance. They believed that gender difference in computer ability may be a perceived difference rather than a real ability difference.

Attitudes toward Computers

A considerable body of research has examined gender differences in attitudes toward computers. Attitudes toward computers have been defined in several different ways such as overall attitudes toward computers, anxiety, liking, confidence, interest, comfort, perceived usefulness of computers, perceived necessity of computers, respect through computers, and attitudes toward computers in society.

Positive Attitudes Favoring Males

Many studies showed that elementary or secondary school boys displayed significantly less computer anxiety, more computer interest, confidence, comfort, positive attitudes toward usefulness of computers, or positive overall attitudes toward computers than did girls at the same school level. Hwang (1990) studied the effects of gender, grade level, and two different types of computer literacy courses on attitudes toward computers among 219 fifth and sixth graders (109 boys and 110 girls) in Korea. Computer attitudes were measured by a 30-item Computer Attitude Scale including three subscales: computer anxiety, confidence, and liking. Results of ANCOVA via the hierarchical multiple regression/correlation (MRC) analysis showed that the gender factor was significant after the effects of the covariates (i.e., pretest scores, home computer ownership, previous programming experience) had been partialled out. Boys expressed more positive attitudes toward computers (adjusted $M = 108.47$) than girls (adjusted $M = 105.45$), $t = 4.19$, $p < .01$.

Chen (1986), investigating gender differences in attitudes toward computers of 1,138 high school students, found that males expressed significantly more positive attitudes toward computers on a six-item Computer Interest subscale ($p < .05$), a three-item Computer Confidence subscale ($p < .001$), and a two-item Respect Through Computers subscale measuring belief that computer skill leads to respect from parents and peers ($p < .001$). Males also exhibited significantly lower levels of computer anxiety on a four-item Computer Anxiety subscale ($p < .001$). After the amount of computer experience was controlled, males still showed more computer confidence and less computer anxiety, although gender differences in levels of interest in computers were not found.

Koohang (1986) examined gender, grade level, and prior computer experience on computer anxiety among 67 high school students in grades 9-12. He found that males ($n = 38$) had significant less anxiety toward computers than did females ($n = 29$), $F(1, 65) = 8.568$,

$p = .005$.

Okebukola (1993) conducted a study in Australia examining the gender factor in computer anxiety and computer interest of 11th-grade students from 14 senior high schools. Students were matched on four variables: home computer ownership, enrollment in computing classes, years of experience of computer usage, and socioeconomic status. Although 148 matching pairs of boys and girls were selected, complete data were collected from 281 students (142 males, 139 females). Results indicated that girls ($M = 4.19$) had a significantly higher level of computer anxiety than did boys ($M = 1.06$), $t = 25.37$, $p < .001$. Boys displayed a significantly higher level of computer interest ($M = 50.69$) than did girls ($M = 30.47$), $t = 34.86$, $p < .001$.

Similar results were also obtained for college students. For example, Koohang (1989) examined the effects of gender, keyboard familiarity, prior computer experience, and different categories of computer knowledge on several types of computer attitudes among 81 undergraduate college students. Koohang found males scored significantly higher on a 12-item computer usefulness instrument ($M = 3.49$) than did females ($M = 3.28$), $F(1, 79) = 4.12$, $p < .05$.

Liu, Reed, and Phillips (1992) studied gender, major, occurrence and prior computer experience of teacher education students' computer anxiety. Data were collected from 914 teacher education undergraduates (277 males and 637 females) during a mandatory computer awareness course over a 4-year period. In regard to gender, they found that males had significantly less computer anxiety ($M = 44.42$) than did females ($M = 48.87$), $F(1, 738) = 21.94$, $p < .0001$.

Wilder, Mackie, and Cooper (1985) examined gender differences in perception of and attitudes toward computers among 334 college students (193 males, 141 females), about one-third of whom were freshmen. They found that males felt significantly more comfortable dealing with computers ($M = 22.8$, where 31 = *complete comfort*) than did females ($M = 18.8$), $F(1, 324) = 20.18$, $p < .0001$.

Okebukola (1993) cited two sources of girls' higher levels of computer anxiety. First, girls generally perceive the computer as a male thing. Second, due to teachers' gender-biased attitude, "boys are usually chosen to assist teacher in the computer class rather than girls", and "teachers make more eye contacts with boys than girls when referring to technology" (p. 186). Liu et al. (1992) attributed males' lower anxiety to a higher percentage of males having programming experience. Similarly, Chen (1986) noted that a major source of gender differences in attitudes is the "greater willingness of males to participate in computer experiences" (p. 278).

Positive Attitudes Favoring Females

One study indicated more computer liking for girls than for boys. In a study with 643 rural students (332 boys, 311 girls) in grades 4-8, McGrath, Thurston, McLellan, Stone, and Tischhauser (1992) found that girls displayed significantly more computer liking (M = 1.63) than did boys (M = 2.18) on an item (based on a 9-point scale, where 1 = *like*, 9 = *dislike*) measuring attitudes toward computers.

No Differences

A number of studies, on the other hand, showed that males and females possessed similar levels of computer anxiety, confidence, liking, perceived usefulness (or necessity) of computers, or overall attitudes toward computers. In a study with 74 eighth graders in CAI settings, Johnson et al. (1986) found no significant gender differences on a 12-item Liking-for-Computers scale or on a 6-item Necessity-of-Computers scale.

Loyd and Gressard (1984b) examined the effects of gender, age, and computer experience on computer anxiety, confidence, and liking among 186 high school, 89 community college, and 79 senior college students. They found no significant gender differences in computer anxiety, computer confidence, or computer liking.

Colley et al. (1994) studied the effects of prior computer experience and gender stereotyping on computer anxiety, confidence, and liking of 144 undergraduate students (103 females, 41 males) taking courses in psychology. They found no significant gender differences in any of these three types of attitudes after the effects of prior computer experience (attendance at a computer course and number of years of experience) and psychological gender role orientation (masculinity and femininity) were removed.

Hunt and Bohlin (1993) studied the effects of gender, age, and past computer experience on teacher education students' computer attitudes. Participants were 518 students enrolled in computing courses designed for preservice and inservice teachers from four campuses of California State University. They found that gender did not contribute significantly to an explanation of the variance in any of the four subscales: computer anxiety, computer confidence, computer liking, and perceived usefulness of computers.

Koohang (1989) examined the effects of gender, keyboard familiarity, prior computer experience, and different categories of computer knowledge on several types of computer attitudes among 81 undergraduate college students. Koohang found no significant gender differences in overall computer attitudes (i.e., computer anxiety, confidence, liking and usefulness) and in three separate types of computer attitudes: computer anxiety, confidence, and liking.

Nickell, Schmidt, and Pinto (1987) studied the effects of gender differences and gender roles on computer attitudes, future expectations about computers, and computer related experience of 60 male and 106 female university students. Data from a computer attitude scale measuring attitudes toward computers in society showed no significant differences between males and females.

Summary

Cooperative versus Individual CAI

Achievement

Results of research comparing the effects of cooperative and individual learning with CAI on achievement were not consistent. Some studies (Dalton et al., 1989; Johnson et al., 1985, 1986; Mevarech et al., 1991; Park, 1993; Reglin, 1990; Stephenson, 1992) indicated that students using CAI cooperatively in pairs or in small groups had significantly better performance or higher scores on achievement tests than those using CAI individually. However, other studies indicated no significant differences in achievement between the two CAI methods (Carrier & Sales, 1987; Justen et al., 1988; Mevarech, 1993; Shlechter et al., 1992; Tanamai, 1989).

Attitudes

Findings of studies examining cooperative versus individual CAI on attitudes toward cooperation, computers, or CAI lesson being studied were also mixed. For example, Johnson et al. (1986) found that cooperative CAI promoted significantly more computer liking than individualistic CAI. However, Park (1993) and Tanamai (1989) found no significant differences in attitudes toward computers between the two CAI methods.

Gender Differences

Computer Literacy Achievement

Research on gender differences in computer literacy achievement has shown mixed results. A number of studies indicated that males outperformed females in computer literacy achievement (Fetler, 1985; Hawkins, 1985; Lockheed et al., 1985; Voogt, 1987). One study (Anderson, 1987) indicated that females performed significantly better in problem analysis of computer programming, although males performed significantly better in problem reading of computer programming. On the other hand, a number of studies indicated no significant gender differences in computer literacy achievement or showed that gender was not a factor significantly related to the performance in a computer literacy course (Chen, 1986; Clarke & Chambers, 1989; Guinan & Stephens, 1988; Linn, 1985; Webb, 1985; Woodrow, 1991).

Attitudes toward Computers

Results of research on gender differences in attitudes toward computers were also inconsistent. Some studies showed that males expressed significantly lower computer anxiety (Chen, 1986; Koohang, 1986; Liu et al., 1992; Okebukola, 1993), higher computer confidence (Chen, 1986; Wilder et al., 1985), more computer interest (Okebukola, 1993), greater computer comfort (Wilder et al., 1985), more positive attitudes toward usefulness of computers (Koohang, 1989), or more positive overall attitudes toward computers (Hwang, 1990) than did females. Only one study (McGrath et al., 1992) showed that girls expressed significantly more computer liking than did boys.

In contrast, some studies indicated no significant gender differences in computer anxiety (Colley et al., 1994; Hunt & Bohlin, 1993; Koohang, 1989; Loyd &

Gressard, 1984b), computer confidence (Colley et al., 1994; Hunt & Bohlin, 1993; Koohang, 1989; Loyd & Gressard, 1984b), computer interest (Chen, 1986), computer liking (Colley et al., 1994; Hunt & Bohlin, 1993; Johnson et al., 1986; Koohang, 1989; Loyd & Gressard, 1984b), perceived usefulness or necessity of computers (Hunt & Bohlin, 1993; Johnson et al., 1986), attitudes toward computers in society (Nickell et al., 1987) or overall attitudes toward computers (Koohang, 1989).

CHAPTER 3

METHODS

Population and Participants

The target population was college students enrolled in computer courses in Taiwan. The accessible population was college students enrolled in introductory computer courses in North Taiwan.

The participants in this study were undergraduate students enrolled in an introductory computer course at two colleges in North Taiwan during the Fall 1996 semester. One of the two colleges is an university with a research focus on marine science and technology and the other is a college established to train and prepare students as elementary school teachers.

A total of 155 students (63 males, 92 females) from four computer classes participated at the beginning of this study and during the treatment period. The two classes at the ocean-focused university primarily consisted of sophomores majoring in Shipping and Transportation Management. Of the two classes at the teacher training college, one was comprised of freshmen majoring in Mathematics and Science Education, and the other was composed of juniors majoring in Special Education. The introductory computer course was a required course for all of these majors.

Two students were absent from class on the day of two posttests (Computer Science Achievement Test and Computer Attitudes Scale); therefore, complete data of the two posttests were collected from 153 students. Of the 153 students, there were 62 (41%) males and 91 (59%) females. The students were between 17 and 31 years of age. The mean age was 20.3 years. Detailed information on the characteristics of the participants is reported in Chapter 4.

CAI Program

A CAI tutorial, "Introduction to Computers", designed by the researcher, was used in this study. The program was designed to introduce the student to computer numbering systems, encoding systems, and hardware systems. The language of the program was Chinese. The program contained six lessons as summarized in Table 1.

Table 1

Contents of the CAI Program

Lesson	Topics
Numbering systems	Decimal, binary, octal, and hexadecimal numbering systems
Data representation	Bit, byte, BCD, standard BCD, EBCDIC, and ASCII
CPU and main memory	ALU unit, control unit, RAM, and ROM
Input devices	Keyboard, mouse, trackball, joystick, scanner, and so on
Output devices	Printer, plotter, monitor, and COM
Auxiliary storage devices	Tape, hard disk, floppy disk, and optical disk

There was a multiple-choice quiz at the end of each lesson. Each quiz consisted of 5-10 items. The questions were designed to assess students' understanding of the material. The program had two versions; one works on Microsoft Windows 3.1 and the other works on the Windows 95 system.

The CAI program was reviewed by four experts in computer education and computer science in Taiwan. They were asked to assess the content, language, display presentations, questions and menus, and other issues of instructional pedagogy such as student control, motivation, interaction, and so forth. To assist in their evaluation, the researcher provided them with a review checklist (see Appendix A), which was adapted from the Quality Review Checklist offered by Alessi and Trollip (1991). The verbal or written comments the researcher received indicated that they were all positive about the great majority of the CAI program. No consistent negative comments were made by them.

Instruments

Computer Science Achievement Test

Students' computer science achievement was measured by the Computer Science Achievement Test (CSAT) developed by the researcher. The CSAT was used as a posttest in this study. The CSAT was written in Chinese and consisted of 40 multiple-choice questions covering the material of the CAI tutorial. The CSAT is presented in Appendix B.

Test-retest reliability of the CSAT was measured in this study by administering this test twice over a 2-week interval and gave a value of .80. The internal consistency of the CSAT was estimated in this study by the Kuder-Richardson method (K-R 20) and gave a value of .78.

The CSAT was reviewed by three specialists in computer science and computer education to estimate the content-related validity. They were asked to evaluate the correspondence between the CSAT items and the objectives of the CAI lessons and the format of the CSAT (i.e., clarity of stems, appropriateness of language, clarity of directions, etc.). They were provided with the CSAT items, the correct answers to the items, and a list of specific objectives. To help their evaluation, a checklist was also offered for them (see Appendix C).

According to their oral comments, they all agreed about the match between the CSAT items and the specific objectives. In addition, they were all satisfied with the format of the CSAT except one stem and one correct alternative. Two changes were then made in accordance with their suggestions.

Computer Attitude Scale

Students' attitudes toward computers were measured by the Chinese version Computer Attitude Scale (CAS). The Chinese version CAS was used as a posttest (see Appendix D).

The CAS was developed by Loyd and Gressard (1984a). It was a 30-item instrument designed to assess attitudes toward working with and learning about computers (see Appendix E). It contained three subscales: computer anxiety, computer confidence, and computer liking. Each subscale consisted of 10 items which presented positively and negatively worded statements. Each statement was rated on a 4-point Likert-type response scale with categories ranging from 1 (*strongly disagree*) to 4 (*strongly agree*). The scoring rule for the CAS in this study was that a 4 (*strongly agree*) was scored 4 on the positively worded items and a 1 (*strongly disagree*) was scored 4 on the negatively worded items. Therefore, a high score corresponded to a positive attitude.

The CAS was chosen for two reasons. First, it was used in several studies measuring attitudes toward computers for college students (Colley et al. 1994;

Koohang, 1989; Loyd & Gressard, 1984b). Second, it had high internal consistency. Its internal consistency measured by coefficient alpha was reported by its authors as .86 for the computer anxiety subscale, .91 for the computer confidence subscale, .91 for the computer liking subscale, and .95 for the total scale (Loyd & Gressard, 1984a).

The internal consistency of the Chinese version CAS was measured in this study by the coefficient alpha method as .90 for the computer anxiety subscale, .80 for the computer confidence subscale, .87 for the computer liking subscale, and .96 for the total scale.

The CAS was translated by the researcher. The translation draft was first evaluated by an expert in English language arts. She was asked to judge whether the translation of each statement is accurate, appropriate, and clear. She made several corrections and suggestions. Then, changes were made based on her corrections and suggestions, and a new version was evaluated by two specialists in computer education and computer science. They did not have any concerns or suggestions about the new version.

Procedures

Prior to the Treatment Period

Teacher Training

To ensure treatment fidelity, the researcher gave the instructors extensive training during the summer and the 1st week of the Fall 1996 semester. The instructors were Dr. Lee, an associate professor at the ocean-focused university, and Dr. Kao, an associate professor at the teacher training college. They were told how to apply cooperative learning strategy and train students before treatments, how to implement the treatments, and how to administer tests and collect data. In addition, they were provided with guidelines and procedures for the implementation of the experiment. The guidelines included the following:

- Apply the cooperative learning strategy to the students' classes prior to the treatment period.
- Before the treatment period begins, inform students that they will use a CAI program either by themselves or with a partner by a manual draw.

- Present the CAI lessons as if they were part of their normal planned activities.
- Your major role is to monitor the activities of two groups of students during the treatment period.

Background Data Form

Students were asked to fill out the Background Data Form in the computer labs at the beginning of the 2nd week of classes. This form and its English translation are presented in Appendixes F and G, respectively. This form required students to provide their demographic and background information. Data from this form are reported in Chapter 4.

Applying Cooperative Learning Strategy

The cooperative learning strategy was applied by the instructors in the computer labs during the 2nd and 3rd week of classes. The instructors first presented the academic material. Students then worked together on a project with a computer in groups of two or three. Each group completed the project which represented the group effort. Students earned scores based on the group project.

Student Training

During the 4th week of classes, the instructors informed the students that they would use a CAI program next week and over the following 5 weeks, and that because of the technical issue they would be assigned to use the program either by themselves or with a partner according to a manual draw. In addition, the instructors told them that the researcher was graduate student who would be working with them while they used the program and that they would have a test covering the CAI lessons after completing the CAI lessons. Then, the instructors gave them an introduction on how to load, run, and complete the CAI program, and taught them how to work on the CAI lessons both alone and with a partner.

Treatments

Treatments were conducted during a 6-week period (from the 5th week to the 10th week). Both the treatment and control groups attended six CAI sessions

(2 hours per session per week) in the computer labs during the regular computer classes. Both groups completed six CAI lessons (one lesson per session per week).

At the beginning of the first CAI session, 155 students in four contact computer classes were randomly assigned by the instructors to one of the two groups: the cooperative CAI (treatment) group, or the individual CAI (control) group. To randomly divide the students into two groups, prior to the treatment period, the researcher assigned each student a number and then selected one number at a time and alternately placed the students in the treatment or control group. Seventy-eight students were assigned to the treatment group, and 77 students were assigned to the control group. (Each class was composed of two groups).

After the assignment of two groups (during the first CAI session), students in the treatment group were assigned to two-member teams. They were asked to work on the first CAI lesson (Numbering Systems) with their partner. In the meantime, they were given a handout which listed guidelines for cooperative work on the CAI lessons as presented in Table 2. Students in the control group were asked to work on the same CAI lesson individually. Both groups of students were informed that they would be administered a test covering this CAI lesson and the other five CAI lessons.

Table 2

Guidelines for Working on CAI Lessons Together

- Make sure both you and your partner agree before entering commands for progress.
- Ask for help from your partner when needed.
- Summarize and explain to your partner what you have learned after each CAI lesson.
- Make sure both you and your partner understand the material before taking the quiz presented at the end of each CAI lesson.
- When questions are presented, explain your answers to your partner and then discuss with your partner until both of you agree on the answers.

Students in the treatment group worked on the CAI lessons with the same partner throughout all six CAI sessions. Students in the control group worked on the same CAI lessons independently within the six CAI sessions. Both groups in each class used the same CAI program in the same computer lab at the same time during each CAI session.

During the treatment period, all instruction was via the CAI lessons. The instructor's role was limited to proctoring the lessons, answering operational or management questions, and monitoring students' activities to ensure that students in the treatment group work together and students in the control group work independently.

To verify that treatment occurred as planned, the researcher went to each class and observed the activities of each class's constituent two groups during each CAI session. At the beginning of the treatment period, the researcher found that some treatment group students, especially those who were in different-sex teams, had no or little discussion with their partner. However, some control group students had a little discussion with each other. When noticing this situation, the researcher discussed this with the instructors and asked them to make sure that both groups worked on the CAI program in a proper manner.

Everything has gone exactly as planned since the correction of this condition.

Posttesting

After the treatment period (during the 11th week of classes), students in the treatment and control groups were individually given the Computer Science Achievement Test (CSAT) and the Computer Attitude Scale (CAS) by the instructors and the researcher.

Research Design

The randomized posttest-only control group design was used in the study. That is, both the treatment and control groups were formed by random assignment, which was described previously. Both groups received different treatments (CAI methods), and then both groups were posttested on the same dependent variables (CSAT and CAS scores).

The design was chosen because it can control for certain threats to internal validity. According to Fraenkel and Wallen (1993), it "is perhaps the best of all designs to use in an experimental study" (p. 248). In addition, McMillan and Schumacher (1989) noted that it is especially good for attitude research. One important reason is that the use of an attitude scale as the pretest may well affect the treatment, and this design does not involve a pretest.

Internal Validity

Fraenkel and Wallen (1993) have identified 10 threats to internal validity: subject characters threat, mortality threat, location threat, instrumentation threat, testing threat, history threat, maturation threat, subject attitude threat, regression threat, and implementation threat. In order to control or minimize these threats, techniques or procedures were used in this study, as presented in Table 3.

Table 3

Techniques or Procedures Used for Controlling 10 Threats to Internal Validity

Threat	Techniques or Procedures
1. Subject Characters	Random assignment was used. In addition, MANCOVA and ANCOVA were conducted to control for the effects of four computer-related variables.

(table continues)

Table 3 (Continued)

Threat	Techniques or Procedures
2. Mortality	Two students (1 male and 1 female, 1 in the treatment group and 1 in the control group) were absent from class on the day of posttests. However, because the loss was the same in all groups (treatment and control, male and female), mortality was not a problem.
3. Location	Two groups were administered treatments (CAI methods) in the same computer labs.
4. Instrumentation	
a. Instrument Decay	The multiple-choice Computer Science Achievement Test was used, and the Computer Attitude Scale was scored on a standard rule by the researcher.
b. Data Collector Characteristics	Two groups were administered instruments by the same data collectors (the instructors and the researcher).
c. Data collector Bias	The instructors were provided with standard procedures for administering the tests during the training period.
5. Testing	This threat did not exist because pretests were not used in this study.
6. History	During the course of the study, no unusual events occurred.

(table continues)

Table 3 (Continued)

Threat	Techniques or Procedures
7. Maturation	Random assignment was used.
8. Subject Attitude	To control for any novelty or Hawthorne effect, prior to the treatment period the instructors applied cooperative learning strategy in students' classes. To control for any demoralization effect, prior to the treatment period the instructors told the students that they would be assigned to use the CAI program either by themselves or with a partner by a manual draw, and during the treatment period the instructors provided equivalent experiences (except treatments) for both groups.
9. Regression	Random assignment was used.
10. Implementation	
a. Different Implementers	Two groups were instructed by the same CAI program and the implementers (instructors) were the same.
b. Implementer's Bias	The instructors were unaware of my hypotheses and goals of the study, and they were trained before administering the treatments. Furthermore, a treatment verification technique was used and found that neither of the implementers had preference for a CAI method.

Analysis of Data

Descriptive Statistics

The descriptive statistics calculated and reported by gender and CAI method included the following data:

- the number of students involved;
- the number of students who have previously taken a computer course;
- the number of students who owned a computer at home;
- the number of students who had previous experience in using a software program;
- the number of students who had previous experience in computer programming; and
- the means and standard deviations of the Computer Science Achievement Test (CSAT) and Computer Attitude Scale (CAS) scores.

In addition, the statistics included the means and standard deviations of the CSAT and CAS scores for the following students:

- who owned a computer at home and who didn't;
- who had previously taken a computer course and who hadn't;

- who had previous experience in using a software program and who didn't; and
- who had previous experience in computer programming and who didn't.

Inferential Statistics

Given that this study involved multiple dependent variables, multiple independent variables, and covariates, multivariate analysis of covariance (MANCOVA) was conducted. By examining the multiple dependent variables together, an omnibus MANCOVA can prevent any inflation of the experimentwise type I and type II error rates, and takes into consideration any possible intercorrelations among the dependent variables (Haase & Ellis, 1987).

MANCOVA carries with it the assumption that the regression planes of the covariates on the dependent variables are the same for all experimental groups. Therefore, a test for homogeneity (parallelism) of regression planes was performed before the use of the MANCOVA model. Because no evidence showed that the assumption was violated, MANCOVA was then conducted.

In the MANCOVA model, there were two dependent variables: the Computer Science Achievement Test (CSAT) scores and the Computer Attitude Scale (CAS) scores. There were four covariates in this model: computer ownership (coded as yes = 1, no = 0), prior computer instruction (coded as yes = 1, no = 0), previous software experience (the number of months), and previous programming experience (the number of months). In addition, there were three research factors: group (coded as treatment = 1, control = 0), gender (coded as male = 1, female = 0), and group-by-gender.

Subsequent to MANCOVA, two univariate analyses of covariance (ANCOVAs) were performed via the analyses of hierarchical multiple regression/correlation (MRC) for each of the two dependent variables. The MRC system was employed because it is a very flexible data-analytic system that may be used whenever a dependent variable is to be studied as a function of, or in relationship to, any research factors expressed as independent variables. In addition, the MRC system is a powerful analytic tool. Cohen and Cohen (1983) stated the following:

> It [the MRC system] yields measures of the magnitude of the 'whole' relationship of a factor

> to the dependent variable, as well as of its partial (unique, net) relationship, that is, its relationship over and above that of other research factors (proportions of variance and coefficients of correlation and regression). (pp. 3-4)

In short, the MRC system is a very suitable tool for analyzing the data of behavioral science research.

As stated previously, two ANCOVAs via hierarchical MRC analyses were conducted for two dependent variables (the CSAT and CAS scores) separately. Each MRC analysis was performed hierarchically by first regressing a dependent variable (Y) on a covariate set A consisting of four independent variables (X_1: computer ownership, X_2: prior computer instruction, X_3: previous software experience, X_4: previous programming experience). X_1, X_2, X_3, and X_4 were coded in the same way as the MANCOVA model. Next, a set B consisting of three independent variables (X_5: gender, X_6: group, X_7: interactions between gender and group) was added and Y was regressed on seven independent variables. The X_5, X_6, and X_7 comparison variables were contrast coded as in Table 4. Last, to check whether the ANCOVA was valid as meeting the assumption of homogeneity of regression, a set A × B consisting of 12 independent variables ($X_8 = X_1X_5$, $X_9 = X_1X_6, \ldots, X_{19} = X_4X_7$) was added and Y was regressed on total 19 independent variables. The hierarchical MRC analysis model was illustrated in Table 5.

Table 4

Contrast Codes for Four Groups

Experimental Group	X_5	X_6	X_7
Treatment-Male	.5	.5	.25
Treatment-Female	-.5	.5	-.25
Control-Male	.5	-.5	-.25
Control-Female	-.5	-.5	.25

Table 5

Hierarchical MRC Analysis by Sets for ANCOVA

Set	Entry Order	Independent Variable
A	1st	X_1 = computer ownership
		X_2 = prior computer instruction
		X_3 = previous software experience
		X_4 = previous programming experience
B	2nd	X_5 = gender
		X_6 = group
		X_7 = gender × group
A × B	3rd	$X_8 = X_1X_5$
		$X_9 = X_1X_6$
		$X_{10} = X_1X_7$
		$X_{11} = X_2X_5$
		$X_{12} = X_2X_6$
		$X_{13} = X_2X_7$
		$X_{14} = X_3X_5$
		$X_{15} = X_3X_6$
		$X_{16} = X_3X_7$
		$X_{17} = X_4X_5$
		$X_{18} = X_4X_6$
		$X_{19} = X_4X_7$

Under the model in Table 5, the contribution to *Y* variance of each set (or partialled set) was tested for significance at the alpha level by the *F* test. In addition, each MRC analysis was performed by a protected *t* test procedure, which requires that if the *F* for a given set is significant, the set's constituent independent variables can be each tested for significance at the alpha level by means of a *t* test, and if the set's *F* is not significant, no tests on the set's independent variables are permitted.

There are several reasons for using sets as the unit of each MRC analysis with the protected *t* test procedure. Cohen and Cohen (1983) stated the following:

> Because the number of sets is typically small, the investigationwise Type I error rate does not mount up to anywhere nearly as large a value over the tests for sets as it would over the tests for the frequently large total number of IVs [independent variables]. Then, the tests of single IVs [independent variables] are protected against inflated setwise Type I error rates by the requirement that their set's *F* meet the α [alpha] criterion. Further, with Type I errors under control, both the *F* and *t* tests are relatively powerful (for any given *n* and f^2 [effect size]).

Thus, both types of errors in inference are kept relatively low and in good balance. (p. 173)

Necessary Sample Size

According to common practice in educational research, the alpha level was set at .05 to test all statistical tests. As suggested by Cohen and Cohen (1983), the power value (1 - beta) of .80 was set. Because of the lack of research evidence on the effect size, a medium effect size was considered. Cohen and Cohen offered the following values: "'small,' f^2 = .02; 'medium,' f^2 = .15; and 'large,' f^2 = .35" (p. 161); therefore, the medium effect size (f^2) was set at .15.

Cohen and Cohen (1983) provided a formula for determining the necessary sample size for an F test on the multiple semipartial correlation squared for set B ($sR^2_B = R^2_{Y \bullet AB} - R^2_{Y \bullet A}$) with Model I error. The formula is

$$n = \frac{L}{f^2} + k_A + k_B + 1$$

where n = the necessary sample size;

k_A = the number of independent variables in set A;

k_B = the number of independent variables in set B;

L = the value for the given k_B and power in the table provided by Cohen and Cohen; and

$f^2 = (R^2_{Y \bullet AB} - R^2_{Y \bullet A}) / (1 - R^2_{Y \bullet AB})$

($R^2_{Y \bullet AB}$ and $R^2_{Y \bullet A}$ are both hypothetical values referring to the population).

Based on the above formula, with alpha = .05, power = .80, f^2 = .15, k_A = 4, k_B = 3, L = 10.9, the necessary sample size for testing the significance of the multiple semipartial correlation squared for set B (sR^2_B) was 81.

Power Analysis

Cohen and Cohen (1983) also offered a formula for determining the power:

$$L = f^2 (n - k_A - k_B - 1)$$

where L = the value to be calculated;

k_A = the number of independent variables in set A;

k_B = the number of independent variables in set B;

n = the sample size; and

$f^2 = (R^2_{Y \bullet AB} - R^2_{Y \bullet A}) / (1 - R^2_{Y \bullet AB})$

($R^2_{Y \bullet AB}$ and $R^2_{Y \bullet A}$ are both hypothetical values referring to the population).

Based on the above formula, with alpha = .05, k_A = 4, k_B = 3, f^2 = .15, sample size = 153, L was found to be 21.75, which fell between L = 17.17 at power = .95 and L = 23.52 at power = .99. Therefore, power was between .95 and .99.

CHAPTER 4

RESULTS

This chapter is divided into two sections. The first section presents the descriptive statistics associated with the data collected from the Background Data Form, Computer Science Achievement Test (CSAT) and Computer Attitude Scale (CAS). The second section presents the inferential statistics which resulted from testing the six null hypotheses outlined in Chapter 1.

Descriptive Statistics

As previously stated, a total of 155 students (63 males, 92 females) participated at the beginning of the study. Of these, 78 students were assigned to the treatment group, and 77 students were assigned to the control group. Every one of the 155 students attended all six CAI sessions during the treatment period. However, 2 students (1 male and 1 female, 1 in the treatment group and 1 in the control group) were absent from class on the day of posttests. Consequently, data for both the achievement (CSAT) and attitude (CAS) posttests were collected from 153 students (62 males and

91 females, 77 in the treatment group and 76 in the control group). Participants with missing data were not used in any computations.

Table 6 presents the number of students and percentage by age, gender, and class standing. As Table 6 shows, a large proportion of the students (92%) were between 17 and 22 years of age. The percentage of females (59%) was higher than that of males (41%). Sixty-eight percent of the students were sophomores.

Table 6

Number of Students and Percentage by Age, Gender, and Class Standing

	n	%
Age		
17~22	140	92
23~31	13	8
Gender		
Male	62	41
Female	91	59
Class Standing		
Freshman	20	13
Sophomore	104	68
Junior	28	18
Senior	1	1

Table 7 presents the number and percentage of students evidencing prior computing experience (i.e., computer ownership, prior computer instruction, previous software experience, and previous programming experience). As shown in Table 7, the majority of the students (82%) had previously taken a computer course. Almost half of the students (49%) had previous software experience. However, less than half of the students (44%) owned a computer, and a small proportion of the students (13%) had previous programming experience.

Table 7

Number of Students and Percentage by Computer Experience

	n	%
Ownership		
Yes	67	44
No	86	56
Course		
Yes	126	82
No	27	18
Software		
Yes	75	49
No	78	51
Programming		
Yes	20	13
No	133	87

Table 8 presents the number and percentage of students by computer experience for the treatment and control groups. As Table 8 shows, the treatment group had a higher percentage of students who owned a computer than did the control group (48% vs. 39%). Similarly, the percentage of students who had previous programming experience was higher in the treatment group than in the control group (18% vs. 8%). However, the treatment group had the same percentage of students who had previous software experience as the control group. In addition, there was almost no difference in the percentage of students who had prior computer instruction between the two groups.

Table 8

Number of Students and Percentage by Computer Experience for the Treatment and Control Groups

	Treatment (n = 77)		Control (n = 76)	
	n	%	n	%
Ownership				
Yes	37	48	30	39
No	40	52	46	61
Course				
Yes	63	82	63	83
No	14	18	13	17
Software				
Yes	38	49	37	49
No	39	51	39	51
Programming				
Yes	14	18	6	8
No	63	82	70	92

Table 9 presents the number and percentage of students by computer experience for males and females. As can be seen in Table 9, the percentage of males who owned a computer was higher than that of females (53% vs. 37%). The percentage of females who had prior computer instruction was higher than that of males (88% vs. 74%). However, there were only negligible male-female differences in the percentage of students who had previous software experience and in the percentage of students who had previous programming experience.

Table 9

Number of Students and Percentage by Computer Experience for Males and Females

	Male (n = 62)		Female (n = 91)	
	n	%	n	%
Ownership				
Yes	33	53	34	37
No	29	47	57	63
Course				
Yes	46	74	80	88
No	16	26	11	12
Software				
Yes	30	48	45	49
No	32	52	46	51
Programming				
Yes	9	15	11	12
No	53	85	80	88

Table 10 presents the means, standard deviations, minimum scores, and maximum scores of the Computer

Science Achievement Test (CSAT) and Computer Attitude Scale (CAS) for all 153 students. As previously stated, the CSAT scores could range from 0 to 40. The CAS scores could range from 30 to 120, with a higher score indicating a more positive attitude.

Table 10

Means, Standard Deviations, Minimums, and Maximums of CSAT and CAS Scores

	M	*SD*	Minimum	Maximum
CSAT[a]	24.39	5.64	10	36
CAS[b]	83.67	11.17	42	115

Note. *N* = 153.
[a]CSAT score range = 0-40.
[b]CAS score range = 30-120.

Table 11 presents the means and standard deviations of the CSAT scores according to group and gender. As shown in Table 11, the treatment group ($M = 26.65$) scored higher than the control group ($M = 22.09$). In addition, males (*M* = 24.48) scored slightly higher than females (*M* = 24.32).

Table 11

Means and Standard Deviations of CSAT Scores by Group and Gender

	n	*M*	*SD*
Treatment	77	26.65	4.46
Control	76	22.09	5.81
Male	62	24.48	6.13
Female	91	24.32	5.32
Treatment Male	28	27.57	4.73
Treatment Female	49	26.12	4.25
Control Male	34	21.94	6.02
Control Female	42	22.21	5.70

Table 12 presents the means and standard deviations of the CSAT scores by computer experience. As shown in Table 12, students who owned a computer, had prior computer instruction, had previous software experience, or had previous programming experience scored higher than those who didn't.

Table 12

Means and Standard Deviations of CSAT Scores by Computer Experience

	n	*M*	*SD*
Ownership			
Yes	67	24.91	5.57
No	86	23.98	5.69
Course			
Yes	126	24.58	5.76
No	27	23.48	5.02
Software			
Yes	75	25.72	5.22
No	78	23.10	5.76
Programming			
Yes	20	28.95	5.17
No	133	23.70	5.40

Table 13 presents the means and standard deviations of the CAS scores according to group and gender. As Table 13 shows, the mean for males (M = 88.05) was higher than that for females (M = 80.68). The control group (M = 83.91) scored slightly higher than the treatment group (M = 83.43).

Table 13

Means and Standard Deviations of CAS Scores by Group and Gender

	n	*M*	*SD*
Treatment	77	83.43	11.56
Control	76	83.91	10.84
Male	62	88.05	11.22
Female	91	80.68	10.17
Treatment Male	28	86.61	12.44
Treatment Female	49	81.61	10.74
Control Male	34	89.24	10.14
Control Female	42	79.60	9.47

Table 14 presents the means and standard deviations of the CAS scores according to computer experience. As shown in Table 14, students who owned a computer, had previous software experience, or had previous programming experience scored higher than those who didn't. Students who had prior computer instruction also scored higher than those who didn't; however, the difference was negligible.

Table 14

Means and Standard Deviations of CAS Scores by Computer Experience

	n	*M*	*SD*
Ownership			
Yes	67	87.66	11.73
No	86	80.56	9.70
Course			
Yes	126	83.79	11.06
No	27	83.11	11.90
Software			
Yes	75	86.63	12.41
No	78	80.82	9.05
Programming			
Yes	20	87.75	15.53
No	133	83.05	10.30

Inferential Statistics

Homogeneity of Regression

As stated in Chapter 3, prior to conducting multivariate analysis of covariance (MANCOVA), it is necessary to test for parallelism of regression planes (homogeneity or regression). According to Finn (1974), the likelihood ratio for a simultaneous parallelism test for multiple criterion measures is

$$\Lambda = \frac{|S|}{|S_E^{*}|}$$

where S is the addition of the adjusted SSCP (sum of saquares and cross products) matrices for all groups and S_E^{*} is the adjusted error SSCP matrix.

Based on the above criterion, the result of adding four adjusted SSCP matrices was found to be

$$S = \begin{bmatrix} 3214.286 & 539.272 \\ 539.272 & 12828.398 \end{bmatrix}$$

The adjusted error SSCP matrix was

$$S_E^{*} = \begin{bmatrix} 33711.389 & 1058.780 \\ 1058.780 & 14622.888 \end{bmatrix}$$

Therefore, the likelihood ratio (Λ) was calculated as .7703. The lambda value was transformed to *F* approximation, and the *F* transformation was found to be 1.53, which did not exceed the .05 critical *F* value, with 24 and 264 degrees of freedom. This indicated that the assumption for MANCOVA was maintained. That is, a single common covariate adjustment for all four groups (i.e., treatment-male, treatment-female, control-male, control-female) suffices, and the regression planes are parallel. Therefore, an omnibus MANCOVA was then performed.

MANCOVA

As stated in Chapter 3, the MANCOVA model included two dependent variables (the CSAT and CAS scores), four covariates (computer ownership, prior computer instruction, previous software experience, and previous programming experience) and three effects tested: the group (treatment vs. control) effect, the gender (male vs. female) effect, and the group-by-gender interaction effect. Table 15 presents Wilks's lambda values and multivariate *F*s for the covariate set, the two main effects, and the interaction effect. As shown in Table 15, the lambda value for the covariate set was .82, which was significant, $F(8, 288) = 3.86$, $p < .05$. This indicated that there was a significant relationship between the four covariates and the overall CSAT and CAS scores. The gender effect was significant, $\Lambda = .90$, $F(2, 144) = 7.94$, $p < .05$. This indicated that gender had a significant simultaneous effect on both the CSAT and CAS scores after the effects of the four covariates were controlled. In addition, the group (treatment) effect was significant, $\Lambda = .84$, $F(2, 144) = 14.09$, $p < .05$. This indicated that group (cooperative CAI vs. individual CAI) had a significant simultaneous effect on both the CSAT and CAS scores after the effects of the four covariates were controlled.

Table 15

MANCOVA of the CSAT and CAS Scores

Source of Variance	Wilks's Λ	Multivariate F	*df*
Covariate Set	.82	3.86*	8, 288
Gender	.90	7.94*	2, 144
Group	.84	14.09*	2, 144
Gender × Group	.98	1.48	2, 144

Note. *$p < .05$.

Significant MANCOVA effects do not indicate which dependent variable(s) accounted for a significant effect. Therefore, follow-up univariate analyses of covariance (ANCOVAs) were performed for each dependent variable. As stated in Chapter 3, ANCOVAs were conducted via the analyses of hierarchical multiple regression/correlation (MRC).

MRC Analysis on CSAT Scores

Table 16 presents the results of the MRC analysis on the Computer Science Achievement Test (CSAT) scores. As shown in Table 16, when the CSAT score (Y) was regressed on set A, the multiple correlation squared

(R squared) was .0915, which was significant, $F(4, 148) = 3.73$, $p < .05$, indicating that about 9% of the total CSAT score variance was accounted for by the covariates. When set B was added and the CSAT score was regressed on seven independent variables, the cumulative R squared was .2323. The increment in R squared due to set B was .1408, which was also significant, $F(3, 145) = 8.86$, $p < .05$. The increment of .1408 represented that about 14% of the CSAT score variance was uniquely accounted for by set B. The multiple partial correlation squared for set B (pR^2_B) was found to be .1550, meaning that set B, freed of the influence of the covariates, accounted for 15.5% of the covariate-adjusted CSAT score variance.

Last, when set A × B was added and the CSAT score was regressed on 19 independent variables, the cumulative R squared was .3351. The increment in R squared due to set A × B was .1028, which was not significant, $F(12, 133) = 1.71$, $p > .05$. Because this increment was not significant, the ANCOVA was valid as meeting the assumption of homogeneity of regression. The independent variables in set A × B were therefore excluded from further inferential analyses.

Table 16

Hierarchical MRC Analysis by Sets on CSAT Scores

Sets Added	Independent Variables Added	cum R^2	ΔR^2	F	df
A	X_1, X_2, X_3, X_4	.0915	.0915	3.73*	4, 148
+ B	X_5, X_6, X_7	.2323	.1408	8.86*	3, 145
+ A×B	$X_8, X_9, \ldots, X_{19}$	.3351	.1028	1.71	12, 133

Note. *$p < .05$. $pR^2_B = .1550$.

As can be seen in Table 16, the multiple correlation squared (R squared) for set A and the increment in R squared due to set B were both significant. Therefore, the partial coefficient (pr, sr, β, or B) for each independent variable in set A and set B can be tested for significance at .05 level by means of a t test according to the protected t test procedure. Table 17 presents the partial regression coefficients for the seven independent variables of the MRC analysis on CSAT scores. According to Table 17, the programming variable was the only covariate which was significant, $t(145) = 1.983$, $p < .05$.

Table 17

Partial Regression Coefficients for Seven Independent Variables of the MRC Analysis on CSAT Scores

Variable	*B*	β	*t*
X_1 (Ownership)	-0.17	-.01	-0.194
X_2 (Course)	0.86	.06	0.780
X_3 (Software)	0.07	.07	0.777
X_4 (Programming)	0.30	.19	1.983*
X_5 (Gender)	0.77	.07	0.895
X_6 (Group)	4.37	.39	5.139*
X_7 (Interaction)	1.80	.08	1.071
Intercept	23.39		

Note. * $p < .05$.

The *B* coefficient for the group variable (treatment-control contrast) was 4.37, which was significant, $t(145) = 5.139$, $p < .05$, indicating that the treatment-control distinction was significantly related to the covariate-adjusted CSAT score variance. Therefore, null hypothesis 1, which stated that there is no difference between the population mean of students who use CAI in two-member cooperative groups and the population mean of students who use CAI individually with respect to computer science achievement, when the effects of computer ownership, prior computer instruction, previous software experience, and previous programming experience are controlled, was rejected.

The *B* coefficient for the gender variable (male-female contrast) was 0.77, which was not significant, $t(145) = 0.895$, $p > .05$, indicating that the male-female distinction was not significantly related to the covariate-adjusted CSAT score variance. Therefore, null hypothesis 2, which stated that there is no difference between the population mean of male students and the population mean of female students with respect to computer science achievement, when the effects of computer ownership, prior computer instruction, previous software experience, and previous programming experience are controlled, failed to be rejected.

In addition, the *B* coefficient for the interaction variable was 1.80, which was not significant, $t(145) = 1.071$, $p > .05$, indicating that the interaction contrast was not significantly related to the covariate-adjusted CSAT score variance. Thus, null hypothesis 3, which stated that there is no interaction between gender and

CAI method in the population with respect to computer science achievement, when the effects of computer ownership, prior computer instruction, previous software experience, and previous programming experience are controlled, failed to be rejected as well.

According to the partial regression coefficients (*B*s) listed in Table 17, the regression equation was

$$\hat{Y} = -\ 0.17\ X_1 + 0.86\ X_2 + 0.07\ X_3 + 0.30\ X_4 + 0.77\ X_5 + 4.37\ X_6 + 1.80\ X_7 + 23.39$$

The adjusted *Y* intercept was

$$\begin{aligned} A' &= A + B_1m_1 + B_2m_2 + B_3m_3 + B_4m_4 \\ &= 23.39 + (-0.17)(0.44) + (0.86)(0.82) \\ &\quad + (0.07)(2.69) + (0.30)(0.88) \\ &= 24.47 \end{aligned}$$

The following regression equation was used to find out the adjusted means of groups:

$$\bar{Y}' = 0.77\ X_5 + 4.37\ X_6 + 1.80\ X_7 + 24.47$$

Then, the adjusted means of groups were found by substituting the values from the coding scheme used to code set B (see Table 4).

Table 18 presents the covariate-adjusted means of various groups. As shown in Table 18, the adjusted mean of the treatment group (M = 26.66) was higher than that of the control group (M = 22.29); the difference (4.37 = B_6) was significant, $t(145) = 5.139$, $p < .05$. Males had a higher adjusted mean (M = 24.86) than females (M = 24.09); however, this difference (0.77 = B_5) was not significant, $t(145) = 0.895$, $p > .05$. The treatment-control difference for males (5.27) was also higher than that for females (3.47), but this difference (1.80 = B_7) was not significant, $t(145) = 1.071$, $p > .05$.

Table 18

Adjusted Means of Various Groups in CSAT Scores

	Treatment	Control	Means of Means
Male	27.49	22.22	24.86
Female	25.82	22.35	24.09
Means of Means	26.66	22.29	24.47

Observed Effect Sizes

Cohen and Cohen (1983) stated that "we use pr^2_j as an effect-size measure for single X_j of the B set" (p. 390). According to this suggestion, the magnitudes of the treatment, gender, and interaction effects regarding computer science achievement were measured by the partial correlations squared (pr^2s) for the group, gender, and interaction variables, respectively, of the MRC analysis on the CSAT scores. Therefore, with respect to computer science achievement, the effect size of treatment was calculated as .1541. This indicated that the group variable (treatment-control contrast) uniquely accounted for 15.41% of the covariate-adjusted CSAT score variance not accounted for by the gender and interaction variables (contrasts). The effect size of gender was found to be .0055, meaning that the gender variable (male-female contrast) uniquely accounted for 0.55% of the covariate-adjusted CSAT score variance not accounted for by the group and interaction variables (contrasts). The effect size of interaction was found to be .0078, representing that the interaction variable uniquely accounted for 0.78% of the covariate-adjusted

CSAT score variance not accounted for by the group and gender variables (contrasts).

MRC Analysis on CAS Scores

Table 19 presents the results of the hierarchical MRC analysis on Computer Attitude Scale (CAS) scores. As shown in Table 19, when the CAS score (*Y*) was regressed on set A, the multiple correlation squared (*R* squared) was .1330, which was significant, $F(4, 148) = 5.68$, $p < .05$. This indicated that about 13% of the total CAS score variance was accounted for by the covariates. When set B was added and the CAS score was regressed on seven independent variables, the cumulative *R* squared was .2296. The increment in *R* squared due to set B was .0966, which was also significant, $F(3, 145) = 6.06$, $p < .05$. The increment of .0966 represented that 9.7% of the CAS score variance was accounted for by set B after the effects of the covariates (set A) have been removed from the research factors of interest (set B). The multiple partial correlation squared for set B (pR^2_B) was found to be .1114, meaning that set B, freed of the influence of the covariates, accounted for about 11% of the covariate-adjusted CAS score variance.

Last, when set A × B was added and the CAS score was regressed on 19 independent variables, the cumulative *R* squared was .3241. The increment in *R* squared due to set A × B was .0945, which was not significant, $F(12, 133) = 1.55$, $p > .05$. Therefore, the ANCOVA was valid as meeting the assumption of homogeneity of regression. The independent variables in set A × B were excluded from further inferential analyses.

Table 19

Hierarchical MRC Analysis by Sets on CAS Scores

Sets Added	Independent Variables Added	cum R^2	ΔR^2	*F*	*df*
A	X_1, X_2, X_3, X_4	.1330	.1330	5.68*	4, 148
+ B	X_5, X_6, X_7	.2296	.0966	6.06*	3, 145
+ A×B	$X_8, X_9, \ldots, X_{19}$	.3241	.0945	1.55	12, 133

Note. $^*p < .05$. $pR^2_B = .1114$.

As can be seen in Table 19, the multiple correlation squared (*R* squared) for set A and the increment in *R* squared due to set B were both significant. Therefore, the partial coefficient (*pr*, *sr*, β, or *B*) for each independent variable in set A and set B can be tested for significance at .05 level by means of a *t* test according to the protected *t* test procedure. Table 20 presents the partial regression coefficients for the seven independent variables of the MRC analysis on CAS scores. As shown in Table 20, the ownership and software variables were two covariates which were significant, *ts*(145) = 3.014 and 2.554, respectively, *ps* < .05. The *B* coefficient for the gender variable was 6.83, which was significant, *t*(145) = 3.986, *p* < .05, indicating that the male-female distinction was significantly related to the covariate-adjusted CAS score variance. Consequently, null hypothesis 5, which stated that there is no difference between the population mean of male students and the population mean of female students with respect to attitudes toward computers, when the effects of computer ownership, prior computer instruction, previous software experience, and previous programming experience are controlled, was rejected.

Table 20

Partial Regression Coefficients for Seven Independent Variables of the MRC Analysis on CAS Scores

Variable	*B*	β	*t*
X_1 (Ownership)	5.19	.23	3.014*
X_2 (Course)	1.92	.07	0.876
X_3 (Software)	0.47	.24	2.554*
X_4 (Programming)	-0.31	-.10	-1.055
X_5 (Gender)	6.83	.30	3.986*
X_6 (Group)	-1.10	-.05	-0.653
X_7 (Interaction)	-3.96	-.09	-1.188
Intercept	79.40		

Note. * $p < .05$.

However, neither the *B* coefficient for the group variable (B_6 = -1.10) nor that for the interaction variable (B_7 = -3.96) was significant, *ts*(145) = -0.653 and -1.188, respectively, *ps* > .05. This indicated that neither of the treatment-control and interaction contrasts was significantly related to the covariate-adjusted CAS score variance. Thus, both null hypothesis 4 and null hypothesis 6 failed to be rejected. Null hypothesis 4 stated that there is no difference between the population mean of students who use CAI in two-member cooperative groups and the population mean of students who use CAI individually with respect to attitudes toward computers, when the effects of computer ownership, prior computer instruction, previous software experience, and previous programming experience are controlled. Null hypothesis 6 stated that there is no interaction between gender and CAI method in the population with respect to attitudes toward computers, when the effects of computer ownership, prior computer instruction, previous software experience, and previous programming experience are controlled.

Based on the partial regression coefficients (*Bs*) in Table 20, the regression equation was

$$\hat{Y} = 5.19\ X_1 + 1.92\ X_2 + 0.47\ X_3 - 0.31\ X_4 + 6.83\ X_5 - 1.10\ X_6 - 3.96\ X_7 + 79.40$$

The adjusted *Y* intercept was

$$A' = A + B_1m_1 + B_2m_2 + B_3m_3 + B_4m_4$$

$$= 79.40 + (5.19)(0.44) + (1.92)(0.82)$$

$$+ (0.47)(2.69) + (-0.31)(0.88)$$

$$= 84.25$$

Therefore, the following regression equation was used to find out the adjusted means of groups:

$$\bar{Y}' = 6.83\ X_5 - 1.10\ X_6 - 3.96\ X_7 + 84.25$$

Then, the adjusted means of groups were found by substituting the values from the codes in Table 4. Table 21 presents the covariate-adjusted means of various groups. As shown in Table 21, males had a higher adjusted mean (M = 87.67) than females (M = 80.84), and the difference (6.83 = B_5) was significant, $t(145) = 3.986$, $p < .05$. The adjusted mean of the treatment group (M = 83.71) was lower than that of the control group (M = 84.81), but this difference (-1.10 = B_6) was not significant, $t(145) = -0.653$, $p > .05$. In addition, the interaction effect ($-3.96 = B_7$) was not significant, $t(145) = -1.188$, $p > .05$.

Table 21

Adjusted Means of Various Groups in CAS Scores

	Treatment	Control	Means of Means
Male	86.13	89.21	87.67
Female	81.28	80.40	80.84
Means of Means	83.71	84.81	84.25

Observed Effect Sizes

According to Cohen and Cohen's (1983) suggestions stated previously, the magnitudes of the gender, treatment, and interaction effects regarding attitudes toward computers were measured by the partial correlations squared (pr^2s) for the gender, group, and independent variables, respectively, of the MRC analysis on the CAS scores. Thus, with respect to attitudes toward computers, the effect size of treatment was calculated as .0029. This indicated that the group variable (treatment-control contrast) uniquely accounted for 0.29% of the covariate-adjusted CAS score variance not accounted for by the gender and interaction variables (contrasts). The effect size of gender was found to be .0988, indicating that the gender variable (male-female contrast) uniquely accounted for 9.88% of the covariate-adjusted CAS score variance not accounted for by the group and interaction variables (contrasts). The effect size of interaction was found to be .0096, meaning that the interaction variable uniquely accounted for 0.96% of the covariate-adjusted CAS score variance not accounted for by the group and gender variables (contrasts).

CHAPTER 5

Discussion

Summary of the Experiment

The purpose of the study was to examine the effects of cooperative versus individual learning with CAI on college students' computer science achievement and attitudes toward computers. Additionally, the study attempted to investigate if gender differences exist in computer science achievement or attitudes toward computers. The participants at the beginning of this study were 155 undergraduate students enrolled in an introductory computer course at two colleges in North Taiwan during the Fall 1996 semester. Prior to the treatment period, the students were asked to fill out the Background Data Form. In addition, they were instructed with cooperative learning strategy and received training on how to complete the CAI program and how to work on the program both alone and with a partner. During the treatment period, they were randomly assigned to the treatment group (78 students) or the control group (77 students). Students in the treatment group worked on six CAI lessons with their partner throughout. Students in the control group worked on the same lessons individually. After the 6-week treatment period, both groups were posttested by a Computer Science Achievement Test (CSAT) and a Computer Attitude Scale (CAS). Data for both posttests were collected from 153 students (77 in the treatment group and 76 in the control group, 62 males and 91 females).

Discussion of Results

Computer Science Achievement

Cooperative versus Individual CAI

The results of the multiple regression/correlation (MRC) analysis indicate that students in a college-level computer course who used CAI cooperatively with their partner had a significantly higher covariate-adjusted mean on the Computer Science Achievement Test (CSAT) than those who used CAI individually. This allows the rejection of null hypothesis 1 and supports the research hypothesis that the population mean of students who use CAI in two-member cooperative groups is greater than the population mean of students who use CAI individually with respect to computer science achievement, when the effects of four computer-related factors (computer ownership, prior computer instruction, previous software experience, and previous programming experience) are controlled.

The result is supported by several other studies (Park, 1993; Reglin, 1990; Stephenson, 1992), which showed that college students who used CAI cooperatively in pairs scored or performed significantly better than those who used CAI individually. The result is also similar with those of a number of studies (Dalton et al., 1989; Johnson et al., 1985, 1986; Mevarech et al., 1991), which indicated that students at the middle school level using CAI cooperatively in pairs or in small groups had significantly better performance or higher achievement than those using CAI individually.

The positive effects produced by cooperative learning with CAI in this study provide empirical support for the importance of peer interaction, which was emphasized by Piaget and constructivists. When students work on a CAI lesson in a cooperative setting, they can discuss the material with their partner(s), share different perspectives on the content, get immediate help and feedback from their partner(s), and motivate each other to learn the material. On the other hand, when students work on a CAI lesson individually, they are limited to the information presented on the lesson. Alternative propositions, which may provoke cognitive conflict and cause the reorganization of thinking, are not available. In addition, oral explanation, elaboration and negotiation with peers are not afforded. Consequently, the lack of peer interactions may limit the advantage of accommodating individual differences in the individual CAI method.

Gender Differences

The results of the MRC analysis indicate no significant differences in the adjusted CSAT means between male and female students in a college-level computer course. This fails to allow the rejection of null hypothesis 2 and fails to support the research hypothesis that the population mean of male students is greater than the population mean of female students with respect to computer science achievement, when the effects of the four computer-related factors are controlled.

This result contradicts those of a number of studies (Fetler, 1985; Hawkins, 1985; Lockheed et al., 1985; Voogt, 1987), which showed that males performed significantly better than females in computer literacy achievement at the elementary or secondary school level. However, this result is congruent with those of two studies (Clarke & Chambers, 1989; Woodrow, 1991), which showed that gender was not a factor significantly related to performance in a computer course at the college level. Moreover, this result is consistent with those of a number of studies (Chen, 1986; Guinan & Stephens, 1988; Linn, 1985; Webb, 1985), which indicated that males performed as well as females in a computer literacy test or in a computer class at the middle or high school level.

Although a number of studies showed that males outperformed females in computer literacy achievement, many of these studies did not control for prior computing experience in examining gender differences in computer achievement. That is, males' superior performance in computer achievement shown in many of these studies could have been due to the fact that males had more computer-related experience. In addition, many studies reporting males had better performance in computer achievement were conducted at the secondary school level. The absence of gender differences in computer science achievement at the college level in this study offers support for Clarke and Chambers's (1989) viewpoint that "the basis for gender differences in computer ability is in fact a perceived difference rather than a real ability difference" (p. 424).

Interactions

The MRC analysis results indicate no significant interactions between the CAI method and gender regarding the covariate-adjusted CSAT scores in a college-level computer course. This fails to allow the rejection of null hypothesis 3 and fails to support the research hypothesis that there is an interaction between gender and CAI method in the population with respect to computer science achievement, when the effects of the four computer-related factors are controlled.

Similar results were obtained by Mevarech et al. (1987), who found no significant interactions between gender and type of instruction (cooperative vs. individual CAI) regarding achievement in language arts, and by Reglin (1990), who found no significant interactions between gender and type of instruction regarding mathematics achievement. This study's result that cooperative CAI yielded consistently superior performance across gender was also found in a study by Dalton et al. (1989).

Attitudes toward Computers

Cooperative versus Individual CAI

The results of the MRC analysis indicate no significant differences in the adjusted means on the Computer attitudes Scales (CAS) between students in a college-level computer course who used CAI cooperatively in pairs and those who used CAI individually. This fails to allow the rejection of the null hypothesis 4 and does not support the research hypothesis that the population mean of students who use CAI in two-member cooperative groups is greater than the population mean of students who use CAI individually with respect to attitudes toward computers, when the effects of the four computer-related factors are controlled.

Similar results were obtained by two studies (Park, 1993; Tanamai, 1989), which indicated no significant differences in attitudes toward computers between college students using CAI cooperatively and those using

CAI individually. However, the result was inconsistent with that of a study with secondary school students by Johnson et al. (1986), who found that students using CAI in the cooperative and competitive conditions expressed more computer liking than those in the individualistic condition.

A possible reason why cooperative CAI did not result in more positive attitudes toward computers is that the 6-week treatment period (12 hours in total) may be insufficient for this method to have a positive effect on attitudes toward computers.

Gender Differences

The results of the MRC analysis show that male students in a college-level computer course had a significantly higher covariate-adjusted CAS mean than female students in the same course. This allows the rejection of null hypothesis 5 and supports the research hypothesis that the population mean of male students is greater than the population mean of female students with respect to attitudes toward computers, when the effects of the four computer-related factors are controlled.

The result is inconsistent with that of a study by Koohang (1989), who studied 81 undergraduate students and found no significant gender differences in overall computer attitudes (i.e., computer anxiety, confidence, liking, and usefulness) and three separate computer attitudes: computer anxiety, confidence, and liking. However, similar results were obtained by Hwang (1990). He studied 219 fifth and sixth graders and found that boys expressed significantly more positive overall attitudes toward computers (i.e., computer anxiety, confidence, and liking) than girls, when the effects of pretest, home computer ownership, previous programming experience were controlled.

In this study computer ownership and previous software experience were found to be significantly related to computer attitudes, indicating that students who owned a computer or students who had more previous software experience expressed more positive attitudes toward computers. When the effects of these two factors and the other two factors (prior computer instruction and previous programming experience) were removed, male students still exhibited more positive overall attitudes toward computers (i.e., computer anxiety, liking, and confidence) than female students.

Three possible factors, the researcher believes, may account for males' more positive attitudes toward computers. First, males in general perceive computing as a male field. For example, a study conducted by Johnson et al. (1986) indicated that boys were more likely than girls to perceive the computer as a male domain. Second, in comparison with females, males receive more encouragement from parents, teachers, or peers to engage in computing activities or to learn about the computer technology (Fetler, 1985; Nelson & Watson, 1990; Proost, Elen, & Lowyck, 1997). Third, as suggested by Nelson and Watson (1990), software based on male-oriented themes may have a positive impact on males' attitudes toward computers. According to a study by Biraimah (1989), 63% of the 1,942 characters found in the software programs she evaluated were males.

Interactions

The MRC analysis results indicate no significant interactions between the CAI method and gender regarding the covariate-adjusted CAS scores in a college-level computer course. This fails to allow the rejection of null hypothesis 6 and does not support the research hypothesis that there is an interaction between gender and CAI method in the population with respect to attitudes toward computers, when the effects of the four computer-related factors are controlled.

The result is consistent with that of a study by Reglin (1990), who found no significant interactions between gender and type of instruction (cooperative vs. individual CAI) regarding mathematics anxiety. However, the result is different from that of a study by Dalton et al. (1989), who found a significant interaction between CAI method and gender regarding attitudes toward instruction and lesson content (human reproductive system). In their study, males in the cooperative CAI group had lower attitude scores than those in the individual CAI group, whereas females in the cooperative CAI group had higher attitude scores than those in the individual CAI group.

Unlike the study by Dalton et al. (1989), this study indicated no significant interactions between CAI method and gender regarding attitudes toward computers. However, this study showed the same trend as their study: males in the treatment group had a lower adjusted CAS mean (*M* = 86.13) than those in the control group (*M* = 89.21), whereas females in the treatment group had a higher adjusted CAS mean (*M* = 81.28) than those in the control group (*M* = 80.4). A possible interpretation for this difference between males and females (though it is not significant) is that males may prefer to work with computers individually whereas females may prefer to work with computers cooperatively.

Conclusions and Implications of the study

Cooperative learning with CAI in this study did not promote more positive attitudes toward computers in a college-level computer course; on the other hand, this method resulted in higher computer science achievement in this course. Additionally, this method led to better computer science achievement for both male and female students. Therefore, it is suggested that instructors apply cooperative learning strategy into CAI settings in computer courses. In creating a cooperative CAI environment, instructors should be familiar with cooperative learning approaches and teach students cooperative learning skills before administering this method in CAI classes. In addition, because of the positive outcomes of cooperative learning with CAI, it is suggested that CAI software be designed for group work.

Findings of the study as to gender differences suggest that there exist no gender differences in computer science achievement in college-level computer courses. On the other hand, this study's results do suggest gender differences in attitudes toward computers in these courses: female students exhibited less positive attitudes toward working with and learning about computers than male students. Females' less positive attitudes toward computers may explain the present trend toward a male dominated computer field. The gender gap in attitudes toward computers needs to be bridged to reverse this trend. According to an analysis of research findings, Nelson and Watson (1990) pointed out that "social interactions among children, their families, and schools can affect attitudes and motivations of young children in very different ways" (p. 350). Family, school, and software may be important factors explaining gender differences in attitudes toward computers. To help close the gender gap, parents should encourage their female children to engage in computing activities. Educators should hold the belief that female students can perform as well as male students in computing achievement. Instructors should also be concerned about the issue of gender and encourage female students to take computer courses and to use computers. Further, secondary and postsecondary schools should provide courses to appeal to more female students. Moreover, computer software should be designed to attract females.

Limitations of the Study

The accessible population of this study was college students enrolled in an introductory computer course in North Taiwan. The participants throughout the study were the 153 undergraduate students enrolled in an introductory computer course at two colleges in North Taiwan. Because the study sample was not randomly selected from the accessible population, the generalization of this study's findings to the accessible population is somewhat limited.

The 153 participants were at two public colleges. One is a national and the other is a municipal college. The research findings, therefore, may not generalize to students at private colleges. Furthermore, the computer course in this study was a mandatory course for all participants. As a result, this study's findings regarding gender differences in computer attitudes may not apply to college students enrolled in an elective computer course. The reason is that female students may not express more negative attitudes toward computers if they choose to take a computer course.

A cooperative learning strategy was applied by the instructors prior to the treatment period. All participants in this study worked on a computer project with one or two partners. Consequently, students who used CAI individually during the treatment period may have been used to working on a computer in a cooperative setting. Therefore, some may have experienced a lack of motivation to use CAI individually, and this may have affected their achievement and attitudes toward computers.

The treatments were conducted over a 6-week period with a total of 12 hours. Findings of this study in respect to attitudes toward computers may be influenced by the short period of time.

Because of the use of the randomized posttest-only control group design, an attitude pretest was not employed in this study. Therefore, the effects of prior computer attitudes were unknown and uncontrolled.

Recommendations for Further Research

Several recommendations are made for future research examining the effects of cooperative learning with CAI on achievement and attitudes:

1. A longer period of time for the treatment is needed in future research, especially in future attitude research.

2. A CAI tutorial program was used in this study. A simulation or problem solving program may be utilized in future studies because these types of program may encourage more discussion between group members.

3. An immediate posttest was used in this study. A delayed posttest may be used for examining retention effects in future achievement research.

4. The CAI program used in this study mainly introduced the student to the general concepts of

computer numbering, encoding, and hardware systems. A program with different topics (e.g., algorithms, telecommunications, comparison of programming languages, etc.) may be used in future studies regarding computer achievement in an introductory computer course.

5. Attitudes prior to the study may have an influence on attitudes after the study; consequently, scores of an attitude pretest may be used as one covariate for future attitude research.

Several recommendations are also made for future research on gender differences in computer science achievement and attitudes toward computers:

1. Previous programming experience in this study was found to be a significant factor related to computer science achievement; consequently, the effects of this factor should be controlled in future research on gender differences in computer science achievement.

2. This study examined gender differences in the understanding of computer binary, encoding, and hardware systems in introductory computer courses. Future studies on gender differences in computer achievement may investigate gender differences in computer programming ability in advanced computer courses.

3. In this study computer ownership and previous software experience were found to be significantly related to attitudes toward computers. As a result, the effects of these two factors should be controlled in future research on gender differences in attitudes toward computers.

4. Participants in this study were from a required computer course. Future studies may investigate gender differences in attitudes toward computers in an elective computer course.

5. Attitudes toward computers in this study is defined as the overall attitudes toward computers including computer anxiety, confidence, and liking. Future research on gender differences in computer attitudes may examine these three attitudes separately or additional dimensions of computer attitudes such as computer interest, computer comfort, perception of computing as a male domain, or perception of the usefulness or necessity of computers.

In addition, because of the positive effects on computer achievement yielded by cooperative learning with CAI, researchers may need to further explore what factors (e.g., group size; group composition such as homogeneous vs. heterogeneous groups or same-sex vs. mixed-sex groups; personality characteristics) are related to cooperative learning with CAI in computer courses. Furthermore, researchers may need to expand the knowledge of which factors other than the seven variables estimated in this study are related to computer science achievement and attitudes toward computers.

REFERENCES

Alessi, S. M., & Trollip, S. R. (1991). *Computer-based instruction: Methods and development* (2nd ed.). Englewood Cliffs, NJ: Prentice-Hall.

Anderson, R. E. (1987). Females surpass males in computer problem solving: Findings from the Minnesota computer literacy assessment. *Journal of Educational Computing Research, 3*(1), 39-51.

Aronson, E., Blaney, N., Stephan, C., Sikes, J., & Snapp, M. (1978). *The Jigsaw classroom.* Beverly Hills, CA: Sage Publications.

Betz, N. E. (1977). Prevalence, distribution, and correlates of mathematics anxiety in college students. *Journal of Counseling Psychology, 25,* 441-448.

Biraimah, K. (1989). *Inequalities in classroom computer software.* Paper presented at the annual meeting of the Eastern Educational Research Association, Savannah, GA.

Bujea, E. & Voyce, S. (1988). *Teaching computing: A practical approach.* Englewood Cliffs, NY: Prentice-Hall.

Carpenter, T. P., Lindquist, M. M., Mathews, W., & Silver, E. A. (1983). Results of the third NAEP mathematics assessment: Secondary schools. *Mathematics Teacher, 76,* 652-659.

Carrier, C. A., & Sales, G. C. (1987). Pair versus individual work on the acquisition of concepts in a computer-based instructional lesson. *Journal of Computer-Based Instruction, 14*(1), 11-17.

Chen, M. (1986). Gender and computers: The beneficial effects of experience on attitudes. *Journal of Educational Computing Research, 2*(3), 265-282.

Clarke, V. A., & Chambers, S. M. (1989). Gender-based factors in computing enrollments and achievement: Evidence from a study of tertiary students. *Journal of Educational Computing Research, 5*(4), 409-429.

Cohen, J., & Cohen P. (1983). *Applied multiple regression/correlation analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates.

Colley, A. M., Gale, M. T., & Harris, T. A. (1994). Effects of gender role identity and experience on computer attitude components. *Journal of Educational Computing Research, 10*(2), 129-137.

Dalton, D. W., Hannafin M. J., & Hooper, S. (1989). Effects of individual and cooperative computer-assisted instruction on student performance and attitudes. *Educational Technology Research and Development, 37*(2), 15-24.

Dede, C. (1983). The likely evolution of computer use in schools. *Educational Leadership, 41*(1), 22-24.

DeVries, D. L.,& Slavin, R. E. (1978). Teams-Games-Tournament (TGT): Review of ten classroom experiments. *Journal of Research and Development in Education, 12,* 28-38.

Fetler, M. (1985). Sex differences on the California statewide assessment of computer literacy. *Sex roles, 13*(3/4), 181-191.

Finn, J. D. (1974). *A general model for multivariate analysis.* New York: Holt, Rinehart, and Winston.

Fleming, M. L., & Malone, M. R. (1983). The relationship of student characteristics and student performance as viewed by meta-analysis research. *Journal of Research in Science Teaching, 20,* 481-495.

Fraenkel, J. R., & Wallen, N. E. (1993). *How to design and evaluate research in education.* New York: McGraw-Hill.

Gredler, M. E. (1992). *Learning and instruction: Theory into practice* (2nd ed.). New York: Macmillan Publishing.

Guinan, T., & Stephens, L. (1988). Factors affecting the achievement of high school students in beginning computer science courses. *Journal of Computers in Mathematics and Science Teaching, 8*(1), 61-64.

Haas, W. (1976). *The potential and limitation of computer assisted instruction in the teaching of foreign languages.* Paper presented at the annual meeting of the American Council on the Teaching of Foreign Languages, New Orleans, LA. (ERIC Document Reproduction Service No. 139 269)

Haase, R. F. & Ellis, M. V. (1987). Multivariate analysis of variance. *Journal of Counseling Psychology, 34*(4), 404-413.

Hawkins, J. (1985). Computers and girls: Rethinking the issues. *Sex Roles, 13*(3/4), 165-180.

Hawkins, S., Sheingold, K., Gearhart, M., & Berger, C. (1982). Microcomputers in schools: Impact on the social life of elementary classrooms. *Journal of Applied Developmental Psychology, 3,* 361-373.

Hooper, S., Temiyakarn, C., & Williams, M. D. (1993). The effects of cooperative learning and learner control on high- and average-ability students. *Educational Technology Research and Development, 41*(2), 5-18.

Humphreys, B., Johnson, R., & Johnson, D. W. (1982). Effects of cooperative, competitive, and individualistic learning on students' achievement in science class. *Journal of Research in Science Teaching, 19*(5), 351-356.

Hunt, N. P., & Bohlin, R. M. (1993). Teacher education students' attitudes toward using computers. *Journal of Research on Computing in Education, 25*(4), 487-497.

Hwang, S. C. (1990). *A comparison of the effects on students' attitudes toward computers of a computer programming course versus a computer programming and awareness course.* Unpublished doctoral dissertation, Florida Institute of Technology, Melbourne, FL.

Johnson, D. W., & Johnson, R. T. (1975). *Learning together and alone: Cooperation, competition, and individualization.* Englewood cliffs, NJ: Prentice-Hall.

Johnson, D. W., & Johnson, R. T. (1986). Computer-assisted cooperative learning. *Educational Technology, 26*(1), 12-18.

Johnson, D. W., & Johnson, R. T. (1987). *Learning together and alone: Cooperative, competitive, and individualistic learning* (2nd ed.). Englewood cliffs, NJ: Prentice-Hall.

Johnson, D. W., Johnson, R. T., Johnson, J. & Anderson, D. (1976). Effects of cooperative versus individualized instruction on student prosocial behavior, attitudes toward learning, and achievement. *Journal of Educational Psychology, 68*(4), 446-452.

Johnson, R. T., Johnson, D. W., Scott, L., & Ramolae, B. (1985). Effects of single-sex and mixed sex cooperative interaction on science achievement and attitudes and cross-handicap and cross-sex relationships. *Journal of Research in Science Teaching, 22,* 207-220.

Johnson, R. T., Johnson, D. W., & Stanne, M. B. (1985). Effects of cooperative, competitive, and individualistic goal structures on computer-assisted instruction. *Journal of Educational Psychology, 77*(6), 668-677.

Johnson, R. T., Johnson, D. W., & Stanne, M. B. (1986). Comparison of computer-assisted cooperative, competitive, and individualistic learning. *American Educational Research Journal, 23*(3), 382-392.

Jones, L. V., Burton, N. W., & Davenport, E. C., Jr. (1984). Monitoring the mathematics achievement of black students. *Journal for Research in Mathematics Education, 15,* 154-164.

Justen, III, J. E., Adams, II, T. M., & Waldrop, P. B. (1988). Effects of small group versus individual computer-assisted instruction on student achievement. *Educational Technology, 28*(2), 50-52.

Kolata, P. S. (1984). Equal time for women. *Discovery, 1,* 22-27.

Koohang, A. A. (1986). *Computerphobia: An empirical study.* (ERIC Document Reproduction Service No. ED 306 948)

Koohang, A. A. (1989). A study of attitudes toward computers: Anxiety, confidence, liking, and perception of usefulness. *Journal of Research on Computing in Education, 22*(2), 137-150.

Kulik, J. A., Bangert, R. L., & Williams, G. W. (1983). Effects of computer-based teaching on secondary school students. *Journal of Educational Psychology, 75*(1), 19-26.

Linn, M. C. (1985). Fostering equitable consequences from computer learning environments. *Sex Roles, 13*(3/4), 229-240.

Liu, M., Reed, W. M., & Phillips, P. D. (1992). Teacher education students and computers: Gender, major, prior computer experience, occurrence, and anxiety. *Journal of Research on Computing in Education, 24*(4), 457-467.

Llabre, M. M., & Suarez, E. (1985). Predicting math anxiety and course performance in college men and women. *Journal of Counseling Psychology, 32,* 283-287.

Lockheed, M. E. (1985). Women, girls, and computers: A first look at the evidence. *Sex Roles, 13*(3/4), 115-122.

Lockheed, M. E., Nielsen, A., & Stone, M. K. (1985). Determinants of microcomputer literacy in high school students. *Journal of Educational Computing Research, 1*(1), 81-96.

Loyd, B. H., & Gressard, C. P. (1984a, Summer). Reliability and factorial validity of computer attitude scales. *Educational and Psychological Measurement, 44,* 501-505.

Loyd, B. H., & Gressard, C. (1984b, Winter). The effects of sex, age, and computer experience on computer attitudes. *AEDS Journal, 18*(2), 67-77.

McClintock, E., & Songuist, J. (1976). Cooperative task-oriented groups in a college classroom: A field application. *Journal of Educational Psychology, 68,* 588-596.

McGrath, D., Thurston, L. P., McLellan, H., Stone, D., & Tischhauser, M. (1992). Sex differences in computer attitudes and beliefs among rural middle school children after a teacher training intervention. *Journal of Research on Computing in Education, 24*(4), 468-485.

McMillan J. H., & Schumacher, S. (1989). *Research in education: A conceptual introduction* (2nd ed.). New York: Harper Collins.

Mevarech, Z. R. (1993). Who benefits from cooperative computer-assisted instruction? *Journal of Educational Computing Research, 9*(4), 451-464.

Mevarech, Z. R., Silber, O., & Fine, D. (1991). Learning with computers in small groups: Cognitive and affective outcomes. *Journal of Educational Computing Research, 7*(2), 233-243.

Mevarech, Z. R., Stern, D., & Levita, I. (1987). To cooperate or not to cooperate in CAI: That is the question. *Journal of Educational Research, 80*(3), 164-167.

Nelson, C. S., & Watson, J. A. (1990). The computer gender gap: Children's attitudes, performance and socialization. *Journal of Educational Technology Systems, 19*(4), 345-353.

Nickell, G. S., Schmidt, C. R. & Pinto, J. N. (1987). *Gender and sex role differences in computer attitudes and experience.* Paper presented at the Annual Convention of the Southwestern Psychological Association, New Orleans, LA. (ERIC Document Reproduction Service No. ED 284 114)

Okebukola, P. A. (1986). Cooperative learning and students' attitudes to laboratory work. *School Science and Mathematics, 86*(7), 582-590.

Okebukola, P. A. (1993). The gender factor in computer anxiety and interest among some Australian high school students. *Educational Research, 35*(2), 181-189.

Okebukola, P. A., & Ogunniyi, M. B. (1984). Cooperative, competitive, and individualistic science laboratory interaction patterns--effects on students' achievement and acquisition of practical skills. *Journal of Research in Science Teaching, 21*(9), 875-884.

Orr, K. L., & Davidson, G. V. (1993). *The effects of group computer-based instruction and learning style on achievement and attitude*. Paper presented at the Convention of the Association for Educational Communications and Technology, New Orleans, LA. (ERIC Document Reproduction Service No. ED 362 192)

Park, I. H. (1993). Cooperative learning and individual learning with computer assisted instruction in an introductory university level chemistry course (Doctoral dissertation, University of Texas at Austin, 1993). *Dissertation Abstracts International, 54,* 08A.

Piaget, J. (1973). *To understand is to invent: The future of Education.* New York: Grossman.

Pines, A. L., & West, L. H. (1986). Conceptual understanding and science learning: An interpretation of research within a source-of-knowledge framework. *Science Education, 70*(5), 583-604.

Proost, K., Elen, J., & Lowyck J. (1997). Effects of gender on perceptions of and preferences for telematic learning environments. *Journal of Research on Computing in Education, 29*(4), 370-384.

Ramist, L., & Arbeiter, S. (1986). *Profiles of college-bound seniors: 1985.* New Your: College Entrance Examination Board.

Reglin, G. L. (1990). The effects of individualized and cooperative computer assisted instruction on mathematics achievement and mathematics anxiety for prospective teachers. *Journal of Research on Computing in Education, 22,* 404-412.

Reyes, L. H., & Padilla, M. J. (1985). Science, math, and gender. *The Science Teacher, 53,* 46-48.

Sharan, S., & Sharan, Y. (1976). *Small group teaching.* Englewood, Cliffs, NJ: Educational Technology Publications.

Sherman, L. W., & Thomas, M. (1986). Mathematics achievement in cooperative versus individualistic goal-structured high school classrooms. *Journal of Educational Research, 79*(3), 169-172.

Shlechter, T. M., Pollock, J. C., Rude-Parkins, C., & Wong, D. T. (1992). *Students' attitudes toward small group CBI: A question of aptitude.* Paper presented at the Convention of the Association for Educational Communications and Technology, Iowa. (ERIC Document Reproduction Service No. ED 348 022)

Slavin, R. E. (1978). Students teams and achievement divisions. *Journal of Research and Development in Education, 12,* 39-49.

Slavin, R. E. (1981). Synthesis of research on cooperative learning. *Educational Leadership, 39* (5), 655-660.

Slavin, R. E. (1986). *Using student team learning* (3rd ed.). Baltimore, MD: Johns Hopkins University.

Slavin, R. E. & Karweit, N. L. (1981). Cognitive and affective outcomes of an intensive student team learning experience. *Journal of Experimental Education, 50,* 29-35.

Steinkamp, M. (1982, April). *Sex-related differences in science attitude and achievement: A quantitative synthesis of research.* Paper presented at the annual meeting of the American Educational Research Association, New York.

Stephenson, S. D. (1992). The effects of student-instructor interaction and paired/individual study on achievement in computer-based training (CBT). *Journal of Computer-Based Instruction, 19*(1), 22-26.

Swafford, J. O. (1980). Sex differences in first-year algebra. *Journal for Research in Mathematics Education, 11,* 335-346.

Tanamai, A. (1989). A comparison of computer-assisted cooperative learning with independent learning (Doctoral dissertation, University of Kansas, 1989). *Dissertation Abstracts International, 50,* 11A.

Taylor, H. G., & Mounfield, L. C. (1994). Exploration of the relationship between prior computing experience and gender on success in college computer science. *Journal of Educational Computing Research, 11*(4), 291-306.

Tobias, S. (1978). *Overcoming math anxiety.* New York: Norton.

Tobin, K., Kahle, J. B., & Fraser, B. J. (Eds.). (1990). *Windows into science classrooms: Problems associated with higher-level cognitive learning.* London: Falmer Press.

Voogt, J. (1987). Computer literacy in secondary education: The performance and engagement of girls. *Computers and Education, 11*(4), 305-312.

Webb, N. M. (1985). The role of gender in computer programming learning processes. *Journal of Educational Computing Research, 1*(4), 441-458.

Wilder, G., Mackie, D., & Cooper J. (1985). Gender and computers: Two surveys of computer-related attitudes. *Sex Roles, 13*(3/4), 215-228.

Woodrow, J. E. J. (1991). Determinants of student teacher computer literacy achievement. *Computers and Education, 16*(3), 247-256.

APPENDIX A

Checklist for CAI Program Review

Checklist for CAI Program Review

1. Subject Matter
   a. Are goals and objectives stated?
   b Is the information relevant to the objectives?
   c. Is the information accurate and complete?
   d Is the level of detail appropriate?
   e. Is the emphasis on that content most related to the objectives?
   f. Is the sequence of presentation appropriate?
   g. Does lesson organization conform to subject-matter organization?
   h. Is the Organization made clear to the student?

2. Language
   a. Is the reading level appropriate for the students?
   b. Is the reading level appropriate for the content?
   c. Is the reading level consistent throughout?
   d. Are technical terms and jargon relevant and explained?
   e. Are abbreviations used appropriately?
   f. Are spellings correct and consistent?
   g. Are page breaks at good points?
   h. Are sentence and paragraph styles consistent?
   i. Are margins appropriate and consistent?

* This checklist was adapted from the Quality Review Checklist offered by Alessi and Trollip (1991).

3. Surface and Features?
   a. Are the displays uncluttered and aesthetic?
   b. Is overwriting avoided?
   c. Do the displays maintain attention to important information?
   d. Are text, graphics, color, and sound used appropriately?
   e. Does text scroll?
   f. Is text layout attractive?
   g. Are type styles always easy to read?
   h. Are input devices appropriate?
   i. Is input efficient?
   j. Do input methods prevent or detect errors?
   k. Is the lesson end indicated?

4. Menus and Questions
   a. Is orienting information included?
   b. Is it clear how to make a choice?
   c. Is it clear how to fix an incorrect choice?
   d. Are questions relevant and well spaced?
   e. Is response economy promoted?
   f. Is it clear how to respond to the questions?
   g. Can the answer be requested?
   h. Can help be requested?
   i. Is more than one try allowed?

* This checklist was adapted from the Quality Review Checklist offered by Alessi and Trollip (1991).

j. Is feedback given and clear?

k. Is the format of feedback the appropriate type (text, graphic, markup, or sound)?

5. Other Issues of Pedagogy

   a. Is the methodology appropriate?

   b. Are directions available and clear?

   c. Is information in appropriate size chunks?

   d. Is lesson length appropriate?

   e. Does student determine pace?

   f. Can the student review?

   g. Are directions available?

   h. Is help available?

   i. Is inappropriate control avoided?

   j. Is motivation intrinsic?

   k. Is computer anxiety minimized?

   l. Is motivation balanced with other instructional factors?

   m. Is interaction frequent?

   n. Are animation and graphics relevant and aesthetic?

   o. Are animation and graphics for important information?

   p. Is the speed of display and motion appropriate?

* This checklist was adapted from the Quality Review Checklist offered by Alessi and Trollip (1991).

APPENDIX B

Computer Science Achievement Test

(CSAT)

電腦概論成就測驗

★★以下共有 40 題選擇題，請仔細閱讀每一題，選出一個最適合的答案，並將答案寫在答案紙上。每題所佔分數相同，答錯不倒扣，記得在答案紙上寫上姓名及學號。

1. CPU 包含
   A. RAM, ROM 及 ALU
   B. RAM, ROM 及 Control Unit
   C. RAM, ROM 及 Microprocessor
   D. ALU 及 Control Unit

2. 假設你有一個 2MB 的主記憶體，這是指那個部分的容量是 2MB ？
   A. RAM
   B. ROM
   C. 軟碟
   D. 硬碟

3. 以下敘述，何者正確？
   A. RAM 在製造時，其資料就被記錄進去了
   B. RAM 又可稱之為〝user-accessible memory〞
   C. 存於 RAM 中的資料可以被讀出，資料也可被寫入 RAM 中
   D. B, C
   E. A, B, C

4. 以下敘述，何者正確？
   A. ROM 可供使用者重複寫入資料
   B. ROM 通常用來儲存不會變更的程式（如 BIOS ）
   C. 當電腦關機後，儲存在 ROM 中的資料就消失了
   D. B, C
   E. A, B, C

5. 記憶體容量〝1MB〞是指
   A. 1,024 個 Bit
   B. 1,024 個 Byte
   C. 2^{20} 個 Bit
   D. 2^{20} 個 Byte
   E. 以上皆非

6. 記憶體容量〝120MB〞是指多少個 KB ？
   A. 120 × 8
   B. 120 × 1,024
   C. 120 × 1,024 × 8
   D. 120 × 1,024 × 1,024
   E. 以上皆非

7. 十進位的 100 用 BCD 碼表示時是
   A. 01100100
   B. 001000000
   C. 000100000000
   D. 以上皆非

8. 大寫英文字母〝D〞的標準 BCD 碼為 110100，如用奇數同位檢查法（加在最左邊）表示則為
   A. 0110100
   B. 1110100
   C. 1101000
   D. 1101001

9. 以下敘述，何者正確？
   A. 一般個人電腦最常用的是 EBCDIC 碼
   B. EBCDIC碼可表示256（2^8）個不同的字元（Character）
   C. EBCDIC 碼無法表示小寫英文字母
   D. 以上皆非

10. 以下敘述，何者正確？
   A. Byte 是由 Binary Digit 一詞而來
   B. 用來表示一個字元（Character）的基本單位是 Bit
   C. 〝0〞或〝1〞稱之為 Byte，它是構成資料最基本的單位
   D. 以上皆非

11. 為了達到不同資料碼間之資料交換而產生的碼是
   A. BCD 碼
   B. 標準 BCD 碼
   C. EBCDIC 碼
   D. ASCII 碼

12. 1. 解譯程式指令
   2. 從事資料的計算
   3. 指揮資料運作的順序
   上列何者是控制單位的功能？
   A. 3
   B. 1, 2
   C. 1, 3
   D. 2, 3
   E. 1, 2, 3

13. 下列何者是輸入裝置？
   A. CRT
   B. Sensor
   C. COM Reader
   D. Optical Disk
   E. 以上皆非

14. 下列何種讀取機（掃描器）可用來讀取印於支票下方的字體？
   A. OMR
   B. OCR
   C. COM
   D. MICR

15. 下列何種讀取機（掃描器）可用來讀取大學聯考答案卡上的記號？
   A. OMR
   B. OCR
   C. COM
   D. MICR

16. 下列何者<u>不是</u>輸入裝置？
   A. Joystick
   B. Trackball
   C. Plotter
   D. Digitalizing Tablet
   E. Voice-Recognition Device

17. 下列何者是非撞擊式印表機？
    A. 菊輪式印表機
    B. 熱感應式印表機
    C. 鏈條式印表機
    D. 點矩陣式印表機
    E. 以上皆非

18. 下列何者是輸出裝置？
    A. Plotter, Scanner
    B. Monitor, Scanner
    C. Monitor, Plotter
    D. Plotter, Optical Disk

19. 假設某人想要印出比較好看的字體，他應該選用下列何種點矩陣式印表機？
    A. 9 針點矩陣式印表機
    B. 18 針點矩陣式印表機
    C. 24 針點矩陣式印表機

20. 假設某人想要買一台列印時聲音較小的印表機，他應該買下列何種印表機？
    A. 菊輪式印表機
    B. 噴墨式印表機
    C. 鏈條式印表機
    D. 點矩陣式印表機

21. 下列何種印表機列的印速度最快？
    A. 行列式印表機
    B. 整頁式印表機
    C. 序列式印表機

22. 以下敘述，何者正確？
    A. 鏈條式印表機一次只能印一個字元
    B. 雷射印表機的列印原理與傳真機類似
    C. 噴墨式印表機印出的字是以點矩陣方式組成
    D. 以上皆是

23. 以下敘述，何者正確？
    A. 筆記型電腦大多是用 CRT 科技
    B. CRT 比平板顯示器輕且耗電量小
    C. 大多數的顯示器是使用液晶顯示的技術
    D. 以上皆非

24. 以下敘述，何者正確？
    A. 嚴格來說 CRT 包含鍵盤及螢幕
    B. 螢幕像素的密度愈高，解析度就愈高
    C. 彩色顯示器是用紅、黃、綠三色組成一個像素
    D. A, B
    E. A, B, C

25. 寬 1/2 英吋的捲盤式磁帶
   A. 最常用於微電腦及中型電腦
   B. 有九道磁軌
   C. 必須格式化後才能儲存資料
   D. 可以用循序方式存取也可以用隨機方式存取
   E. 以上皆非

26. 51/4 英吋 DS/DD 磁碟
   A. 只能作循序存取
   B. 存取速度比硬碟快
   C. 是一種次儲存體
   D. B, C
   E. 以上皆非

27. 31/2 英吋 DS/HD 磁碟
   A. 儲存容量大約為 1.44MB
   B. 儲存容量比 31/2 英吋 DS/DD 磁碟小
   C. 儲存容量比 51/4 英吋 DS/HD 磁碟小
   D. A, C
   E. 以上皆非

28. INTEL 80486 是一種
   A. 微處理機
   B. 輸入裝置
   C. 輸出裝置
   D. 儲存設備

29. Winchester 磁碟機上的讀寫頭會在磁碟記錄面上相同的磁軌中同時移動，這些相同的磁軌稱之為
   A. 磁柱
   B. 磁區
   C. 磁蕊
   D. 磁碟組
   E. 以上皆非

30. 下列何種光碟像磁碟一般可以重複記錄資料？
   A. MO Disk（磁電光碟）
   B. CD-ROM Disk
   C. WORM Disk
   D. 以上皆非

31. 下列何種光碟可以供使用者隨機存取？
   A. MO Disk（磁電光碟）
   B. CD-ROM Disk
   C. WORM Disk
   D. 以上皆是

32. 磁碟機將讀寫頭移動到正確磁軌所需的時間稱之為
   A. Access Time
   B. Seek Time
   C. Rotational Delay Time
   D. Data Transfer Time

33. 磁碟機從磁碟內讀取資料或將資料存入磁碟所需的時間稱之為
A. Access Time
B. Seek Time
C. Rotational Delay Time
D. Data Transfer Time

34. 一般判斷電腦處理資料速度的快慢，都是看那個單元？
A. 輸入單元
B. 輸出單元
C. 記憶單元
D. CPU

35. 某大公司每星期都要將公司所有客戶資料做成備份，你認為這家公司應該用那種輔助儲存體做備份比較合乎經濟效益？
A. CD-ROM Disk
B. WORM Disk
C. 磁碟
D. 磁帶

36. 以下敘述，何者錯誤？
A. CPU 是硬體
B. 記憶體是硬體
C. 磁碟片是軟體
D. 作業系統是軟體

37. 十進位的 43.375 是二進位的
A. 101011.011
B. 101011.110
C. 110101.011
D. 110101.110
E. 以上皆非

38. 十進位的 120.625 是十六進位的
A. 87.10
B. 87.A
C. 78.A
D. 67.B
E. 以上皆非

39. 十六進位的 34.A 是二進位的
A. 101101.110
B. 101110.101
C. 110100.101
D. 110101.110
E. 以上皆非

40. 八進位的 262.6 是十進位的
A. 156.25
B. 158.25
C. 176.75
D. 192.75
E. 以上皆非

APPENDIX C

Checklist for CSAT Evaluation

Checklist for CSAT Evaluation

1. Does each item measure one (or more) specific objective?
2. Is each objective assessed by any of the items?
3. Does each stem clearly present the problem to be addressed?
4. Is there only one defensible correct or best option?
5. Is each distracter plausible?
6. Are overlapping options avoided?
7. Is the level of reading skills required by each item appropriate for the student's ability?
8. Is the printing clear?
9. Is the size of type appropriate?
10. Are the directions clear?

APPENDIX D

Computer Attitude Scale

(Chinese Version)

電腦意見調查

以下共有三十題敘述，請在每題敘述之後，圈選出一個適當的數字，以表達你對該敘述的感覺。數字１～４分別代表的意義如下：

1	2	3	4
：非常不同意	：不同意	：同意	：非常同意

1. 電腦一點都不使我覺得恐懼。	1	2	3	4
2. 使用電腦會讓我非常緊張。	1	2	3	4
3. 當別人談論到電腦時，我沒有壓迫感。	1	2	3	4
4. 對電腦，我感到排斥及憎恨。	1	2	3	4
5. 上電腦課，我一點也不覺得麻煩。	1	2	3	4
6. 電腦讓我覺得不舒服、不自在。	1	2	3	4
7. 上電腦課時，我會覺得輕鬆自在。	1	2	3	4
8. 當我想到要用電腦的時候，我就覺得情緒低落。	1	2	3	4
9. 當我在使用電腦的時候，我會覺得輕鬆自在。	1	2	3	4
10. 電腦讓我覺得不自在而且不知所措。	1	2	3	4
11. 我對電腦並不在行。	1	2	3	4
12. 大致上而言，試著在電腦上解決新問題的感覺還不錯。	1	2	3	4
13. 我想我不會去做比較高深的電腦工作。	1	2	3	4
14. 我相信我可以用電腦做事情。	1	2	3	4
15. 我並不是那種電腦很行的人。	1	2	3	4
16. 我相信我可以學會電腦語言。	1	2	3	4
17. 我覺得使用電腦非常困難。	1	2	3	4

18. 我覺得我可以在電腦課程中得到好的成績。	1	2	3	4
19. 我覺得我沒有辦法能應付電腦課程。	1	2	3	4
20. 在使用電腦方面，我非常有自信。	1	2	3	4
21. 我喜歡使用電腦。	1	2	3	4
22. 我對於運用電腦解決問題的挑戰沒有興趣。	1	2	3	4
23. 我覺得使用電腦是有趣而且刺激。	1	2	3	4
24. 我對思考電腦的問題沒有興趣。	1	2	3	4
25. 在使用電腦時，如果有一個問題無法馬上解決，我會一直想辦法，直到找到答案為止。	1	2	3	4
26. 我不瞭解為何有些人會花那麼多時間使用電腦，而且似乎還自得其樂。	1	2	3	4
27. 一旦開始使用電腦，我就很難停下來。	1	2	3	4
28. 我會儘可能少用電腦。	1	2	3	4
29. 在上電腦課時如果有問題沒有解決，下課後我還會繼續思考。	1	2	3	4
30. 我不喜歡和別人談論電腦。	1	2	3	4

APPENDIX E

Computer Attitude Scale

(English Version)

Computer Opinion Survey

Instructions: Please indicate how you feel about each of the following statements. **Circle** the appropriate number by using the scale below:

4 = Strongly Agree
3 = Slightly Agree
2 = Slightly Disagree
1 = Strongly Disagree

1.	Computers do not scare me at all.	**1 2 3 4**
2.	Working with a computer would make me very nervous.	**1 2 3 4**
3.	I do not feel threatened when others talk about computers.	**1 2 3 4**
4.	I feel aggressive and hostile toward computers.	**1 2 3 4**
5.	It wouldn't bother me at all to take computer courses.	**1 2 3 4**
6.	Computers make me feel uncomfortable.	**1 2 3 4**
7.	I would feel at ease in a computer class.	**1 2 3 4**
8.	I get a sinking feeling when I think of trying to use a computer.	**1 2 3 4**

9. I would feel comfortable working with a computer. 1 2 3 4

10. Computers make me feel uneasy and confused. 1 2 3 4

11. I'm no good with computers. 1 2 3 4

12. Generally I would feel OK about trying a new problem on the computer. 1 2 3 4

13. I don't think I would do advanced computer work. 1 2 3 4

14. I am sure I could do work with computers. 1 2 3 4

15. I'm not the type to do well with computers. 1 2 3 4

16. I am sure I could learn a computer language. 1 2 3 4

17. I think using a computer would be very hard for me. 1 2 3 4

18. I could get good grades in computer courses. 1 2 3 4

19. I do not think I could handle a computer course. 1 2 3 4

20. I have a lot of self-confidence when it comes to working with computers. 1 2 3 4

21. I would like working with computers. 1 2 3 4

22. The challenge of solving problems with computers does not appeal to me. 1 2 3 4

23. I think working with computers would be enjoyable and stimulating. 1 2 3 4

24. Figuring out computer problems does not appeal to me. 1 2 3 4

25. When there is a problem with a computer run that I can't immediately solve, I would stick with it until I have the answer. 1 2 3 4

26. I don't understand how some people can spend so much time working with computers and seem to enjoy it. 1 2 3 4

27. Once I start to work with the computer, I would find it hard to stop. 1 2 3 4

28. I will do as little work with computers as possible. 1 2 3 4

29. If a problem is left unsolved in a computer class, I would continue to think about it afterward. 1 2 3 4

30. I do not enjoy talking with others about computers. 1 2 3 4

APPENDIX F

Background Data Form

(Chinese Version)

背景資料表

請認真、確實填寫這份表格以提供一些有關你個人的背景資料。填寫此表的方式是在你所選擇項目旁的小方格內打勾(例如：☑)，或是在畫線處簡答。

你的姓名： ____________ 你的學號： ____________

1. 你的性別是？ ☐ 女 ☐ 男

2. 你現在是大學幾年級？ ☐ 大一 ☐ 大二 ☐ 大三 ☐ 大四

3. 你的年齡是？ ____________

4. 你的系別是？ ______________________

5. 你曾經上過電腦課嗎（包括高中、國中、及國小）？ ☐ 有 ☐ 沒有

6. 你自己有電腦嗎？ ☐ 有 ☐ 沒有

7. 你有沒有用過任何一種文書處理、電子試算表、或資料庫系統之類的軟體？
   ☐ 有 ☐ 沒有

   如果有的話，你最熟悉的軟體是什麼？你對這個軟體用過多久(以月為單位)？

   軟體名稱： ______________________________
   使用過的時間： ________ 個月

8. 你有沒有寫過程式？ ☐ 有 ☐ 沒有

   如果有的話，你最熟悉的程式語言是什麼？你用這個語言寫過多久程式(以月為單位)？
   語言名稱： ______________________________
   寫程式的時間： ________ 個月

9. 你有沒有在上課時和同學分組討論及研究的經驗？ ☐ 有 ☐ 沒有

10. 你有沒有在上課時使用電腦輔助教學(CAI)軟體學習其課程的經驗？
    ☐ 有 ☐ 沒有

    如果有的話，你有沒有和同學一起使用電腦輔助教學(CAI)軟體學習其課程的經驗？ ☐ 有 ☐ 沒有

APPENDIX G

Background Data Form

(English Version)

Background Data Form

Instructions: This form is designed to help me understand your background. Please answer the following questions as accurately and honestly as possible. **Check** (✓) or **fill in** your response as appropriate.

Please indicate your student ID: __________

1. What is your sex? ❑ Female ❑ Male

2. What is your class standing? ❑ Freshman ❑ Sophomore ❑ Junior ❑ Senior

3. What is your age? ____________________

4. What is your major? ____________________

5. Have you ever taken a computer course (including in the secondary and elementary schools)? ❑ Yes ❑ No

6. Do you own a computer at home? ❑ Yes ❑ No

7. Have you ever used a word processing, spreadsheet, or database software program? ❑ Yes. ❑ No

   If yes: What is your most frequently used program?

   ____

   How many months have you used it? __________

8. Have you ever written a computer program? ❑ Yes ❑ No

If yes: What kind of computer language are you most familiar with? ______________

How many months have you written programs with this language? ______________

9. Have you had previous experience in cooperative learning (in non-CAI settings)? ❑ Yes ❑ No

10. Have you ever used a CAI program in class? ❑Yes ❑No

If yes: Have you ever used a CAI program cooperatively with your partner(s)?
❑Yes ❑ No

APPENDIX H

Raw Data

I.D.	Group	Gender	Age	Ownership	Course	Software	Programming	CSAT	CAS
001	T	M	19	N	Y	0	0	31	76
002	C	F	18	Y	N	0	0	21	78
003	T	F	18	Y	Y	0	0	28	92
004	C	F	18	N	Y	0	0	22	87
005	C	F	18	N	Y	0	0	16	79
006	T	M	18	N	Y	0	0	29	77
007	T	M	18	N	Y	0	0	23	85
008	T	M	20	N	Y	0	0	30	99
009	C	M	19	N	Y	0	0	19	85
010	T	F	20	N	Y	0	0	20	75
011	T	M	18	Y	Y	1	0	29	102
012	T	M	19	Y	Y	0	0	32	95
013	C	M	18	Y	Y	0	0	23	83
014	C	M	18	Y	Y	0	0	34	87
015	T	F	18	N	Y	2	0	26	91
016	C	M	18	N	Y	0	0	32	88
017	C	F	17	N	Y	0	0	23	82
018	C	M	19	Y	Y	0	0	15	78
019	C	F	19	N	Y	2	0	25	83
020	T	F	18	N	Y	0	0	24	83
021	C	M	25	Y	N	0	0	12	87
022	C	M	21	Y	N	2	0	19	103
023	C	M	20	N	Y	2	0	13	84
024	T	M	21	Y	Y	6	0	23	103
025	C	M	20	Y	Y	2	0	20	90
026	T	M	23	N	N	0	0	25	66
027	C	F	21	N	Y	0	0	23	77
028	T	F	20	Y	Y	2	0	24	82
029	T	F	20	Y	N	8	0	30	90
030	T	F	19	Y	Y	3	0	25	80
031	T	F	20	Y	Y	1	0	21	97
032	C	F	21	N	Y	1	0	21	75
033	C	F	20	Y	Y	1	0	20	108
034	C	F	21	N	Y	0	0	16	76
035	C	F	21	N	Y	0	0	12	73
036	T	F	22	N	Y	0	0	22	67
037	T	F	21	N	Y	0	0	22	106
038	C	F	21	N	Y	0	0	30	68
039	C	F	22	N	Y	6	0	30	84
040	T	F	21	Y	N	0	0	24	90
041	C	F	18	Y	Y	1	0	24	82
042	T	F	20	N	Y	1	0	32	88
043	C	F	21	Y	Y	0	0	15	75
044	C	F	19	N	Y	0	0	15	94
045	T	M	20	Y	Y	6	12	35	115
046	T	M	19	Y	Y	0	0	33	96
047	T	F	20	N	N	0	0	21	72
048	T	F	20	N	Y	0	0	26	75
049	T	F	19	N	Y	2	0	29	85
050	C	F	20	Y	Y	2	0	10	50

051	C	F	19	N	Y	0	0	16	69
052	C	F	19	Y	Y	0	0	21	75
053	T	M	19	Y	Y	4	0	24	77
054	C	M	21	N	Y	0	0	30	81
055	T	M	20	Y	Y	2	0	32	91
056	C	F	20	N	N	1	0	28	73
057	T	F	21	N	N	0	0	20	71
058	T	F	20	N	Y	0	0	29	70
059	C	M	20	Y	Y	0	0	21	86
060	T	F	20	N	Y	0	0	27	86
061	C	F	18	N	Y	1	0	23	76
062	T	F	19	N	Y	0	0	29	64
063	T	M	21	N	N	1	0	33	79
064	C	F	19	N	Y	6	6	30	79
065	T	F	20	N	Y	1	0	30	76
066	T	F	20	N	Y	0	1	33	81
067	T	F	20	N	Y	0	0	23	69
068	C	F	20	N	Y	0	0	14	63
069	C	M	19	Y	N	12	0	30	111
070	T	F	20	N	N	0	0	23	82
071	C	M	20	N	Y	0	0	17	88
072	T	F	19	N	N	0	0	23	71
073	C	F	24	N	Y	2	0	36	80
074	C	M	20	Y	Y	2	0	24	104
075	C	F	20	N	Y	0	0	13	70
076	C	M	19	N	N	4	0	29	86
077	C	F	18	N	Y	0	0	28	75
078	T	M	23	N	Y	0	0	29	84
079	C	F	20	Y	Y	1	0	33	84
080	T	F	21	N	Y	12	0	28	98
081	T	M	19	Y	Y	24	6	21	87
082	C	M	19	Y	Y	6	0	27	87
083	T	M	20	N	Y	6	0	23	75
084	C	F	20	N	Y	0	0	18	91
085	C	F	19	N	N	0	0	27	80
086	C	F	19	Y	Y	0	0	24	77
087	C	F	19	N	Y	1	0	25	85
088	T	F	22	Y	Y	12	4	35	83
089	T	F	20	Y	Y	6	4	30	82
090	T	F	21	Y	Y	6	6	34	98
091	T	F	20	Y	Y	24	6	31	86
092	T	M	22	Y	Y	0	12	35	95
093	T	M	20	Y	Y	0	2	30	75
094	C	M	31	N	Y	6	1	24	86
095	T	F	20	Y	Y	12	0	30	92
096	C	M	20	Y	Y	12	4	29	92
097	C	F	21	N	Y	1	4	21	76
098	T	F	20	Y	Y	0	0	26	87
099	C	M	24	N	Y	0	0	13	89
100	C	M	25	N	Y	4	0	15	97

101	C	F	20	Y	N	0	0	23	90
102	T	M	18	Y	N	0	0	18	82
103	C	F	20	N	Y	21	0	23	91
104	T	F	19	N	Y	0	0	25	74
105	T	F	23	Y	Y	0	0	20	79
106	C	F	19	Y	Y	4	0	26	82
107	C	F	19	N	Y	3	0	23	69
108	T	M	19	N	Y	0	0	29	70
109	T	F	21	N	Y	0	0	21	78
110	T	F	19	Y	Y	1	0	24	81
111	C	M	21	N	Y	0	0	11	87
112	T	M	19	N	Y	0	0	26	94
113	T	M	20	Y	N	2	0	18	71
114	T	F	20	Y	N	0	0	20	81
115	C	M	20	Y	Y	2	0	18	88
116	C	F	20	Y	Y	2	0	23	80
117	C	F	21	N	Y	0	0	19	78
118	C	M	21	N	Y	0	0	21	89
119	C	M	22	N	N	0	0	21	90
120	T	F	21	Y	Y	0	0	24	76
121	C	M	19	Y	Y	0	0	23	91
122	C	M	21	Y	Y	2	6	20	114
123	T	F	19	Y	Y	2	0	24	80
124	C	M	19	Y	N	1	0	21	109
125	C	F	22	N	Y	8	0	27	85
126	T	F	20	N	Y	1	0	28	84
127	T	F	19	N	Y	2	0	24	91
128	T	F	20	N	Y	0	0	25	82
129	T	F	21	N	Y	8	0	31	87
130	C	M	19	N	Y	1	0	28	79
131	T	F	20	N	Y	1	0	20	94
132	T	F	20	N	Y	6	0	27	86
133	C	M	19	N	N	1	0	25	76
134	T	M	28	Y	N	2	0	24	87
135	C	M	25	N	Y	0	0	19	82
136	T	M	24	N	N	0	0	32	99
137	T	F	20	Y	Y	0	0	23	68
138	C	F	21	N	Y	6	0	18	86
139	C	M	22	Y	Y	12	0	27	105
140	T	F	21	Y	Y	36	36	34	82
141	T	F	22	N	Y	2	8	34	42
142	C	M	26	N	N	0	0	23	72
143	T	M	21	Y	Y	12	4	30	105
144	T	M	22	Y	Y	2	0	26	76
145	T	F	21	Y	Y	36	8	25	92
146	C	F	21	Y	Y	1	3	24	94
147	C	F	21	N	Y	1	0	24	85
148	C	F	22	Y	Y	0	0	23	79
149	T	M	23	N	N	1	0	28	73
150	T	M	20	Y	Y	12	2	24	91
151	C	M	20	N	N	0	0	16	75
152	C	M	21	Y	Y	0	0	27	85
153	T	F	21	Y	Y	0	0	26	73

APPENDIX I

Letter of Permission

Dr. Brenda H. Loyd
264 Ruffner Hall
University of Virginia
405 Emmet Street
Charlottesville VA 22903

Ching-Heng Shen
3151 S. Babcock St. #168
Melbourne, FL 32901

Dear Ching-Heng Shen:

I, Dr. Brenda Loyd, am giving you permission to translate the Computer Attitude Scale instrument into Chinese and use the Chinese version in your study.

Brenda H. Loyd
Dr. Brenda Loyd

5/7/96
Date