COMPARISON OF STUDENT ACHIEVEMENT IN OPEN VERSUS CLOSED COMPUTER LABORATORIES

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Susan Allitt-Wheeler

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In fall 2002 research was conducted to determine if achievement was influenced by lab type (open or closed) in a computer specific skills course.

One experienced instructor was responsible for the lecture and lab classes. Demographic and self-efficacy surveys and a pretest were administered the first two days of class.

Achievement was measured using total points earned during the semester and posttest scores. Total points represented the sum of all assignments, quizzes, tests and final exam scores. There was no significant difference in either total points or posttest scores based upon lab treatment. Additional factors such as self-efficacy, gender and the interaction of gender and lab treatment were analyzed.

Self-efficacy was not a predictor of achievement in this research. Only analysis of total points and gender indicating females in both lab treatments scored higher than males was close to significant. Females scored higher as a result of receiving higher scores on lab assignments, not tests or quizzes.

In voluntary written comments the last day of class the majority of students indicated they would prefer assignment to an open lab. Students with higher means preferred open lab while students with lower mean total points preferred closed labs.

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This work is dedicated to Anne V. Allitt, mother of the writer. She instilled the belief that "I can do anything I set my mind to." She stepped in when the local public elementary school failed to provide the necessary learning environment for a basic education. It was because of her determination and tutoring that the writer succeeded in school and developed a love of learning and teaching.

S. A. W.

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CHAPTER I

INTRODUCTION

The impact of computer technology in education is evolving causing college educators to reevaluate computer course content (Denning, Gries, Mulder, Tucker, Turner & Young, 1989; The Joint Task Force on Computing Curricula, 2001). The focus of this research is the value of closed computer laboratories in entry level software application courses. Entering college freshmen tend to be more computer literate than students in the past bringing the need for closed laboratories into question for students in these courses. To frame this issue, consider the growth in computer use and availability in secondary schools in the United States.

The National Center for Education Statistics reported in *A Profile of the American High School Sophomore in 2002* that in the high school sophomore class "Nearly 90 percent had a computer available at home" and access to a computer at home was reported by 98 percent of students. In this high school sophomore class 47 percent of the students who expected to graduate from a four-year college and 67 percent of the students who expected to graduate with a professional or graduate degree used the computer for school assignments at least once or twice a week. The implication is that these students at least have a basic knowledge of microcomputers and some applications.

While many college classes incorporate some degree of computer use in their curriculum, it was typically classes that focused specifically on computer use that most often offered or required computer laboratory (lab) sections (Newby & Fisher, 2000). These classes are in one of three broad categories: computer science, information systems and software applications. Computer science was defined by the Computing Sciences Accreditation Board (CSAB) as "the body of knowledge concerned with computers and computation. It has theoretical, experiment, and design components" (Denning et al., 1989).

Introductory courses in information systems generally provide an overview of information processing concepts. These concepts have included the role of computers in business, the components of computer and information systems, and computer communications. In addition to information processing concepts, some introductory courses have also included software application instruction.

Various college departments typically offered the software applications classes which commonly focused instruction on a productivity suite such as Lotus Suite® or Microsoft Office®. Some departments offered instruction in web editors, graphic design, multimedia production and other application software.

A course in application software was the focal point of this research. A typical format for an application software course is one or more lectures per week and one or more computer laboratory class sessions per week. If the instructor did not personally attend the computer laboratory session, one or more graduate students, undergraduate students or other staff members usually supervised the session.

A computer laboratory section may be classified as either closed or open. A closed computer laboratory was defined by Denning et al. (1989) in terms of the “3 Ss”: Scheduled, Structured and Supervised. For this research a closed lab occurs in a computer facility, a room equipped with computer hardware and software provided by the institution for the purpose of supporting class or student activities, that is scheduled for a specific class during which only the students assigned to that laboratory are allowed to work. A faculty member, graduate student, undergraduate student or staff member supervises the laboratory. Students are expected to work on activities pertaining to the class. In this research the students using the closed computer laboratories make up the control group.

An open laboratory means that there is no specific scheduled class in a computer facility to accompany the lecture that students are required to attend. Students assigned to an open lab are provided assignments that typically would have been worked on during a closed lab, but are allowed to complete the work at a place and time of their choosing. Generally there is no supervision for an open lab.

Focus of this Study

This study began with some very basic questions which are as follows:

Question 1: Achievement: Is there a difference in achievement as measured in total points scored for the semester or posttest scores between students assigned to closed labs (control group) and those who are assigned to open labs (experimental group)?

Questions 2: Self-efficacy: Is computer self-efficacy a predictor of achievement as measured by total points or posttest? If self-efficacy is a predictor of achievement in this research, then is there a difference in computer self-efficacy between students assigned to closed labs (control group) and students in open labs (experimental group)? If the mean self-efficacy is significantly different between the labs, then how does the self-efficacy correlate with achievement in this research? Is there a difference in self-efficacy based on gender?

Question 3: Gender Factors: Is gender a predictor of achievement as measured by total points earned or posttest score? Will there be a difference in achievement in open and closed labs based on gender?

Question 4: Interaction of lab and gender: What affect does the interaction of lab (open or closed) and gender have on achievement as measured in total points scored for the semester or the score on posttest?

Question 5: Which would the student chose? If given a choice which would the students choose to enroll in, an open or closed lab? Why?

Significance of the Problem

If students do equally well in open computer laboratory compared to closed computer laboratory environments, the questions may be asked: “Is it necessary to schedule closed laboratory sections for all introductory computer specific skills classes?” and “Could the time spent in lab be allotted to additional class (lecture) instruction time?” For students without closed laboratory time it means more freedom to choose the time and place when they work on assignments and collaborate with fellow students. For schools there are potential savings benefits. There may be a cost reduction in staff needed to supervise these laboratories, reduction in the number of computer lab facilities and an increase in availability of facilities open to walk-ins.

Definition of Terms

Blackboard® – A course management software system that allows online access to course materials. Features include an online repository for course documents, discussion threads for class interaction, e-mail lists for the instructor's use, group designations for student group collaboration, online testing and surveys, and grade maintenance.

Computer experience – Experience an individual has had using a computer that may include high school computer classes, computer clubs, computer camps and home activities. These are variables that may be identified in a computer self-efficacy survey.

Computer facility – A room that is equipped with computer hardware and software provided by an institution for the purpose of supporting class or student activities.

Computer self-efficacy – For this research computer self-efficacy is the belief by a student that he or she could control his or her performance as it relates to computers. Computer self-efficacy in this research was measured using the Computer Self-Efficacy survey developed by Cassidy and Eachus (1998).

Closed computer laboratory – A closed computer laboratory was defined by Denning et al. (1989) in terms of the "3 Ss": Scheduled, Structured and Supervised. A faculty, graduate, undergraduate or staff member supervises the laboratory and students are expected to work on activities pertaining to the class. In this research a closed lab occurred in the computer facility that was scheduled for a specific class during which only the students assigned to that laboratory were allowed to work in the facility. In this research the students using the closed computer laboratories make up the control group and the instructor supervised all close lab sessions.

Final exam – A comprehensive written exam administered at the end of the semester. In this research the final exam was included as a component of total points.

Introductory computer course – The course described in this paper consisted of instruction in components of a microcomputer productivity suite (Microsoft Office®) and taught computer specific skills as defined by the Computing Curricula 2001 (CC2001).

Laboratory – Within this paper the word laboratory is sometimes referred to as lab.

Open computer laboratory – In this research an open laboratory had no specifically scheduled class time in the computer facility and there was no formal supervision. All students were free to come and go from the computer facility as they wished.

Posttest – A written exam covering features of the software applications that was taught in MS 120, Introduction to Microcomputers. This exam was taken by students at the end of the semester and was the same exam as the pretest. Neither the pretest or posttest score was included in the total points.

Pretest - A written exam covering features of the software applications that was taught in MS 120, Introduction to Microcomputers. This exam was taken by students during the second day of class. Neither the pretest nor posttest was included in the total points.

Section – In this research a section was a scheduled class that met at a specific time and location. A student enrolled in one lecture section and one laboratory section.

Session – A session was one occurrence of a lecture or computer laboratory meeting. During the academic semester in 2002 each section of the course met for one 90-minute laboratory session per week.

Self-efficacy – Self-efficacy are the beliefs by an individual regarding his or her ability to control his or her performance in specified activities such as computer used in this research.

Software application exam – An exam administered upon completion of the class studying a single software package.

Total points – Total points is the sum of all assignments, quizzes, tests and final exam scores. Total points do not include the score on the pretest or posttest. The maximum total points possible were 860 for this course.

Variables

Dependent variables in this research are the lab session (open, closed), gender (male, female) and a combined of gender and lab session (male open, male closed, female open, female closed). The two lab sections were identified as open computer laboratory (experimental group) and closed computer laboratory (control group).

Independent variables include total points earned in the class, scores on the pretest and posttest, scores earned on each application of the three components of the posttest (PowerPoint®, Excel® and FrontPage®) and the computer self-efficacy scores.

Target Population

Research was conducted at the Tabor School of Business at Millikin University, a private Baccalaureate College located in Decatur, Illinois. Students were required to take the three semester-hour introductory computer application course MS 120, Introduction to Microcomputers, during their first year at the university. Students in the business school were not allowed to "competency out" of this course by taking a test to demonstrate their skills in the applications covered in the course. Students enrolled in other departments were permitted to enroll in this course as an elective any time during their attendance at the university.

Approximately 120 students signed up for this course in the fall semester, 2002, 87 of students were the subjects in this research. During the semester four students withdrew from the university leaving 83 students in the class. The MS

120 introductory computer course consisted of two hours of lecture and two hours of lab per week.

The subjects in this research presented a unique opportunity to study a homogeneous group of students who were similar in age, ethnicity and grade level in a class taught by one instructor.

Hypotheses

Achievement

Hypothesis 1: There will be no statistically significant difference in mean total points earned (which includes all assignments) between students assigned to closed labs (control group) and those assigned to open labs (experimental group).

Hypothesis 2: There will be no statistically significant difference in the mean posttest scores between students assigned to closed labs (control group) and those who are assigned to open labs (experimental group).

Hypothesis 3: There will be no statistically significant differences in the mean posttest scores in each of the application sections (Excel®, PowerPoint® and FrontPage®) between students assigned to closed labs (control group) and those assigned to open labs (experimental group).

Self-Efficacy

Hypothesis 4: There will be no statistically significant difference in achievement as measured by mean total points earned compared to mean self-efficacy scores.

Hypothesis 5: There will be no statistically significant difference in achievement as measured on mean posttest scores compared to mean self-efficacy scores.

Hypothesis 6: There will be no statistically significant difference in mean self-efficacy scores for students assigned to closed labs (control group) and those assigned to open labs (experimental group).

Gender Factors

Hypothesis 7: There will be no statistically significant difference between mean self-efficacy scores based on gender.

Hypothesis 8: There will be no statistically significant difference in mean total points earned based on gender.

Hypothesis 9: There will be no statistically significant difference in mean posttest scores based on gender.

Hypothesis 10: There will be no statistically significant differences in mean posttest scores in each of the application sections (Excel®, PowerPoint® and FrontPage®) based upon gender.

Interaction of lab and gender

Hypothesis 11: There will be no statistically significant difference in mean total points between open and closed labs based on gender.

Hypothesis 12: There will be no statistically significant difference in mean posttest scores between open and closed labs based on gender.

Instrumentation

Achievement related data was collected over the 15 week semester. Total points, as an indicator of achievement, represented the accumulation of points during the semester from a variety of multiple-choice written exams, hands on practical exams, lab assignments and quizzes which had been used in similar form for the previous three semesters by the researcher. The previous experience in teaching this course helped the researcher to validate the materials used in these classes. The pretest and posttest were identical and consisted of a multiple choice exam divided into three sections that corresponded to the three application software packages PowerPoint®, Excel® and FrontPage®. The pretest was administered during the second day of class; this was then administered at the end of the semester as the posttest. Included with the posttest was a three question sheet that asked the students about which lab treatment they would prefer (open or closed) if they were to have the option for another similar class. Filling out this form was voluntary and 79 did submit responses although only 76 indicated a preference for a lab option. Neither the pretest nor the posttest was included in the total points.

During the first day of class a survey was administered to collect demographic information and data on student computer self-efficacy. The computer self-efficacy test was the product of research conducted by Cassidy and Eachus (1998).

Data Analysis

Data were analyzed using SPSS version 13.0. Descriptive statistics were used to determine means, standard deviations and ranges for variables. t tests were used to test the means of variables such as total points, posttest scores and self-efficacy scores against grouping variables such as lab treatment and gender. A Cronbach Alpha test was used to test the reliability of the self-efficacy test. Pearson product-moment correlations were used to compare pretest with posttest, self-efficacy with total points, and self-efficacy with posttest. ANOVAs (Analysis of Variance) were used to test interactions of gender and lab treatment against total points, posttest scores and self-efficacy scores. Some basic statistics and comments were included on student preferences for labs.

Assumptions

Interpretation of the statistics was based on the following assumptions:

1. Responses on the survey and self-efficacy test by the students were accurate.
2. Students in one section did not provide answers to questions on tests to students in a subsequent class.
3. Students working on lab assignments outside of class were submitting the product of their own efforts.
4. The selected methodology was appropriate for assessing student achievement in the class.
5. There is validity to the class developed assessment tools used by the researcher in this class.

Organization of the Study

This study is divided into five chapters. Chapter I provides an introduction to the problem, definition of terms, identification of variables, research questions, instrumentation, data analysis and assumptions. Chapter II presents a review of the related literature to this study including computer science courses, non-computer science courses, self-efficacy and gender related topics. Research Design and Methodology is described in Chapter III. Chapter IV presents data and analysis of information pertaining to the sample size and demographics as well as the research questions and their results. Chapter V presents the discussion, conclusions and recommendations for further study.

CHAPTER II

REVIEW OF RELATED LITERATURE

The literature reviewed in this chapter was divided into four areas of research: computer science courses, non-computer courses, self-efficacy and gender. Research concerned the influence of open and closed computer labs on achievement in computer science related courses is reviewed. More recently a limited amount of research on achievement in courses falling under the category of general education computer courses (CC2001) or non-computer science courses have been published. When studying achievement there are many other factors in addition to lab treatment that may be considered. Literature that addresses the topics of computer self-efficacy and gender as they relate to success in computer science is discussed.

Introduction

Denning et al. (1989) stated that introductory computer science courses should be accompanied with laboratories "under the guidance of a lab instructor who ensures that each student follows correct methodology." Tucker (1991) clearly defined the role of closed labs in computer science courses in Computing Curricula 1991 (CC1991) and expanded on Denning's Computing as a Discipline (1989).

Structured computer labs in computer science, CS1 and CS2 courses as identified in Computing Curricula 1991 (Tucker, 1991) were perceived as valuable facilitators in student learning since the closed lab provided the student with opportunities to develop problem solving skills. This document was directed at a defined computer science curriculum and consideration was not given to any courses outside of the computer science curriculum such as those that might fall under the general education category.

Ten years later, after many advances in computers and computer technology, the Computing Curricula 2001 (CC2001) stated that computer science had evolved into a laboratory science much like biology, chemistry, and physics. The report calls attention to the importance of laboratories: “Most courses in a computer science program must include a laboratory component that requires students to develop their technical skills and acquire an understanding of effective professional practice” (CC2001, 53).

A major difference between the CC1991 report and the CC2001 report was that for the first time a report addressed those aspects of computer science “relevant to all citizens and academic disciplines” (CC2001). In Chapter 12, Computing Across the Curriculum, the report identified the three types of knowledge that may be included in general education: computer-specific skills, fundamental and enduring computing concepts, and general intellectual capabilities. The course studied in this research focused on software applications which fell under the computer-specific skills category.

The computer-specific skills included basic software application suites (examples: Microsoft Office®, Lotus Suite®), email, and accessing the World Wide Web. Basic computer-specific skills generally are not static, as versions and upgrades to these applications require the user keep abreast of changes in order to be proficient in their use.

Fundamental and enduring computer concepts encompass a body of knowledge that are concept driven and are not software application specific. Fundamental concepts can be applied to newer versions or changes in applications or preferred vendor of the time. These may include “algorithms, complexity, machine organization, information representations, modeling, and abstraction” (CC2001).

General intellectual capabilities refer to the broad intellectual skills that may apply to all areas of study and are not restricted to just the study of computer science. Falling under this classification are “Problem solving, debugging, logical reasoning and effective oral and written communication skills” (CC2001).

The CC2001 report recognized that institutional challenges such as providing adequate computing facilities may be a factor in determining how these courses were implemented. Specific questions that might be asked by a course designer included: “Should the class be taught using a large lecture format or small discussion sections? Should it include a formal laboratory? Informal laboratory? No laboratory?”

The research described in this paper is concerned with the impact of open versus closed computer laboratories on achievement in classes that teach productivity software suites (computer skills category). Despite the popularity of general education computer courses on college campuses the researcher was able to locate just two studies (Brown, Day, & Meade, 1988; Newby & Fisher, 1997, 2000, 2001) where the focus in a non computer programming class was on achievement in open versus closed labs.

There have been numerous studies that support the belief that in computer science courses closed laboratories have a positive influence on achievement. Thweatt (1994) compared open and closed labs, Doran and Langan (1995) discussed a cognitive approach to studying computer science courses, Kumar (2003) investigated the affect of closed labs on retention of students in the class and test scores, and McCauley, Pharr, Pothering, and Starr (2004) proposed an approach for evaluating the effect of having the same or different instructors for lecture and labs. Several papers are reviewed as background to provide an insight in to the rationale behind computer labs in computer science.

Many studies were conducted before the proliferation in computers and the trickle down instruction of computer skills into the high schools. In addition computer systems and operating system software have become more user friendly resulting in basic skills being easier to master. There were many studies conducted when computing was restricted to college computer science courses. The evolution in computer technology requires that more studies be conducted in areas clearly defined in Computing Curricula 2001 as general education (non-computer) science courses.

Computer Science Courses

The influence of closed labs has been a topic covered in the literature for many years some going back to the era when mainframes were the only computing option. Two more recent studies, Thweatt (1994) and Kumar (2003) are reviewed plus a proposal for new research is mentioned (McCauley et al., 2004).

Kumar (2003) reported a project to improve student retention rate in classes (percentage of students starting and completing the class) in Computer Science I at Ramapo College in New Jersey. He reported the retention rate was "between 40-50%" in the three credit hour introductory programming classes when the courses were taught in lecture only format. Closed labs were incorporated into the courses in 2001 resulting in a course equivalent to four contact credit hours.

The author compared two sections of the course in fall 1998 with open lab sections to two sections of closed labs in 2001 (one section in spring 2001 and one section in fall of 2001). All four sections were taught by the same instructor; however, students in the 2001 sections received more hands-on, supervised practice in closed lab sessions. In the closed lab class students were required to stay after lecture for the first 45 minute lab session, but were not required to stay during the second 45 minute lab session. There was no mention of whether attendance was taken during either or both lab sessions.

The instructor and two teaching assistants provided assistance to students in the closed lab session. During the closed labs students were provided incremental programming exercises which were reviewed at the end of the lab session but not graded. The exercises provided during the closed lab were in addition to the programming projects that both the 1998 and 2001 classes were expected to complete. The paper compared student retention rates in class, scores on all exams, final grades in the class, and completed programming projects.

The research indicated that closed labs did not help improve retention. The retention rate increased from just over 58% ($\underline{N}$ = 70 enrolled, $\underline{N}$ = 41 retained) in 1998 to close to 60% ($\underline{N}$ = 65 enrolled, $\underline{N}$ = 39 retained) in 2001. The increase was not significantly higher for students in the closed lab classes. The practical experience solving problems and programming along with additional assistance from the instructor and lab assistants may have been the reason for the improvement in retention.

Kumar reported the letter grade results for the two both sets of classes. The closed labs classes in 1998 showed a higher percentage of A's while the percentage of B's was higher in the 2001 open labs. Grouping the scores together resulted in more students (63%) in the 1998 open labs receiving A's or B's than the 2001 closed lab (54%). In addition there was a higher percentage of D's and F's in the closed lab (33%) compared to (29%) in the open. No explanation is given for these results.

Analysis of test scores indicated a significant difference on the first test between the closed and open lab sections but no significant differences between the second test and the final exam scores. Discussion of the differences between the lecture format and closed lab class indicated that the first test administered in fall 1998 was hand written and given without access to a computer. This test was scored using different criteria for grading when compared to the grading criteria in the remaining tests in 1998 and all tests in 2001. These tests were online and students had access to a compiler allowing them to check the code they had written. The online test was timed, and the author felt that time exams negated the advantage of having access to the computer during the test.

The implications of this research indicated that having closed labs might be beneficial during the first third of a course when students are learning how to use the software, the programming environment, and are able to verify the accuracy of their programs. The author suggested that perhaps reduction in closed labs after the first test may be a topic that should be further investigated.

A potential problem with the design of this research was that it used comparative data between classes that occurred several years apart. During that time, the instructor may have changed textbooks, lectures, and programming assignments. Presentation of the course material may have been modified after the 1998 session if the instructor identified where students had problems and addressed those problems in subsequent semesters. Students enrolled in the 2001 courses may have had more computer experience prior to taking the class. Finally, just the addition of extra lab assignments may have led to greater understanding of the programming assignments.

Thweatt (1994) reported a study on Computer Science I courses for two sequential semesters during the academic year 1992-1993. The fall 1992 classes were taught by different instructors using the same tests, assignments and coordinated lectures. Students were randomly assigned to either the open or closed lab sections. Students enrolled in spring 1993 classes were given the opportunity to enroll in either an open or closed lab section. Both 1993 sections were taught by the same teacher using the same tests, assignments and lectures. One difference between the two spring sections was that the closed lab class met twice per week for 75 minute sessions while the open lab class met for 50 minutes three days per week.

Thweatt's conclusions included "closed labs apparently make a positive difference overall." Individual analysis of group results showed that in the fall 1992 with different teachers, there was no significant difference in exam scores between the two groups. The spring 1993 group shows "the comprehensive exam mean of the closed lab group (M = 81.0, n =17) was nearly significantly higher (p = .053) than the mean of the open lab group (M = 74.4, n = 24)". When the data were combined for both classes semesters the "comprehensive exam mean of the closed lab group (M = 81.66, n = 35) was significantly higher (p = .013) than the open lab group mean (M = 75.6, n = 45)." Results were still significant if GPA was controlled resulting in a difference of p = .014. While the original rationale for adding a closed lab was to increase retention, there was no significant difference in student retention in class between closed and open lab classes recorded. No detail was provided on the grade distribution, student retention rate in class or student profiles. Self-selection by the students for either an open or closed lab may have been a contributing factor to the increased difference in means.

Evaluations of the effectiveness of closed labs in the computer science curriculum are on-going. In a recent proposal by McCauley et al. (2004) a controlled environment experiment will be conducted to test the effectiveness of the same and different lecture and lab instructors using a closed lab environment for CS I classes. Their research will test the effectiveness of labs. The only controlled variables between the classes will be that in the controlled group the lab instructor will be the lecture instructor while in the experimental group the lab instructor will not be the lecture instructor.

The previously described research activities are examples of the research into the effectiveness of closed labs in computer science. In comparison there are very few that look into the affect of closed labs on computer-specific skills, fundamental and enduring computing concepts, and general intellectual capabilities as described in CC2001.

Non-Computer Science Courses

Courses that fall under the non-computer science courses fall under the general education category as identified by the Computing Curriculum, 2001. The interaction of computer ownership and attendance in lab (Brown et al., 1988), the influence of microcomputers on achievement by Cates (1992), and the comparison of computing labs environments in computer related courses (Newby & Fisher, 1997, 2000, 2001) have been reviewed.

Brown et al. (1988) investigated the effects of computer ownership and attendance in the laboratory in an introductory information systems class. Achievement by the students was determined by the grade on a single applications test and a final grade earned in the course. The researcher looked at variables beyond computer ownership and computer laboratory attendance that might have impact on the grades. Among the tested variables were the number of hours the student studied, the student use of study guides, and other factors.

There are several differences in Brown's research from this research. The class Brown observed consisted of instruction in a software program named *Ability*® and computer information concepts. The application taught in Brown's research was not as widely used as the Microsoft Office Suite® is today. It is doubtful that these students had previous exposure to the software and prior knowledge was most likely limited.

Brown stated that 74 percent of the students who owned a computer attended the computer laboratory while 87 percent of the students who did not own a computer attended computer laboratory. Students who owned a computer and attended computer laboratory sessions scored higher on the computer application test. Brown implied that when considering the overall course, owning a computer may only indicate greater interest in course material. The Brown study relied upon self-reported data acquired from the students and course grades that were based on concepts unrelated to computer usage.

Cates (1992) in a study of graduate students reported on the influence of microcomputers on achievement. In this research the performance in the course should not have been affected by computer ownership since the achievement differences were based upon analysis skills of the students. Computer use was not the focus of the course. The results tended to indicate that those graduate students who owned computers did achieve higher scores on individual tests and on overall grades.

Newby and Fisher published three successive papers on learning environments with the premise that perceived classroom (learning) environments may be predictors of student learning. The first paper focused on the development of an instrument to measure attitudes towards computing and assessment of laboratory learning environments. They reported on the assessment of computer laboratory environments and the influence on learning using the Computer Laboratory Environment Inventory (CLEI) and the Attitude towards Computing and Computing Courses (ACCC). Both instruments were developed at Curtin University of Technology Business School in Western Australia.

The subjects of the Newby and Fisher (1997) study were undergraduate and postgraduate level students. The paper did not provide any details on the computer component of the class such as how many class sessions were held in the computer laboratory facility or the importance of the computing component on the student's grade. The only reference to the computer was: "All of these courses involved using a computer to develop information systems."

Newby and Fisher (2000) used the data from the development of the two test instruments (CLEI and ACCC) at the Business School at Curtin University of

Technology to sample students in programming courses and more general courses that included application software (i.e., spreadsheets). There were 208 students in this study. Achievement was measured using three components: examinations, assignments and laboratory exercises. However, not all courses included all three components. Most courses included a final examination and some included a score for one computer assignment.

Newby and Fisher (2000) concluded "Although there is little direct association between computer laboratory environment and achievement, the model indicates that there is an indirect effect of environment on achievement through attitude."

Newby and Fisher (2001) compared open and closed computer laboratories based on data obtained by their CLEI and ACCC instruments developed in previous studies. They also looked at student outcomes. Subjects were students enrolled in courses taught through the business schools at the respective institutions. Using data on achievement from the closed laboratories classes held at Curtin University of Technology ($\underline{N}$ = 104) they compared the achievement of subjects who attended open laboratory sessions held at California State University ($\underline{N}$ = 109). Despite the difference in location and time of year the courses were taught, the authors indicated that the instructor who taught both classes considered the students "similar in academic level and background."

The computing environment at Curtin was a combination of a centralized computer and some networked microcomputers, while in California the laboratory had networked microcomputers. There was no mention of previous experience with computers, computer ownership by students or student access to the class software outside the laboratory.

Achievement was defined as a grade that was composed of a final examination, laboratory exercises, and other assignments. According to the researchers: "Both the examination and the assignments tested knowledge and skills that should have been gained mainly in the laboratory classes, whose main purpose was to give practical experience of material covered in the lectures" (Newby & Fisher, 2001). This study "did not show a significant difference in the means for achievement, it did show a lower mean for anxiety and higher mean for perceived usefulness of the course for those courses with closed computer laboratories" (Newby & Fisher, 2001). They indicated that student attitudes and achievement could be improved with closed labs.

Self-Efficacy

Bandura (1994) stated: "Perceived self-efficacy is defined as people's beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives." How one feels, thinks, behaves and motivates themselves is determined by an individual's self-efficacy. The influence of these beliefs initiates motivation, cognitive processes and reactions to situational demands. Research began with medically related behavioral research in areas such as eating disorders like bulimia (Schneider, O'Leary, & Bandura, 1985), fear arousal (Bandura, Reese & Adams, 1982), and smoking reduction (Baer, Holt & Lichtenstein, 1986) to name a few.

Research in other areas such as computer self-efficacy has expanded on Bandura's work. Harrison, Rainer, Kelly, Hochwarter, and Thompson (1997) examined task-specific performance in a work setting and its relationship to self-efficacy perceptions using a Computer Self-Efficacy Scale (CSE) to measure computer-related knowledge and skills combined with a performance measurement instrument. They hypothesized "that individuals with higher levels of performance on computer-related tasks would demonstrate higher self-efficacy perceptions" and that "individuals with lower level of performance on computer-related tasks were expected to demonstrate lower self-efficacy perceptions." Their research supported both hypotheses.

Smith (2001a) investigated the relationship between computer-related task performance and computer self-efficacy with a small number of students (N = 10) in an introductory computer application course. Smith stated that this was exploratory research intended to validate instruments and procedures. Both the self-efficacy and performance tests were administered during the last three days of a five week summer session. "Many students arrive in introductory computer applications courses with great confidence in their ability to perform a computer-related task, but are often unable to accomplish the task without extensive instructions."

Other research on self-efficacy dating from the mid 1980s helped developed a framework upon which self-efficacy in general can be validated. A number of factors which may contribute to variances in self-efficacy were explored including computer ownership, amount of time an individual spends using a computer and successful experiences in classes where a computer is used (Albion, 2001, Torkzadeh & Koufteros, 1994).

Smith's research (2001b) explored Bandura's theory that "personal efficacy beliefs can be developed by four major sources of influence." According to Smith "experience alone will not heighten computer self-efficacy." She asserted that Bandura's four sources of influence: "mastery experiences, vicarious experiences, verbal persuasion, and affective states" may "interact to modify computer self-efficacy beliefs." This also appeared to correspond with Albion (2001) who suggested that self-efficacy may be increased by positive encouragement of computer use by teachers.

The computer self-efficacy research by Cassidy and Eachus (1998) resulted in a validated test that correlates computer self-efficacy to computer experience, familiarity with software packages, computer ownership, computer training and gender. Since the publication of this scale, it has been used by Christian (2000) to measure computer competence, confidence and learning. In this research it was used to test if self-efficacy was an indicator of achievement.

Their instrument was designed to correlate computer self-efficacy to computer experience, familiarity with software packages, computer ownership, computer training and gender. Developed in two phases, the test used a six point Likert scale that expressed agreement/disagreement with 30 items. Approximately half of the statements required a negative response to control for affirmation bias. Using Cronbach's Alpha test to determine reliability, they reported that the internal consistency of the 30-item scale had an alpha = 0.97, N

= 184, and a highly significant test-retest reliability of $\underline{r} = 0.75$, $\underline{p} < 0.0005$, $\underline{N} = 210$ over a period of one month. Validity was tested "...by correlating the self-efficacy scores with a self-reported measure of computer experience and with a number of computer packages used." The self-reported computer experience correlated at $\underline{r} = 0.79$, $\underline{p} < 0.0005$, $\underline{N} = 212$ and the familiarity at $\underline{r} = 0.75$, $\underline{p} < 0.0005$, $\underline{N} = 210$.

Gender

Numerous studies on computer-related gender differences focus on issues related to students entering or already enrolled in computer science curriculums (Sackrowitz & Parelius, 1996; West & Ross, 2002; Tjaden & Tjaden, 2000). Self-efficacy and attitude towards computers have been identified as potential predictors of a student's career choice, success in computer related classes and selection of computer science as a major in college (Busch, 1995, Cassidy & Eachus, 1998; Moorman, P. & Johnson, E., 2003).

Busch (1995) studied computer attitudes and perceived self-efficacy by having students complete a questionnaire upon completion of a required introductory computer course in a Norwegian college. Software applications studied were word processing (Word Perfect®) and spreadsheet (Lotus 1-2-3®). Results indicated that males had a higher self-efficacy expectation with the more complex tasks within these two applications. Predictors that might account for differences in self-efficacy varied for the two applications. Previous computer experience in word processing was a good predictor for difference in self-efficacy related to complex tasks in WordPerfect® while previous programming experience was a predictor in Louts related questions.

Using subjects from two major universities, Princeton and Rutgers, Sackrowitz and Parelius (1996) concentrated their research on the success in an introductory computer science course and the gender differences in preparation and skills. Their findings indicated that males entered the introductory course with stronger programming skills and more previous involvement with computers than the females. Incoming programming skills were important to higher final grades and those with less incoming programming skills had lower achievement in the courses. Also, males generally exhibited higher grades and achievement.

Cassidy and Eachus (1998) stated that males had higher scores in self-efficacy, experience with computers and familiarity with software packages than females. Even when students had prior training the males scored higher than females in these areas.

Wilson and Shrock (2001) studied predictor factors for success in an introductory computer science course. They found that self-efficacy and gender were not among the predictive factors in their study but rather "comfort level" and math background appeared to have the greatest influence on success in the class. Comfort level was explained as a "continuous variable" that was a combination of scores from seven questions regarding feelings about answering questions in the class, anxiety levels and the student's perceptions on class assignments and concepts in the class. Self-efficacy was measured using a different instrument.

Perceptions and attitudes seemed to be the gender related variables which stood out in some studies. Moorman and Johnson (2003) studied high school students in advanced mathematics and computer science classes and their attitudes towards computer science. They found that the females “showed tremendous academic potential” based upon grades in these courses but the females who scored higher than the males perceived that the males were more naturally inclined to succeed in these subjects and made their career choices accordingly.

Gender bias toward computers is a potentially important factor in female success in these courses and therefore included in this research.

Summary

Research into open and closed labs has resulted in numerous studies supporting closed labs for computer science courses. Fewer studies in the general education category of computer related courses have been conducted, and none were designed to test the impact on achievement based solely on lab treatment. Studies that focused on the impact of computer self-efficacy and gender were discussed to provide background for other variables in this research.

CHAPTER III

RESEARCH DESIGN AND METHODOLOGY

Enrollment at Millikin University in 2002 was approximately 2,000 full time students. The fall semester classes began on August 26, 2002 and ended with a final exam first week in December, 2002.

Research Design

All students enrolled in the class completed a computer self-efficacy survey the first day of class. Included in the survey were questions related to the level of the student's experience with computers and applications.

On the second day of lecture all students took a pretest which also was given as a posttest at the end of the semester. The pretest and posttest consisted of three parts, one for each of the three software applications taught in the class: PowerPoint®, FrontPage® and Excel®. Comparisons were made between the total pretest and posttest scores as well as comparisons between scores in both pretest and posttest for each of the software applications covered in the class. On the last day of class students were asked to indicate whether they would prefer to enroll in an open or closed lab and explain the reasons for their choice of labs.

The test-retest method using equivalent forms were used to support the reliability of the scoring in the course. The test-retest instruments used in

PowerPoint® were a written exam, a quiz, and the creation of a PowerPoint® presentation. The test-retest instruments for FrontPage® and Excel® were a written exam, a quiz, and a hands-on practical exam. In addition, scores in each application exam were compared to the scores on both pretest and posttest.

The maximum number of total points was 860 during the semester. There were written and hands-on exams for each of the software applications plus a final totaling 500 points. Lab exercises, quizzes and homework assignments accounted for the remaining 360 points. Neither the pretest nor the posttest scores were included in the total points accumulated during the semester. Table 1 shows the break down of the 500 points as described above.

Table 1

Total Points Possible Per Software Application Exam

Application	Written Exam	Hands-on Practical
PowerPoint®	60	50
Excel®	100	100
FrontPage®	70	70
Final Exam	50	

Data Collection and Procedures

The research consisted of a quasi-experimental design with non-equivalent controls. Analysis of posttest scores and test-retest using equivalent forms were used to test the null hypotheses that manipulated closed computer laboratory scores versus open computer laboratory scores that resulted in no significant difference in student achievement. A comparison of these data with the results of the computer self-efficacy survey was made.

Assignment of Students

This research used nonequivalent groups. Incoming students enrolled during the summer months or the week before the start of classes in the fall. During registration, students created a schedule of classes based upon the times various classes meet. If there were conflicts in class times, the registrar assigned a student to a particular section. Students enrolled in the lecture and laboratory sections without prior knowledge of the planned experimental design. Each lecture class was divided into two laboratory sections. The instructor was unable to control the behavior of students with regards to adding or dropping the class after the first day of attendance. None of the students chose to change their lab sections after learning of the research at the end of the first day of class and all students signed consent to participate forms.

Administration of Class

One instructor, the researcher, using the same class materials, taught both class lecture sections and was responsible for all control and experimental computer laboratory sections. This instructor had taught the same course for three successive semesters prior to the research experiment using the same or similar class materials. Exams, quizzes, and laboratory activities were identical in lecture and laboratory sections and administered the same day for all sections.

Each lecture section was composed of students attending either the experimental or the control laboratory class.

In lecture, students were told that the instructor would be available outside of class to assist students. The instructor's office, home telephone number and e-mail address were provided on the syllabus and the class website. All students were told that if they needed assistance they could stop by the instructor's office or contact the instructor by telephone or e-mail. Office hours were maintained during specified times to insure students could contact the instructor in her office. The instructor logged the name, time and the nature of the assistance provided to any students requesting assistance outside of class. Only a few students took advantage of contacting the instructor outside of class and most of the contacts were made during the first few days of lecture on FrontPage®, the application that was new to the majority of students. If a question was asked in a one-on-one discussion with the instructor, the information was then covered in the next day of lecture.

Assignments for experimental and control laboratory sections were identical. The semester assignments were provided in a packet during the first full week of class, each assignment was to be submitted electronically when due using the Blackboard® system. Due dates for all laboratory work were the same date and time for all labs sections. The instructor used a grading gird for each assignment to insure consistency in grading.

Students in the closed labs were required to attend all lab sessions. In the open laboratory sections there were three mandatory laboratory class periods that students were required to attend. The first laboratory class was to explain laboratory procedures while the other two laboratory classes are reserved for the students to take hands-on practical exams. The dates of these laboratory sessions were listed in the syllabus which was handed out in lecture and available on Blackboard®, a course management system that allows online access to course materials.

All students in the lectures session were provided with sample practical exams ten days prior to taking the exams in lab. Review of the sample practical exams for Excel® and FrontPage® was presented during the lecture day preceding the exam.

Students were required to take online quizzes through the Blackboard® website. Quiz dates and topic areas were listed in the syllabus which was handed out in lecture and available during the semester on Blackboard®. At the end of the semester the final exam was administered during finals weeks on campus.

Letters of Compliance

A request for an institutional review of research using human participants was filed with Millikin University's Institutional Review Board (IRB). Forms of consent are included as Appendix A in this document. Chairperson, Rene Verry, forwarded the IRB approval from Millikin University. A request to Illinois State University's Institutional Review Board was filed and approved.

CHAPTER IV

RESULTS

Sample Size and Demographics

The research group consisted of 83 students, 50 males and 33 females, ranging in age from 18 to 51 with an average age of 19. The class consisted of 59 freshmen, 18 sophomores, five juniors and one senior and two no responses. All freshmen were business majors in the Tabor School of Business; the remaining students were from other departments at the university.

During the first lecture session a survey was taken by 86 students, one student was absent. During the semester four students withdrew from this class and the university resulting in a test group of 83 students. The first day survey results provided information on student demographics and some individual computer background information. A self-efficacy test was also given in class that day.

Of 86 students who filled out the survey, 72 students indicated that they arrived on campus with a computer, and 79 reported that they had access to a computer while off campus. The students indicated a preference for Windows® operating system (PC) over an Apple® operating system (MAC®) ($\underline{n}$ = 78 PC, $\underline{n}$ = 3 MAC®, $\underline{n}$ = 5 no response). In response to the question: "What is your self-report on your experience with computers?" one answered "Extensive", 26 answered “Quite a lot”, 45 answered “Some experience”, nine answered “Very Limited” and six did not respond to the question.

The survey asked students about their experience level with the various software packages that were to be covered in the class. As Table 2 shows, the majority of the class seemed to have some level of experience with PowerPoint® and Excel® ; while most of them had not used FrontPage® or unsure if they could use it.

Table 2

Skill Level Student Self Evaluation

Skill Level Question	Rating	FrtPg		PPT		Excel®	
		N	%	N	%	N	%
I have not used this	1	45	52.3	16	18.8	16	18.8
Not sure I can use this	2	34	39.5	20	23.5	22	25.9
I can use this application satisfactorily	3	6	7.0	35	41.2	36	42.4
I can use this very well	4	1	1.2	14	16.5	11	12.9
Total Responses		86		85		85	

Note. FrtPg = FrontPage®, PPT = PowerPoint®.

Hypotheses

Hypothesis 1: There will be no statistically significant difference in mean total points earned between students assigned to closed labs (control group) and those who are assigned to open labs (experimental group). The obtained t value (-0.728) did not fall in the critical region and therefore the null hypothesis of no difference in the mean of student's total points is supported. The total points for those in the closed labs were not significantly different from those in the open labs, $t(83) = -0.728$, $p > 0.05$, two tailed.

Hypothesis 2: There will be no statistically significant difference in the mean posttest score between students assigned to closed labs (control group) and those assigned to open labs (experimental group). The obtained t value (0.152) did not fall in the critical region and therefore the null hypothesis of no difference in the means of student's posttest score is supported. The mean posttest score for those in the closed labs was not significantly different from the mean posttest score in the open labs, $t(83) = 0.152$, $p > 0.05$, two tailed.

Table 3 contains the mean, standard deviation and number of subjects in each lab session for total point and posttest scores.

Table 3

Mean Total Points, Posttest Scores by Lab

	Total Points			Posttest Score		
Lab Session	M	SD	N	M	SD	n
Open Lab	660.25	121.49	36	34.20	4.33	36
Closed Lab	680.47	128.18	47	34.05	4.90	47

Hypothesis 3: There will be no statistically significant differences in mean posttest score in each of the application sections (Excel®, PowerPoint® and FrontPage®) between those students assigned to closed labs (control group) and those assigned to open labs (experimental group.)

For PowerPoint® the obtained t value (0.232) did not fall in the critical region and therefore null hypothesis of no difference in the mean PowerPoint® score is supported. The mean PowerPoint® score for those in the closed labs was not significantly different from the mean in the open labs, $t(83) = 0.232$, $p > 0.05$, two tailed.

For Excel® the obtained t value (-0.092) did not fall in the critical region and therefore null hypothesis of no difference in the mean Excel® score is supported. The mean Excel® score for those in the closed labs was not significantly different from the mean in the open labs, t (83) = -0.092, p > 0.05, two tailed.

For FrontPage® the obtained t value (0.420) did not fall in the critical region and therefore null hypothesis of no difference in the mean FrontPage® score is supported. The mean FrontPage® score for those in the closed labs was not significantly different from the mean in the open labs, t (83) = 0.420, p > 0.05, two tailed.

Levene's Test for equity of variance was computed with no significant differences being found for any of the tests on the applications. Therefore, homogeneity of variance was assumed.

The analysis of the three software application showing the lab session, mean of scores for each application, standard deviation, number of students and t-score for each lab session is shown in Table 4.

Table 4

Mean Posttest Scores by Application and Lab Treatment

Application	Lab Session	M	SD	n	t
PowerPoint®	Open	6.54	1.46	36	.232
	Closed	6.47	1.40	47	
Excel®	Open	18.97	3.35	36	-.092
	Closed	19.04	3.22	47	
FrontPage®	Open	8.69	1.34	36	.420
	Closed	8.53	1.84	47	

Hypothesis 4: There will be no statistically significant difference in achievement as measured by the mean total points compared to the mean self-efficacy score. Using Pearson product correlation coefficient, a weak correlation of r (83) = 0.132 was found. The obtained r value did not fall in the critical region and therefore the null hypothesis of no correlation between mean self-efficacy score and mean total points is supported.

Hypothesis 5: There will be no statistically significant difference in achievement as measured on the mean posttest score compared to the mean self-efficacy score. Using a Pearson product correlation coefficient, a weak correlation of r (83) = 0.122 was found between the means on self-efficacy and the mean posttest. The obtained r value did not fall in the critical region and therefore the null hypothesis of no correlation between the mean self-efficacy score and mean total points is supported.

Hypothesis 6: There will be no statistically significant difference in the mean self-efficacy score in students assigned to closed labs (control group) and the mean of those assigned to open labs (experimental group). The obtained t value (0.311) did not fall in the critical region and therefore the null hypothesis of no difference in the mean self-efficacy score is supported. The mean self-efficacy score for those in the closed labs was not significantly different from the mean in the open labs, t (83) = 0.311, $p > 0.05$, two tailed.

Hypothesis 7: There will be no statistically significant difference between the mean self-efficacy score based on gender. The obtained t value (-0.234) did not fall in the critical region and therefore the null hypothesis of no difference in the mean self-efficacy score compared to gender is supported. The mean self-efficacy score for females was not significantly different from the mean self-efficacy score for males, t (83) = -0.234, p > 0.05, two tailed.

Table 5 shows the mean and standard deviation on the self-efficacy survey broken down by lab treatment and gender.

Table 5

Mean Self-Efficacy Scores by Lab Treatment and Gender

Group	M	SD	N	t
		Lab Treatment		
Open	147.24	28.87	36	.311
Closed	145.34	26.01	47	
		Gender		
Males	145.6	28.95	50	.234
Females	147.0	24.52	33	

Hypothesis 8: There will be no statistically significant difference in mean total points earned based on gender. The obtained t value (-2.70) did not fall in the critical region and therefore the null hypothesis of no difference in mean self-efficacy score based on gender is supported. The mean total points for females was not significantly different from the mean total points for males, t (83) = -2.70, p > 0.05, two tailed.

Hypothesis 9: There will be no statistically significant difference in mean posttest score based on gender. The obtained t value (0.859) did not fall in the critical region and therefore the null hypothesis of no difference in the mean posttest score based on gender is supported. The mean posttest score for females was not significantly different from the mean total points for males, $t(83) = 0.859$, $p > 0.05$, two tailed.

Table 6 compares the mean and standard deviation of total points and posttest scores for males and females.

Table 6

Mean Total Points, Posttest Scores by Gender

		Total Points		Posttest Score	
Gender	n	M	SD	M	SD
Males	50	642.7	131.0	33.7	4.49
Females	33	715.6	102.2	34.8	4.84

Hypothesis 10: There will be no statistically significant differences in mean posttest scores in each of the application sections (Excel®, PowerPoint® and FrontPage®) based upon gender.

For PowerPoint® the obtained t value (-.629) did not fall in the critical region and therefore the null hypothesis of no difference in the mean

PowerPoint® score is supported. The mean PowerPoint® score for males was not significantly different from the mean PowerPoint® score for females, t (83) = -.629, $p > 0.05$, two tailed.

For Excel® the obtained t value (-.797) did not fall in the critical region and therefore null hypothesis of no difference in the mean Excel® score is supported. The mean Excel® score for males was not significantly different from the mean Excel® score for females, t (83) = -.971, $p > 0.05$, two tailed.

For FrontPage® the obtained t value (-.922) did not fall in the critical region and therefore null hypothesis of no difference in the mean FrontPage® score is supported. The mean FrontPage® score for males was not significantly different from the mean FrontPage® score for females, t (83) = -.922, $p > 0.05$, two tailed.

Levene's Test for equity of variance was computed with no significant differences being found for any of the tests on the applications. Therefore, homogeneity of variance was assumed.

The analysis of the three software applications showing the gender, mean of scores for each application, standard deviation, number of students and t-score for males and females is shown in Table 7.

Table 7

Mean Posttest Scores by Application and Gender

Application	Gender	M	SD	n	t
PowerPoint®	Males	6.42	1.42	50	-.629
	Females	6.62	1.43	33	
Excel®	Males	18.78	3.26	50	-.797
	Females	19.36	3.27	33	
FrontPage®	Males	8.47	1.54	50	.922
	Females	8.81	1.78	33	

Hypothesis 11: There will be no statistically significant difference in mean total points between open and closed labs based on gender. There was no significant overall difference in mean total points scored between groups based on lab type and gender, one-way ANOVA $F(3,79) = 2.558$, $p = 0.061$ and therefore the null hypotheses of no difference in mean total points is supported.

Table 8 presents the mean, standard deviation, and number for the combinations of gender and lab treatment. Table 9 is the one-way ANOVA summary table.

Table 8

Mean Total Points by Gender, Lab Treatment

	Males			Females		
Group	M	SD	n	M	SD	n
Open Lab	629.3	122.6	23	715.0	105.0	13
Closed Lab	654.1	122.6	27	716.1	105.0	20

Table 9

Analysis of Variance Total Points by Gender, Lab Treatment

Source	SS	df	MS	F	P
Between Groups	113405.0	3	37801.7	2.558	0.061
Within Groups	1167258	79	14775.4		

Hypothesis 12: There will be no statistical significant difference in the mean posttest scores between open and closed labs based on gender. There was no significant overall difference in the mean posttest scores between groups based on lab type and gender, one-way ANOVA $F(3,79) = 1.341$, $p = 0.267$ and therefore the null hypothesis of no means difference based on lab type and gender is supported.

Mean and standard deviation of posttest scores for the combinations of gender and lab treatment is shown in Table 10. Table 11 shows the one-way ANOVA.

Table 10

Mean Posttest Scores by Gender, Lab Treatment

	Males			Females		
Group	M	SD	n	M	SD	n
Open Lab	33.1	4.7	23	36.2	2.8	13
Closed Lab	34.2	4.4	27	33.9	5.6	20

Table 11

Analysis of Variance Posttest Scores by Gender, Lab Treatment

Source	SS	df	MS	F	P
Between Groups	85.4	3	28.5	1.341	0.267
Within Groups	1676.6	79	21.2		

What Students Said

A total of 79 students participated in filling out portions of a preference survey on lab assignments after they completed the posttest. The first question concerned the opportunity to enroll in a class with an open or closed lab. Descriptive statistics show that the majority would choose to enroll in an open lab (Table 12).

Table 12

Preferred Lab Choice by Actual Lab Enrolled

	Enrolled in Closed Lab		Enrolled in Open Lab	
Preferred Lab	Frequency	Percent	Frequency	Percent
Open Lab	19	28.4	30	44.8
Closed Lab	12	17.9	6	9.0

Note. 67 Responses

The responses from the students who had been assigned an open included several similar reasons:

- "I would work on the labs in my room and I and I could finish it all at once. If I had any questions I would just visit your office."
- "Open because I could learn all the necessary information during lecture."
- "Open because I like the fact of doing the work when I want to and not during a scheduled time."
- "That way if you have your own computer you can do it in your room. Also you can do it on your own time."
- "I would choose the open lab just because I have a busy schedule and that would be one less class I have to go to during the day."

Their responses were consistent with the comments that students who were assigned to closed lab but would choose open if given the chance:

- "I would prefer an open lab because I have a busy schedule."

- “I would enroll in the open lab. The closed lab leaves no flexibility in schedule and no real advantage.”
- “I would choose open so that I could do the labs on my own time.”

The answers seemed to identify two similar reasons to enroll in an open lab: the desire to work when they wanted to work on assignments and the option to choose where they worked. The majority of the responses from students, 61 percent, in both the open and close labs exhibited a preference for open labs.

Of the students assigned to open or closed lab and who would choose closed lab the responses included:

- “More one-on-one learning.”
- “I would make myself enroll in the closed lab because that's where I got most of my things done. It's hard to work on them outside of class.”
- “Closed because you have to go. It gives you time to actually do the work and get it done.”
- “I would rather attend a closed lab because I like having the help readily available if I need it.”
- “Closed lab, I think they are better because the teacher is there for you to ask questions to.”
- “I would rather have been in the closed class because it made me come to class and do work.”

Comparing the student preferences to the means and standard deviation for each group provided some interesting information. The mean for total points was higher for students who preferred to enroll in an open lab while students preferring closed lab had lower mean total points. The fact that students with lower mean scores chose to attend closed labs may indicate that they know more about their study habits and abilities on the computer and if given an option could chose the lab option best for their learning style and ability.

Table 13 provides a breakdown of mean total points and standard deviation for enrolled lab and preference.

Table 13

Mean Total Points Compared to Lab Choice

	Enrolled in Closed Lab			Enrolled in Open Lab		
Preference	M	SD	n	M	SD	n
Open Lab	691.14	103.7	18	698.63	89.2	30
Closed Lab	672.75	119.7	12	622.17	102.4	6

Note. 66 Responses

A review of the list of disadvantages that students cited for having an open lab shows that most students were aware of the challenges of an open lab. Examples of the disadvantages were:

- "The biggest challenge for me was to make sure to go and get the lab done. Sometimes it just slips your mind."
- "Sometimes there are questions that nobody can help you with."

- "I was able to complete work when I had time. Sometimes it was frustrating when I was sitting in my room doing the work and got stuck with no one to help me."
- "Having to remember that there is homework."
- "Challenges would be having to be motivated to do labs on your own and also to be able to understand the in class lectures well enough to do it on your own."

Based on this preference survey it appears that students generally understand the challenges of an open lab and if given an opportunity most seem able to choose the one that would work best for them.

Summary

No significant differences were found between the open and closed labs test results in this study. Achievement in this research was measured by mean total points and mean posttest scores. Analysis was performed to insure groups were homogenous with respect to computer self-efficacy and to determine if gender or the interaction of gender and lab treatment influenced the results of the research. Tables were included to present numerical data. Independent sample t tests, Pearson product correlation and one way ANOVAs were used to analyze the data in this chapter. The results of a preference survey indicate that at the end of the semester students had formed an opinion which lab would be best for them. The mean scores seem to indicate that those students who did well in the class based upon mean total points tended to prefer the open lab.

CHAPTER V

DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

Discussion

Based on the analysis of the data collected during the semester there may be some merit in considering alternatives to closed computer labs in application skills courses. Self-efficacy, gender and the interaction of each with lab treatment were tested to see if they might be influential factors. The data on self-efficacy in this research did not appear to be a predictor of achievement. Achievement was close to significantly higher for females than males as measured by total points but posttest scores were not significant. More students indicated that they would prefer open lab to closed lab and analysis indicated that students may be able to make a reasonable decision on which lab option to select.

Comparison of the means of the pretest to posttest scores and mean score on each software application portion show that students scored higher on the posttest. Excel® scores exhibited the largest gain in mean score followed by FrontPage®. PowerPoint® was an application that many students (58%) appeared to feel comfortable with based on survey results. Analysis of the mean pretest to mean posttest portions related to PowerPoint® showed no great difference in number of questions answered correctly although the standard deviation was a little less. High school instruction in software applications generally include an introduction to Excel®, but in personal conversations with various students by the researcher, it appeared that most students had very little knowledge of formulas and functions, topics emphasized in this class. Over 55% indicated that they were able to use this application fairly well or very well. FrontPage® was an application with which many students had little prior experience. Under 7% of the students responding to the survey indicated they were able to use this application well or very well. There was improvement on the posttest in the mean scores for this application. Table 14 summarizes the means and standard deviations for the pretest and posttest scores.

Table 14

Means Comparison Pretest to Posttest Scores

Application	Pretest		Posttest	
	M	SD	M	SD
PowerPoint®	6.00	1.57	6.50	1.42
Excel®	10.16	3.24	19.01	3.26
FrontPage®	6.06	2.19	8.60	1.63

Based on the analysis of data it appeared that the lab condition (open or closed) has no influence on achievement as discussed in Hypotheses 1 through 3 for the predominately freshmen class in the Tabor School of Business. Achievement was measured using a number of different factors (posttest scores, total points, and scores on each of the application exams). Each consistently tended to lead to similar results: there was no significant difference in mean scores. Based upon these results it seems that the need to require closed labs for applications specific courses deserves further study.

Investigating the results more closely, the following observations were noted. Mean total points accumulated by students in the closed labs were slightly higher although not significantly. Mean test scores for each of the application areas showed that students in the open labs scored higher by a few points on each of the written tests (not significant). In contrast students in the closed lab scored slightly higher on the practical exams in Excel® and FrontPage®. Review of the lab assignments did not show a trend with students in the open lab scoring a higher mean on some assignments and lower mean on others. There were no major differences in scores on the quizzes given during the lecture session.

Although the students assigned to open labs and closed labs were randomly selected, effects of other variables were considered. A number of papers discussed the influence of self-efficacy on success in specific activities. A Cronbach's Alpha test to verify reliability on the results of the self-efficacy data obtained in this research resulted in an alpha = 0.960, $\underline{n}$ = 84 which was consistent with the results of Cassidy and Eachus (1998). The comparison of the Cronbach's Alpha test results for the Cassidy and Eachus (1998) and this research is shown in Table 15.

Table 15

Cronbach's Alpha Comparison

	α	N
Cassidy & Eachus (1998)	0.97	184
Wheeler (2005)	0.96	84

Hypotheses 4, 5 and 6 tested whether self-efficacy was a predictor of achievement in this research. The tests indicate that there was no significant correlation between the mean self-efficacy score and achievement as measured by the class as a whole on mean total points scored and mean posttest scores. Although there was no significant correlation, consideration was given to the possibility that within one of the groups there could be a high correlation and in the other a low correlation so the test was applied to each lab treatment. Again there were no significant results (Table 16).

Gender is often a variable considered in research that studies achievement. Hypotheses 8 through 10 tested the difference in achievement based on gender using various measures. In this research gender did not have a significant impact on achievement when tested against the class as a whole. However, the interaction of gender and lab condition indicated that females had higher mean total points in the class than the males (p = .061, Table 9).

The data for Hypotheses 11 and 12 were analyzed to see if the interaction of gender and lab condition resulted in significant results.

Using a t test to compare the mean self-efficacy score of males and females, females (n = 33, M = 147.04) scored slightly higher than males (n = 50, M = 145.61). The average age was 19.1 with 63% 18 years old and 21% 19 years old. In comparison the Cassidy and Eachus (1998) students had a mean age of 26.2 and consisted of 55% females. In the self-efficacy test all males (n = 94, M = 150.44, SD = 23.12) scored higher than all females (n = 113, M = 113.68, SD = 31.22). The mean scores were also analyzed as four separate groups attending the university with dissimilar educational backgrounds plus a fifth group of Internet users not attending the university and represented a diverse population (n = 41, M = 144.02, SD = 15.36). The group of software engineering students consisting of 63 males, 2 females scored the highest mean (n = 65, M = 159.05, SD = 15.41). In contrast post-registration nurses, all females, as a group scored the lowest (n = 31, M = 101.52, SD = 30.5). The differences in the means of the groups may have been based on level of educational background, use of computers in their field, and the course of study of participants.

Christian (2000) reported that females showed higher mean scores (n = 57, M = 145.0, SD = 20.9) over males (n = 34, M = 131.4, SD = 21.7). Christian used a research group that was 71% freshmen (hence younger with less educational experience than Cassidy and Eachus), and more ethnically diverse (with 67% African American, 23% Caribbean American, 8% others and 1% no responses). The group consisted of students in Introduction to Computers or an Education and Life Seminar. Ethnicity was not reported in Cassidy and Eachus

(1998). An ethnic breakdown of Tabor students showed 84% of the class white and 8% African American with the remaining percent fitting in the "other groups" category.

Table 16 shows the summative results of the self-efficacy test by three studies: Cassidy and Eachus (1998), Christian (2000), and Wheeler (2005).

Table 16

Self-Efficacy Scores by Gender for Three Studies

Study	Gender	N	M	SD
Cassidy & Eachus (1998)	Males	94	150.44	23.12
	Females	113	113.68	31.22
Christian (2000)	Males	34	131.4	21.7
	Females	57	145.0	20.9
Wheeler (2005)	Males	50	145.60	28.95
	Females	33	147.04	24.52

Cassidy and Eachus (1998) indicated there was a difference in mean self-efficacy scores between those who owned a computer (n = 141, M = 141.17, SD = 27.93) compared to those who did not own a computer (n = 71, M = 110.48, SD = 33.30). Christian reported 76% of the subjects had access to a computer while in this study 87% of the Tabor students arrived on campus with their own computer. Statistical analysis of self-efficacy means were not calculated for the latter two groups.

Reviewing the interaction of gender and lab treatment females in both open and closed labs had higher mean scores and lower standard deviations for total points when compared to males as shown in Table 12. Using an ANOVA $F(3,79) = 2.558$, $p = 0.061$ the result was close to significant.

Table 17 shows the means of total points, posttest scores and self-efficacy scores by gender for each lab treatments.

Table 17

Mean Total Points, Self-Efficacy by Gender and Lab Treatment

		Total Points		Posttest Scores		Self-Efficacy Scores	
Group	n	M	SD	M	SD	M	SD
Females							
Open	20	716.05	105.04	33.86	5.66	151.75	22.28
Closed	13	715.00	101.93	36.23	2.83	139.80	26.90
Males							
Open	27	654.11	138.96	34.19	4.6	140.63	27.91
Closed	23	629.30	122.64	33.06	4.66	151.45	29.67

Females in closed labs had higher mean scores and lower standard deviation in posttests than males in closed labs as shown in Table 15. Females in the open labs scored almost the same as the males in the closed lab but females had a slightly larger standard deviation than males. Using an ANOVA F

$F(3,79) = 1.341$, $p = 0.267$ shows that the difference in posttest scores between males and females by lab treatment are not significant.

Self-efficacy for the interaction of gender and lab treatment indicated that males in the closed lab and females in the open lab had higher, similar scores, with males showing a wider standard deviation. Males in the open labs and females in the closed labs were closer on the low end of the self-efficacy.

If self-efficacy was not the reason for the variability in total points earned by females, the question still remained what factors contributed to the females' higher score? Analysis of lab scores showed that females earned more points per lab assignment in both open and closed lab sections than did males. Quiz scores did not show a trend favoring either males or females in either open or closed lab (quizzes were taken by students in lecture class).

By reviewing the scores on lab assignments the researcher found that females scored more total points because they receive higher mean scores on lab assignments. This was because the females completed their lab assignments more accurately, more completely and in a more timely fashion than the male students, thus receiving more points per assignment. While no points were deducted for a late assignment, grades for assignments completed after the application exam were not recorded.

Enright (1999) indicated that the major role of the software applications instructor in closed computer laboratories at Wentworth Institute of Technology, Boston, Maryland, was "to provide reassurance to students that may be unfamiliar with the computing environment or computers in general." This is consistent with the researcher's experience over fifteen years as an instructor in closed laboratory sessions at the college-level. It may be possible that this role as defined by Enright (1999) is diminished in importance for traditional college students who have been exposed to computer applications in secondary school and have had access to a computer at home. If true, it may follow that faculty contact hours in these sections could be reduced or that instructors may increase the lecture portion of a class thus allowing more instructional time. Both of these options may allow more access to computer laboratory facilities for all students. This is important because more non-computer related classes are dependent upon computerized tools such as word processing for preparing assignments. Many classes stress team activities and the computer laboratory facility is a potential meeting place where students can work collaboratively. Another advantage of eliminating closed laboratories is that computer laboratory facilities usually have additional software, hardware and printing capabilities that students may not have individually on their own systems. Reduction in the number of closed computer laboratories should allow all students more access to these facilities.

Recommendations for Future Research

This experiment was conducted with a small, homogenous group of students at a small university. A replication of the same experiment in a larger university setting where the introductory application skills computer course consists of a larger lecture class with more subjects and more lab sections may provide more robust results. Using a larger target group should increase the diversity of age, grade level and ethnicity of the students that this research did not have.

A replication of this research should be done to confirm the results of this study. Several features not often seen in the literature but present in this research should be included in a replication. Lecture and all lab sections should be under the direction of the one instructor during the same semester. Having multiple instructors adds a degree of variability that may influence the results. The instructor in future research should have developed and taught the class previously to insure the validity of the assessment tools used in the replication of this research. An instructor teaching a course for the first time may not have time to prepare all materials and test them for validity once the research begins.

Although no data were selected to show conclusively that self-efficacy can be increased by the instructor's efforts, informal feedback from students in MS 120, Introduction to Microcomputers, suggested that self-efficacy did increase. Providing positive feedback, providing examples of the exams, answering questions in lecture and responding quickly to student requests for assistance all should improve self-efficacy and insure that the student has positive reinforcement. The self-efficacy test in this research was given during first day of class. In future research the same self-efficacy test should be administered at the end of semester to see if the self-efficacy scores changed. Studies have shown that self-efficacy may be enhanced during an experience based upon external factors such as mastery experiences, seeing one's peers succeeding in an experience, social persuasion that convinces the individual that they can succeed and changes in the emotional reactions to an activity or experience.. During the research project, these factors may have affected self-efficacy toward computers as measured at the beginning of the class.

The higher total points scored by female subjects in both open and closed labs over the males was not anticipated. Literature on gender differences reviewed for this research seemed to indicate that males should exhibit higher achievement. Based solely on classroom observations it appeared that females seemed to pay more attention in class, ask questions more and to take their work more seriously than the males in the class. At the Tabor School of Business there is a greater emphasis on business related skills and high emphasis on mathematical skills. Perhaps this factor may have self-selected only the more talented, goal oriented females into the major.

In the final analysis this research may provide the basis for future research and a reevaluation of how introductory computer courses are delivered at the college level.

Concluding Remarks

For nearly 20 years researchers have been studying the value of computer laboratory work in the process of educating students in the new technology of computers. These studies can be segmented by grade level, student experience, subject matter, and teaching method as well as by socioeconomic, cultural and gender. If that is all there were, this subject would have been exhausted and research would have been on other topics. The problem that complicates the subject is the continuously changing technology of computers and computer applications combined with the trend in education to use computers as a learning tool at younger and younger ages.

We have the problem of comparing computer laboratory studies of the past with the present since the relative knowledge of entering students is increasing at an accelerating pace. Did the student of 20 years ago with no computer experience enter a class with the same expectations and self efficacy as one today? Also, can we measure the difference even if we have the information backing the prior studies? It may be safe to say that even with a continually evolving course content, the value of some computer laboratories as supplemental learning tools is diminishing. If this is the case, the logical extension is to question the relative value of a closed laboratory environment to the educational goals of a degree program. The institution also could question the value of that closed laboratory to the total cost structure of that same degree program.

In general terms, a closed laboratory has more value in the learning process if the course material requires physical or mental experimentation or if it is new to the student and relatively complex to learn. Science labs are classic examples. Computer science labs of 20 years ago could also fall into this category since problem solving with this new electronic tool was learning by experience what was for many a very complex and challenging educational process. However, an entry level computer applications class for college freshmen today tends to be a process of refining and expanding existing knowledge. The course could be considered a process of bringing students to a computer literacy level required to master upper level courses.

The research conducted at the Tabor School of Business provides just one small cube of knowledge in the matrix of the value of closed laboratories to a computer science curriculum. These results indicate that the value of a closed laboratory in applied computer education is diminishing. However, further research should be conducted to expand the body of knowledge into other areas of the matrix and to further study the technology and socioeconomic trends as they evolve. It is likely that higher educational institutions will begin to discontinue or at the very least make optional closed laboratories for entry level applied computer science courses.

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APPENDIX A

INFORMED CONSENT FORMS

Student Achievement in Open Versus Closed Labs

Consent Form Experimental Group

Researcher: Susan Wheeler

The purpose of this study is to determine whether there is difference in learning between students who attend an instructor supervised computer lab and those who complete assigned work without the instructor present.

If you agree to participate in this study you will be a member of the experimental group. Members of this group are not required to attend an instructor supervised lab session. The advantage to belonging to this group is that you may elect to work on the weekly hands-on computer assignments in a location and time of your choosing. You may work in your room on your own computer, on any computer on or off campus or in the Tabor computer lab.

During scheduled lab time, the instructor will be in her office where you can contact her for help. If you need assistance you may contact her by telephone, email, or go to her office and request help. Do not be afraid to ask for help. You may contact the instructor whenever you require assistance, not just during lab sessions.

Independent work requires more personal discipline by the student. To prevent any student from falling behind, the instructor will monitor the assignments to insure that all students turn in assignments on time, and are given feedback in a timely fashion. Any student who appears to be having problems with class assignments will be contacted and assistance provided as needed.

Students in both the experimental and control groups will be graded using the same criteria.

If you wish to withdraw from this study, you may. The instructor must be notified and you will be required to attend one of the supervised labs for the remainder of the semester. Withdrawal from this research will not affect your grade in any way.

Consent to Participate:

I have been informed about the nature of this study, and I voluntarily agree to participate in this study. I also give my consent that any data collected as a result of my participation in this study may be used for educational and/or scientific purposes.

I understand that the response I given will be considered confidential, reported only as group data, and that every possible effort will be made to preserve my anonymity regarding these data.

I understand that I am free to discontinue my participation at any time, or refuse to answer any questions, without penalty. I understand that one of my legal rights regarding negligence and the liability of Millikin University or its agents have been waived. I understand that if I have any questions regarding the study, I can contact the instructor, Susan Wheeler. If I have any questions about rights as a subject, I may contact Dr. Rene Verry, Chair of the Millikin Institutional Review Board. I will be given a copy of this consent form to keep, and the researcher will keep another copy on file.

I affirm that I have read this entire statement, and that I have been given an opportunity to ask any questions I may have regarding this form and this study.

______________________________ ______________________________

Participant's/Legal Guardian's Printed Name *Participant's/Legal Guardian's Signature*

Participant's Birthrate (MO/Yr) _______ *Date*_________

____

Signature of Person Obtaining Consent & Title

(PI= Principal Investigator, CO=Co-investigator, RA= Research Assistant)

*Approved consent form valid until:*______.

Created and maintained by Rene Verry at Millikin University. Last updated 8/17/00.

Student Achievement in Open Versus Closed Labs

Researcher: Susan Wheeler

The purpose of this study is to determine whether there is difference in learning between students who attend an instructor supervised computer lab and those who complete assigned work without the instructor present.

If you agree to participate in this study you will be a member of the control group. Members of this group are required to attend an instructor supervised lab session. The advantage of belonging to this group is that you will work on the weekly hands-on computer assignments in a designated location and time with a supervising instructor present.

You may have the same access to the instructor outside of class that all students have. You may also contact the instructor whenever you require assistance, not just during lab sessions.

Since this is the standard way of conducting a computer lab session, there is little risk involved. The instructor will monitor assignments and provide feedback in a timely fashion. Any student who appears to be having problems with class assignments will be contacted and assistance provided as needed.

Students in both the experimental and control groups will be graded using the same criteria.

If you wish to withdraw from this study, you may. The instructor must be notified. Withdrawal from this research will not affect your grade in any way.

Consent to Participate:

I have been informed about the nature of this study, and I voluntarily agree to participate in this study. I also give my consent that any data collected as a result of my participation in this study may be used for educational and/or scientific purposes.

I understand that the response I given will be considered confidential, reported only as group data, and that every possible effort will be made to preserve my anonymity regarding these data.

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I affirm that I have read this entire statement, and that I have been given an opportunity to ask any questions I may have regarding this form and this study.

_________________________________ _________________________________

Participant's/Legal Guardian's Printed Name *Participant's/Legal Guardian's Signature*

Participant's Birthrate (MO/Yr) _______ *Date*_________

____

Signature of Person Obtaining Consent & Title

(PI= Principal Investigator, CO=Co-investigator, RA= Research Assistant)

*Approved consent form valid until:*______.

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