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Computer competency of New Hampshire high school students : an outcome assessment.

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COMPUTER COMPETENCY OF NEW HAMPSHIRE HIGH SCHOOL STUDENTS: AN OUTCOME ASSESSMENT

A Dissertation Presented

by

GERALD P. JOYCE II

Submitted to the Graduate School of the
University of Massachusetts in partial fulfillment
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School of Education

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DEDICATION

This dissertation is dedicated to my wife and family for their unceasing support and patience, through the many years that I have attended school while working. I owe them more than I can ever hope to repay.

It is also dedicated to the guidance and forbearance of my dissertation committee, who were all extremely helpful in organizing, pursuing and completing this project. G. Ernest Anderson, William C. Venman and Robert N. Moll all provided help well beyond that normally required by the duties of their job and profession, and each exhibited endurance well beyond that normally rendered by people in similar positions.

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Hinsdale Jr/Sr High School, Hinsdale, NH.
Hollis Area High School, Hollis, NH.
Keene High School, Keene, NH.
Monadnock Regional High School, Swanzey, NH.
Nashua High School, Nashua, NH.
St. Paul's School, Concord, NH.

I would also like to publicly acknowledge the encouragement, forbearance, understanding and occasional pressure from some of my many friends and associates; Norman Gross, Jim Horrigan, Lowell Shindler and Steve Trepani to name just a few alphabetically.

ABSTRACT

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AN OUTCOME ASSESSMENT

MAY 1992

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This study measured the computer competency of New Hampshire high school seniors, using the National Assessment of Educational Progress (NAEP) 1986 assessment. Six different test booklets, cumulatively containing 124 cognitive items and 75 demographic items were used. An additional 35 demographic questions beyond the NAEP items were collected from a survey designed for this dissertation.

One hundred and sixty eight students (95 males, 68 females, 5 unknown) from eight public and two private high schools across the state were sampled based upon an enrollment size distribution. The total enrollment of the sample schools represented 15% of the total state high school enrollment of 52,400 students. An average of 8.4% of the seniors at each participating school were assessed. Essentially all students have completed a one semester computer competency course, as required by state regulations.

The analysis was conducted utilizing non-parametric statistics for demographics and Z-Tests for comparisons to the NAEP national sample. The microcomputer statistical packages of <u>MINITAB</u> and <u>EXECUSTAT</u> were used.

Conclusions. First, the computer competency levels of New Hampshire are significantly greater than both the national average and the higher New England average as measured during the NAEP national survey in 1986 at the 95% confidence level. Second, it made no difference whether the computer competency course was taken in high school or junior high school, public or private school, small, medium or large school, or different types of communities (i.e. city, rural etc.). Third, the cognitive outcome was significantly correlated at the 95% confidence level with: sex of the student, number of years of computer usage, curriculum content of the first course, semesters of computer courses studied, time of the first computer course and word processing usage. Finally, the cognitive outcome was not significantly affected by the following characteristics: attitude, self-assessment, home computer ownership, programming courses, timing of <u>last</u> computer class.

Students perceived that computers were not integrated into the curriculum as many in the state expected. Classroom computer usage was substantially limited to computer classes. Students overwhelmingly desired more computer usage in classes.

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GLOSSARY

ABBREVIATIONS USED IN THIS STUDY

DOE — United States Department of Education, Washington, DC.

ERIC — Educational Resources Information Center database [machine readable, CD-ROM]. See bibliography for more details.

ETS — Educational Testing Service. Contractor charged with carrying out the 1985-1986 NAEP national survey of United States high school students. Also company which administrators the Scholastic Aptitude Test (SAT) and Graduate Record Examinations (GRE) among others. Kent Ashworth is the current contract officer at ETS for NAEP.

MCLAA — Minnesota Computer Literacy and Awareness Assessment. A computer competency test developed by MECC in 1979. See definition section of this study, and Smith (1992).

MECC — Minnesota Educational Computer Consortium, Minneapolis, MN. Melanie Smith is the current individual with responsibility for MCLAA inquiries.

NAEP — National Assessment of Educational Progress. A division of OERI, DOE, Washington, DC.

NCES — National Center for Educational Statistics, DOE, Washington, DC. Mr. Tongsoo Song (ED/NCES/EAD/OIB) was contact for this study, and individual to whom requests for secured NAEP material should be directed.

NHDQ New Hampshire Demographic Questionnaire. A survey form designed for this study and administered to students along with one cognitive booklet. Questions were numbered from 45 to 80. For example, question 52 would be referred to as NHDQ-52.

The entire questionnaire is contained in Appendix F, along with the item counts of each response, and a symbol to indicate the statistical significance of the average cognitive scores for each response.

NHSDE New Hampshire State Department of Eduction, Concord, NH.

OERI Office of Educational Research and Improvement. Contact was Gary W. Phillips Acting Associate Director at the time of this study.

PSYCLIT American Psychological Association Literature database. The PSYCLIT database [machine readable CD-ROM]. See Bibliography for further details

CHAPTER 1.

INTRODUCTION

1.1 Background

In 1948, there were virtually no computers used in the world. By 1978, there were fewer than half a million. Currently, there are over 45 million microcomputers alone (Juliussen, 1989, p. 1.2). This tremendous growth has generated a demand by society to teach its young the skills and understanding necessary to successfully use this technology to compete in the world market place. By October, 1989, 15% of all U.S. households reported they owned a computer. Presently, 24% of all children 3 to 17 years old have access to a computer at home. Nationwide, fully 40% of all high school students report the use of a computer at home (Census, 1991, p. 10). There has been pressure from parents, businesses and all levels of government to teach students the basic knowledge and skills necessary to utilize these resources.

Many people in industry and government feel the technological training the country provides to its citizens is one of the major factors helping the country remain world competitive (Bolte, 1990). Yet not all people are content with the results of the educational effort (Business Week, 1988). Some even believe the effort will never achieve its goals (Webster & Robins, 1986). Others feel that vast resources have been spent with little direction or results (Knauth, 1989). Much of this conflict has remained local, but it can be extremely vocal (Hogan, 1990). These popular feelings have made themselves known in legislatures, executive offices and school boards around the country as a call for effective action.

Individual schools have responded to these various conflicting opinions and pressures. They have combined computers and classrooms in various ways (Business Week, 1987). States, as a whole, have also responded in various ways. One response, which has been subject to much debate, has been to require all students to take a "computer literacy" course in high school or junior high school. The state of New Hampshire has adapted this approach. Other states have required integration of the computer into all curricula at various grade levels.

The educational debate of the merits of teaching computer competency is beyond the scope of this study. Chapter 2 of this dissertation provides many references to various aspects of the controversy. A direction and decision was made to teach computer competency in New Hampshire. The results or outcome of that decision and how well the states students achieved computer competence is the subject of this study.

1.1.1 Computer competency course

It is instructive to briefly mention the various arguments for and against a specific computer literacy course. The purpose of this discussion is not to justify or explain the various arguments, it simply to enumerate them as a background to help understand the social and political environment.

This section presents the major arguments that have been proposed against computer competency or computer literacy courses. These terms will be defined in the definition section of this chapter. For the moment, these terms are synonymous and mean the minimum skills the state requires of all high school graduates. Various groups desired high school students to achieve this computer literacy or computer competency for various reasons. Primarily these reason can be traced to four goals:

- To increase analytical thinking and problem solving capabilities.
- To allow the newly acquired computer skills to be used to enhance learning and to be able teach other subjects better, faster and more cheaply through computer assistance.
- To reduce computerphobia, aversion, anxiety, fear, discomfort or other undesirable feelings toward computers. These feelings had plagued the students parents during the 1960's through the 1980's.
- To provide job training of benefit to both the students and local industries. Industry needed workers with computer skills, and by and large, they were not available in the numbers required from the older generations due to computer anxiety as well as lack of training.

One of the mechanism utilized by educational systems to achieve these goals is to provide a special course in computer competency or computer literacy to be completed by all students in the school systems. This course was typically one semester in length, and taught in late junior high school or early high school. These competencies were assumed to be acquired by passing a single semester course.

This competency or literacy course should not be confused with a different course to provide special skills or knowledge required of a few students interested in certain subjects or above average abilities. This specialized type of course is generally a computer science course, concentrating on computer programming and architecture. A computer science course is an entirely different concept, and not a subject of this discussion.

The introduction of a computer literacy course was not without opposition from various quarters within the educational and computer establishment. Some of the basic arguments against expecting a single semester course, required of all students are tabulated below, along with some of the popular rebuttals. These arguments are presented for information only, and no inference should be made on their validity, forcefulness or acceptability.

<u>Education</u>	A single computer competency courses does not promote analytical thinking or problem solving abilities to any great extent.
	The counter argument is no single course beyond those already required in virtually all high schools has been shown to accomplish this increase in clear thinking, including computers.
	Studies of the ability of computer courses to promote analytical problem solving are ambiguous.

Learning efficiency

A computer course does not produce the skills or talents necessary to promote enhanced learning depth or breadth in other, non-computer subjects. The history of Computer Aided Instruction (CAI) has not shown any great learning efficiencies in either cost of delivery or enhanced learning of students. Hence, there is no reason for a student to study computers with the aim of improving the delivery cost-effectivness of other educational subjects.

This argument was often countered by observing that the properly used, computers do enhance efficiency. Most teachers just cannot use them properly. Thus this argument is an really attacking teachers, not computer courses.

New arguments in favor of computer skill are the new capabilities in library data bases and electronic networks. While Johnnie may be able to read, he may not be able to find the necessary academic reference material without computer skills. But this state has not yet arrived.

Anxiety Reduction

Using a computer for a one semester course does not reduce anxiety as well as the alternative using the computer in a large number of situations over a full four years of high school. The latter option is best provided through the use of computer in many classes and subjects throughout a school career.

In rebuttal many studies indicate a reduction in anxiety from taking a single computer course. These studies were not generally available until 1986-1988 time frame however. They are discussed in the literature review. However, research results are not unanimous.

Secondly, the relation between anxiety reduction and actual computer skills has yet to be proven.

<u>Expense</u>

Computer competency courses generally entail expensive laboratories. The extra funds could better be used in the more traditional academic fields.

The rebuttal is that as computer prices dropped, computers are no more expensive to teach than any other laboratory science. Mastery of technology of any type requires a capital investment.

<u>Funding</u>

Computer teaching is a new cost burden upon school systems. Computer departments have not generated new funds to cover the increased costs. This has reduced available funds for other school programs.

The counter argument is that computer studies are a political rationale for raising separate funds, which otherwise would not have been available for education. Most equipment monies in New Hampshire was raised with special funds available only for computer purchases. While this funding may not really reduce the increased cost of teaching, it does make it less expensive than other laboratory sciences.

Definitive funding studies on a state-wide bases simply do not exist which could resolve these conflicting viewpoints on a factual basis.

<u>Intellectual Challenge</u>

It is difficult to have a single course which is challenging to students of all preparations, backgrounds and ability. Different students would need different course material to challenge students. The course is generally reduced to the level of the students with the lowest ability. Elective courses, on the other hand, are geared to special groups of students, and better meet their needs.

This argument is mitigated by generally open guidelines in state computer competency requirements. They specify the minimum requirements, not the maximum. Courses can be tailored to students needs and abilities. Such grouping is common in mathematics and science courses, and the techniques are well known.

Lost Opportunity

When a computer course is taken, some other course must be forfeit. The computer course must have more value than the course it replaces. This value has not been shown for the majority of students.

This effect is mitigated if state requirements are not reduced in other areas, and the required computer course replaces one of large number of electives. For example, in New Hampshire, approximately one-third of the available course time is used by required courses. Approximately one-third of the time is used for required electives courses in special groups. Approximately one-third of the time is available for electives.

College preparatory students generally studied computers in any event, and the practical effect of requiring the course in New Hampshire was to have the non-college bound students study computers, during what was often a study hall.

Teachers

Computer courses generally require special teachers, who are difficult to acquire. Teacher accreditation in computer studies or computer science is not available in New Hampshire, or many other states.

This is a chicken and egg question. Without courses and positions, teachers will not be found. With a required course, positions will become available. As jobs become available, teachers will be located.

Job Training

Some educators feel that the purpose of education is not to provide specific job training to all students. In the computer field, the software and hardware change rapidly. Todays training is not valuable in tomorrow's job market. Specific elective job training courses should be available.

The argument has been countered to some extent by the prevalence in industry of three major software functions, word processing, databases and spread sheets. These have provided a stable objective for computer courses. Students have found themselves more employable with computer skills.

The training vs. education difference of opinion has been ongoing since long before computers were introduced to education. The introduction of computers has not settled the disagreement. However, state politicians and local tax payers have been quite forceful in expressing their opinion that computer skills would be taught, independent of whether or not it was considered training or education.

Course Content

The content of a computer competency course changes quickly. The texts change increasing expenses. Software changes yearly. Hardware changes, and constantly needs repair. A stable curriculum seems impossible. This makes the course extremely difficult to teach and evaluate. It makes it too difficult for many school districts.

The curriculum has stabilized somewhat. Several sources are mentioned in Chapter 2 which address the general congruence among various groups on the most desired course content. Software and hardware has been fairly stable for over five years now.

Course Objectives

The very purpose of computer courses and computer literacy has never found wide agreement among educators. A definition of computer literacy with wide support has been actively sought for at least ten years. If the product cannot be defined, a course which would meet the desired objectives cannot be designed, nor teachers trained to teach the course and so forth.

The counter, while there has been little agreement on the definition, there has been agreement on what should constitute a minimal competency. Much of the disagreement is on the maximum competencies desired.

Resistance to Change

There has been a great resistance to changing teaching methods and curriculums with the introduction of technology. This is as true of computer competency courses as it has been for all other technologies. The speed which some groups wish to introduce of computers simply cannot be achieved in the real world. The size, inertia and complexity of todays educational system simply will not permit such speed.

The rebuttal is the progress made in managing technological change. Rapid change of this type can be managed. Larracey (1988) reports upon a the methods utilized in New Hampshire to manage the introduction of a computer course into its school system. The literature survey of this study, Chapter 2, identifies further documentation in this area.

Educational Crisis

The educational system is in a state of crisis in many subjects. There are great fundamental problems which need solutions. Computer competency interferes with focusing on those solutions. It is viewed as a "magic bullet" which will somehow solve our educational problems. It cannot and will not do so.

The counter-argument is to de-couple the two ideas; using the computer to enhance teaching other subjects, which it may not do; and teaching students how to use a computer for many purposes. They are not mutually exclusive concepts. Knowledge of computer usage will be needed along with a solution to the more fundamental problems.

Following this line of counter-argument, it will make no difference if Johnnie can write, if he cannot use a computer to write with, use an electronic mail system to send his written work to others, and use an electronic data base to find the written works of others.

<u>Computers integration throughout curriculum</u>

While computers are necessary, they are really only useful only in the context of application areas or other disciplines. The computer knowledge required by students is best obtained by integrating computer usage in all subjects throughout the curriculum. Many states which do not require a computer course have utilized this approach.

There are really four counters to this argument:

1. Integration has not really worked in states where it was tried. See references in chapter 2, particularly California and Wisconsin.

2. The large number of computer competent teachers required for this approach are simply not available at this time. The skills are best taught by the specialists in the area, just as mathematics, music and other specialty courses are taught.

3. A great duplication of computer teaching effort can be saved by centralizing the teaching. Integration could make many teachers repeat basic material unless very careful scheduling and sequencing of students can be achieved.

4. Integration teaches computer use in a subject. It does not necessarily teach about the computer itself. Some areas are really unique to the computer itself, and typically not covered in an integrated course. Computer programming is one example. Disk file maintenance is another example.

Since there has been no outcome assessments in other states, a quantitative state by state comparison of the effectiveness of these two methods is not possible. This dissertation does provide a base line for future research to directly measure the effectiveness of this wildly discussed method.

<u>Course effectiveness</u> Even if a separate computer course was actually taught on a state wide basis, students really would not achieve a significant increase in computer competency. The results of a single course on a state wide basis simply would not achieve dramatic results on a large scale.

This dissertation is designed to produce data to support or refute this argument.

In New Hampshire, there was a backlash to the computer competency courses in 1988. The principal arguments raised by those seeking a repealing of the required one semester course was the desire for more elective courses and the integration of computers into other courses. These can be summarized by the following quotations from those public hearings:

> ... [since] computers are being utilized as instructional tools across the curriculum and hence there no longer exists a need for a specific unit requirement in this area (Barrett, 1989, p. 2).

> Not all subjects are right for all kids. If you have a student who is going on to a post-secondary program -- they may attend high school with as few as two electives....[speaker at public hearing] supports the recommendation [to delete required computer course] because it will provide flexibility in scheduling....[and] allow students to take advantage of other programs. (Hogan, 1990, p. 1)

The prevailing opinion at the public hearings and the subsequent governor's educational mission statement is summarized by the following two quotes:

> people believe strongly that young people need to be computer-literate if this country is to be economically strong....(Keene Sentinel, 1990, April 14).

> Todays students need to know more than reading, writing and arithmetic. Computers are used more and more in the work place, and therefore have become more essential in the classroom, where tomorrow's workers are being trained (Keene Sentinel, 1990, April 28).

1.1.2 New Hampshire school system

New Hampshire as a state is located in the northern section of New England. It is bordered by Vermont in the west, Maine in the east, Canada to the North, and Massachusetts in the south. According to the New Hampshire Department of Natural Resources, it is 9,304 sq. miles in size, or 44th in the nation. It has a population of slightly more that one million citizens. The state has 1,300 lakes and ponds, 40,000 miles of streams, and is approximately 80% forested. Its largest city is Manchester with 100,000 inhabitants. It has a large base of light manufacturing and "high technology" industry.

The New Hampshire school system is rather unique in that the principal source of control and funding is the local towns. While the state is 16th overall in total per pupil spending (Digest, 1990, p. 156), it is 50th in state spending (Digest, 1990, p. 153). The difference is local taxes, and a system of very local school control through a town meeting system. The ability of the state department of education to influence schools in detail is small, although it can and does set educational standards, such as computer competency education. It is up the individual school districts how to implement that educational goal.

New Hampshire school systems are above average on a nationwide basis, but probably average in New England. The Governor's report contains an excellent summary of the school system:

> ... cumulative four-year dropout rate is approximately 25 percent, local business leaders tell us that an estimated 25 percent of high school *graduates* are not qualified for entry-level positions and our highly touted SAT scores, if corrected for our high socioeconomic ranking and low minority populations would look no better than those in the rest of the country. (NH Governor's, 1990, p. 10).

Little valid comparative data exists on state rankings. The recent National Assessment of Educational Progress (NAEP) state comparative mathematics tests lists two states as better than New Hampshire, eleven states at the same level, and 25 states as worse than New Hampshire (Ashworth, 1992). Mathematics does correlate highly with computer competence, and without other information (which this study will provide), this could be assumed to be representative of the state computer abilities as well. In mathematics, it is on an equal level with the other New England states. In short, it is an excellent state school system, but by no means the best in the country.

1.1.3 New Hampshire computer competency

New Hampshire instituted policies to introduce computers to its schools, students and teachers. The mission of the states educational system was presented by the Governor of the state:

> Business and higher education must now utilize significant resources for remedial education to prepare students for basic college courses or to enter the work force. Our future prosperity as a state and a nation depends on our ability to provide the work force with well-trained and educated citizens who can help lead New Hampshire and the nation into the next century (NH Governor's, 1990, p. 6).

This theme was continued in the following extract for the accompanying handout:

> In this information age, computer literacy is an essential element of learning. Without computer skills students will be unable to manipulate the vast amounts of information that will be presented to them throughout their lives. Although it is included here as an academic competency, it is really a tool to be used in all the other skills areas. Computer competency is inextricably integrated throughout all of the academic skills. (NH Governor's, 1990, insert, p. 11.

This section on computer literacy is repeated in its entirety in Appendix A. In effect, the state decided the debate by requiring computer competency skills to be mastered by its students as a requirement for high school graduation. It was the school systems mission, by definition, to teach these skills to its students. Further debate upon the subject in New Hampshire is academic. The state supports that policy by requiring all teachers to have a pre-service course in the use of computers to teach their subjects. Local school districts have invested further resources and have reached a level of one computer per 12.6 students (Rubega, 1989).

The mandated course requirement began in 1984, and all students graduating after 1988 were to have completed the course. The computer purchases for teachers were carried out and in-service training was conducted in the 1986-1990 time frame. The program has now stabilized for the state, districts, schools and students.

It is now an appropriate time to evaluate the effectiveness of this state program. This study evaluates the results by testing the computer competency knowledge of a state-wide sample of students. From the evaluation of one state's experience some broader conclusions can be made concerning the efficacy of requiring a computer competency course as a general policy.

1.2 Purposes

There are several related purposes of this study. The primary purpose can be summarized as determining if the actions taken and resources expended by the State of New Hampshire in fact achieved some increase in computer literacy. Other related areas are explored as a by-product of the general purpose. These purposes can be enumerated as follows:

1. Locate significant differences among types of schools throughout the state, if any.

2. Compare the state of New Hampshire schools to the nation as a whole.

3. Identify differences, if any, in computer competency outcome attributable to different local school policies.

4. Discover discriminators, if any, attributable to student demographics or curriculum choices.

5. Discover demographic characteristics which have been identified in the research literature but which do not make a significant difference in New Hampshire at this time.

To achieve these purposes, this study utilized a well-designed and validated examination developed by the Educational Testing Service (ETS) for the National Assessment of Educational Progress (NAEP). This examination was given to a national sample of students, including second semester high school juniors, in the spring of 1986. For the present study, the examination was administered to a sample of first semester seniors throughout the state of New Hampshire, in the fall of 1991. The information collected was then utilized to address the specific purposes described in the following sections.

1.2.1 Intra-state school differences

The collected information was utilized to determine if computer competency outcomes in the sample schools are significantly different among themselves, and if the scores exhibit an expected normally distributed outcome. If differences exist, they must be accounted for when determining a state-wide weighting or averaging scheme to allow for further comparisons.

1.2.2 State-wide computer competence

The study will compare New Hampshire computer competency scores to the best available national content measurement of computer competency. If New Hampshire's computer competency programs, in total, are successful there should be a measurable difference in state scores compared to a national sample. If it can be shown that the state results exceed those of the nation, as a whole, then one can conclude that the state's computer competency programs, policies and procedures, taken as a whole, are effective.

1.2.3 Local school differences

There are many differences in school characteristics and in local school policies. This study will examine the extent to which they make a difference in computer competency. Examples of these differences are:

- School control: public or private.
- School size: small, medium or large.
- School community: city, or rural.
- Computer competency course curriculum.
- Timing of computer competency course.

1.2.4 Student discriminators

The third purpose of this study is to identify demographic characteristics, unique to each student, that correlates with the computer competency scores. Many of these have been identified in previous research literature. These discriminators have been determined for students going further in computers in college (Carabetta, 1991), but not for high school students in general.

1.2.5 Student non-discriminators

Many student characteristics have been identified in the literature, which seem to affect student computer competence. The fourth purpose of the study is to determine which characteristics do not seem to significantly affect computer competence within the state. Previous literature has identified many factors which, while discriminators in another time and place, may no longer be significant in New Hampshire with its required computer competency course.

1.2.6 Make recommendations

Finally, recommendations will be made to assist the state and school districts in planning their future actions with respect to computer competency.

1.3 Definitions

Several terms are used throughout this study which require an operational definition. Some of them have been controversial for many years.

Computer competency score, competency score or just score, means the average percentage score on the 1986 computer competency examination. A single students score is calculated as follows:

$$\text{Student Score} = \frac{\text{Number of correct responses}}{\text{Number or responses + number skipped}} \times 100$$

Formula 1
Student Score

All scores referred to in this study are average scores unless otherwise noted. The average score or score for a group of students is:

$$\underline{\text{Average Score}} = \frac{\sum_{K=1}^{\text{Number of Students}} (\text{Student Score})_K}{\text{Number of Students}}$$

Formula 2
Average Score

Computer competency is defined by this author, for purposes of this study as the clearly delineated computer knowledge, skills and abilities generally expected by a social group (such as a state, school district) of all students as a condition of high school graduation. The expectations may be inappropriate for the purposes desired or not agreed to by all individuals, but this is not relevant. The definition may also change with time, location or sub-classification of students. It will certainly change as the social group considered is changed. For example, businessmen may have different definitions than teachers, or New Hampshire's may be different than Boston's. As will be shown in the literature review, there is no consistent, clear definition which has lasted very long that is more precise than this definition.

Computer literacy for purposes of this study, is synonymous with competency. As a term, it was used in the late 1970's and early 1980's. It began to be transformed into "computer competency" in the mid 1980's. By the early 1990's the transformation was nearly, but not entirely, complete. Merkle (1990) has argued, along with many others over the years, that using the term "computer literacy" implicitly compares it with more traditional literary skills such as reading and writing, and that this comparison is invalid. Secondary school systems' responses to that type of criticism has been to shift to the "competency" form of terminology.

New Hampshire has written and approved state requirements for its students to graduate from high school. The computer competency requirements are referred to as mandated or state mandate. As part of the mandate, several alternative methods are made available to local school districts to help students fulfill these requirements. Within each alternative, school districts have some latitude in the exact details of implementation.

The smallest school grouping analyzed in this study is a state. Various references are made throughout this study to state requirements. The state regulations referred to are assumed to be true representations of the situation in the state. Districts that do not follow state regulations for any reason, however valid, are beyond the scope of this study. Smaller school units, such as specific schools, districts and counties are avoided unless a study reported that they were representative of a state sample.

Assessment instruments as used in this study are not only assessments or tests, but the entire set of procedures used to administer the test, the method of scoring and interpreting the tests. ETS and NAEP prefer the use of the broader term.

1.4 Delimitations

This study has the following delimitations:

- The study only addresses basic, minimum competency skills which are to be provided to all high school students. It does not address more advanced or specialized skills or those only available to small groups.
- The computer cognitive content will be measured utilizing the NAEP computer competency examination. This is a quantitative measurement of the cognitive aspects of computer competency. It is not an attitude or anxiety survey.
- Both public and private schools are included in the sample, just as they were in the NAEP survey.
- All subjects are high school seniors in New Hampshire high schools in the fall of 1991.
- It was not required that students have completed the computer competency at the time they participated in this assessment.
- The assessment was limited to one class period of participating students time at the school.
- The study concentrates on student characteristics that are generally subject to school policies and procedures, such as courses offered, course timing, curriculum contents.
- A student's sex and areas of knowledge directly related to a "computer experience" are considered.
- A student's race, socioeconomic background, and parental demographics are beyond the scope of this study.

1.5 Assumptions

The following assumptions are contained in this study:

- The school sample is, in fact, representative of the state as a whole.

- The students selected in each school were representative of the students at that school.

- The NAEP computer competency examination accurately measured nationwide computer competence.

- The NAEP statistics, particularly the variance, represent the population, as a whole, at that time.

- Computer competence is not significantly affected by a one semester difference in students age (NAEP tested second semester high school juniors and this study tested first semester seniors).

- The national computer competency has not significantly changed since the NAEP sample in 1986.

The last assumption is that the level of computer competency, nationwide, has not changed since 1986. This assumption is based on a simple fact; a more current national sample doesn't exist, nor is one planned through at least 1996 (NCES, 1991, p. 71). Literature relating to both the necessity and validity of this assumption are presented in subsequent chapters.

1.6 Significance

This study is aimed at two major groups with interests in computer competencies: those with an interest in the nation, as a whole, and those with local interest in the state of New Hampshire.

1.6.1 National

There has been a negligible amount of cognitive testing in computer competency since microcomputers came to dominate both the educational and business areas. The NAEP study has data on such a grand scope concerning the nation as a whole that one cannot sort the different state results or different types of competency programs.

New Hampshire was one of the first states to adopt computer competency definitions and standards (1983) and require a computer course for high school graduation. The program has had sufficient time to be implemented and stabilize. An evaluation of this state is, in effect, an evaluation of using a required computer course as a method for achieving computer competency.

The process has been well documented. The state's distribution of hardware, software and personnel resources has been documented (Rubega, 1988, 1989) to aid others in assessing the model's efficacy. The goals of different segments of the state, the curriculum content, and approach have also been investigated on a state wide basis (Carter, 1988). The administration and implementation of the state mandate and technology, into school districts, has also been documented (Larracey, 1989).

This study completes the process started in 1984, by examining the computer competency outcome of this total experience. This study is the most up-to-date information concerning computer competency available. New Hampshire has become a yardstick by which other states and regions may measure the results of their own programs and progress in achieving computer competency in their students. Since other states have not yet conducted this type of assessment, New Hampshire can only compare itself to the nation at this time. The only national assessment was conducted in 1986.

1.6.2 New Hampshire

There have been no outcome assessments of computer competency in this state. An enormous amount of money and time has been expended to give the students of this state a degree of computer competence. This study provides needed data about the effectiveness of these resource expenditures. The state is currently assessing further changes in the curriculums of its high school systems. This study provides some information to help base future programmatic and resource decisions in the computer competency area.

CHAPTER 2.

LITERATURE REVIEW

The literature review is organized into four general areas:

- General literature, which investigates the general history, definition and goals of computer competency.
- Assessment instruments, which discusses the tests and measurement instruments that have been developed and validated over the years.
- Assessment results, which investigates the findings of various assessments.
- The New Hampshire experience, which develops the background information necessary to locate this study's quantitative results into a place, situation and time.

Each of these areas has an extensive literature in its own right. While all four are related to this study, in general they have not been related in other literature.

2.1 General literature

A 1972 report by the Carnegie Commission cited four major educational revolutions: the invention of reading and writing, the emergence of the profession of teacher/scholar, the development of movable type, and now the invention of electronic technology including calculators, computers, video technology, electronic data banks, satellites and communications (Carnegie Commission, 1972). This revolution covers a wide range and encompasses many areas.

The scope of this study is quite narrow; the outcome evaluation of a single state. However, some context of what is being assessed, and other types of assessments, is useful to establish a context for future evaluations.

This review is split into three major sections. The first provides a general, but brief, presentation of computer literacy or competency. This section also explores the literature available about different states and their literacy programs and assessments. The second explores the literature and documentation available that specifically concerns the state of New Hampshire. Finally, the only three large sample assessment instruments (tests) that have been developed and actually used are explored.

2.1.1 History of computers

While there were many mechanical machines that performed repetitive operations, there were no stored-program electronic computers, as they are defined today, before 1948. In 1978 there were less than a half million computers in use. As of 1990 there were over 45 million microcomputers alone (Juliussen, 1989, p. 1.2). Given a current work force of approximately 110 million people (Statistical Abstract of US, 1989) it can be derived that there is approximately one computer for each two and one-half American workers! The history and growth of computers has had several excellent moments. Some of the many textbook authors worthy of mention are Kershner (1990) and Anderson (1988). Of the works of the early pioneers, this study would recommend Goldstine (1972).

2.1.2 Computer literacy research

The large increase in the number of computers during their short 42 year history has had numerous consequences. It has resulted in rapidly changing views of what the average American citizen and worker need to know to be (in the opinion of some) a fully functioning member of society. The term computer literacy came into being to describe this "minimal knowledge." Its definition was always very imprecise. "Like other .. buzzwords of the past, the term has been widely used by technicians, educators and computer hucksters, but is rarely used the same way twice" (Benderson, 1983, p. 4). Just as two people cannot agree on what a person "needs to know" about anything substantive, little agreement exists on the definition of computer literacy.

The earliest reference to the term computer literacy occurs in ERIC. It is an article by Brightman advocating a computer literacy course for non-majors in junior colleges (Brightman, 1970). The next reference appears two years later. The earliest reference this study could locate offering a definition for computer literacy is quoted by Billings (1988, p. 16), citing 1972 Conference Board of Mathematical Sciences (Conference Board of Mathematical Sciences, 1972):

> "all students should become computer literate and this is best accomplished through specific computer-oriented course work."

The Conference Board introduced two important concepts at this time: computers were for everybody and computer literacy was best obtained via formal education. Thus, computers were being thought of as a tool for the masses, not just the computer specialist. It was not clear whether "all students" really needed an introduction to computer science or if this broader audience needed course work distinct from the future computer specialist. Such subtle, but troublesome, distinctions were to come later.

The first review concerning the status of computers was presented in 1973 (Molnar, 1973). This article describes some of the programs of the National Science Foundation directed at computer education. The same year also saw the first direct reference to computer literacy courses in kindergarten through twelfth grades (K-12) curricula (Springer, 1973). Oregon published a curriculum guide for computer literacy in 1974 (Dunlap, 1974), and one school district in New Jersey published a curriculum guide (Newark School District, 1976).

These papers represent virtually all publications prior to 1976 regarding computer literacy. 1976 is of interest because in the following year the Apple II was introduced (Juliussen, 1989, p. 11.6). In effect, it marked the beginning of the microcomputer revolution.

By this time, there was much confusion among:

- computer teaching a subject.

- teacher teaching a subject with the computer as a tool.
- student using a computer to reinforce or test an already taught subject.
- teaching about the computer itself.

Education proponents were usually talking about the first three areas as, "the centralized course-ware development, and delivery, of the entire kindergarten through High School (K-12) curriculum was being touted as the wave of the future" (Kurland, 1987, p. 320). In those proponents' minds, inclusion of the computer into that curriculum was not an issue. Those proposing "computer literacy" were talking about inserting "teaching about the computer" into the curriculum. How the remainder of the subjects were taught was not considered an issue. These two groups still exist.

By 1977 the blame for at least some of the expensive computer failures of the past, was placed at the feet of "incompetent" personnel who possessed a "computer attitude" problem. The earliest "computer attitude" literature dates to this period, although according to some authors it does not seem to mature until the early 1980s (Collins, 1985; Nickell, 1988; Rossen, 1987). Conceptually, computer literacy was, at least, partially postulated as a mechanism to overcome computer anxiety, aversion and computerphobia which in turn would make for more productive workers (Meier, 1985; Rossen, 1987).

The desire for a sufficient number of computer workers to fuel the economy became a national concern. The National

Science Foundation (NSF), a branch of the National Academy of Sciences (NAS), was active in computer literacy since at least 1973. One of its goals was the definition and measurement of computer literacy. In 1979, the NSF funded the development of a test to measure computer literacy. The result was the Minnesota Computer Literacy and Awareness Assessment (MCLAA) by the Minnesota Educational Computing Consortium (MECC) (Smith, 1992). This test is the topic of a later subject.

The NSF seemed to be primarily concerned with science, mathematics and the development of programmers. With the injection of NSF funding computer literacy literature began to flourish in the early 1980's. The term computer literate for many of the educational community in this era was a novice programmer. Devoe credits Luehrmann (Luehrmann, 1984) with coining the actual term computer literacy (Devoe, 1991, p. 5). As clearly demonstrated, the term was in existence at least 10 years earlier, but Luehrmann was certainly one of the more vocal proponents of computer literacy. He was also a major supporter in respect to the importance of programming as a component of computer literacy. Literacy was to be achieved through introductory programming instruction, particularly in BASIC.

Others disagreed with Luehrmann within just a few short years (Benderson, 1983, p. 5-7). Computer literacy, still not really defined, began to be widely discussed by 1982. "Computer literacy may soon be a prerequisite skill for effective participation in our society and as much a necessity as reading literacy" (Heinssen, 1987, p. 50). The literature began to show signs of debate on exactly how this new literacy should really be defined, if at all. By the early 1980s, several "literacy" texts had become available to implement the computer literacy curriculum. These early texts divided the course into an awareness area, and programming. Programming began with LOGO in the early grades, BASIC in high school, and PASCAL in college (Kurland, 1987, p. 324).

Other groups were active at this time. The EDUCOM computer literacy project began in the Fall of 1983 (Gilbert, 1984). This group identified computer networks and computer literacy as the two most important new activities. The project, complete with meetings and newsletters, lasted for two years (Gilbert, 1986). Its demise marked a sharp drop in the amount of computer literacy research material.

1984 saw the introduction of the Computer Literacy Act of 1983 and the Computer Literacy Act of 1984 (Congress, 1984). The bills actually passed the House, but not the Senate. The mere fact that they were introduced and had passed one body of congress indicate the extent of the activity surrounding computer literacy during this period.

The NAEP computer competency committees also started work in 1983 to prepare the assessment to be given in 1986 (NAEP, 1986g). This study is detailed in a later section of this study. This national assessment probably represented the peak of the computer literacy era. By the time the study had been published, in 1988, cheap and readily available microcomputers had reduced the cost and access to computers to something less than a national crisis. NSF reduced its funding in this area. EDUCOM terminated its computer literacy project in 1986. NAEP terminated computer literacy funding after the 1986 computer literacy assessment, although other efforts in other subjects continued. Research in this area gradually declined.

To illustrate the rise and fall of interest in computer literacy, a count of publications was conducted in ERIC, PSYCLIT and Dissertations International On-Line (DAO) using just "computer literacy" as a qualifier. A count of titles for each publication year since 1965 was performed. The results are presented in Figure 2.1. To provide some reference to the years in question, the preparation work on the NAEP assessment used in this study was begun in 1984. It was given in 1986. The results were published in 1988.

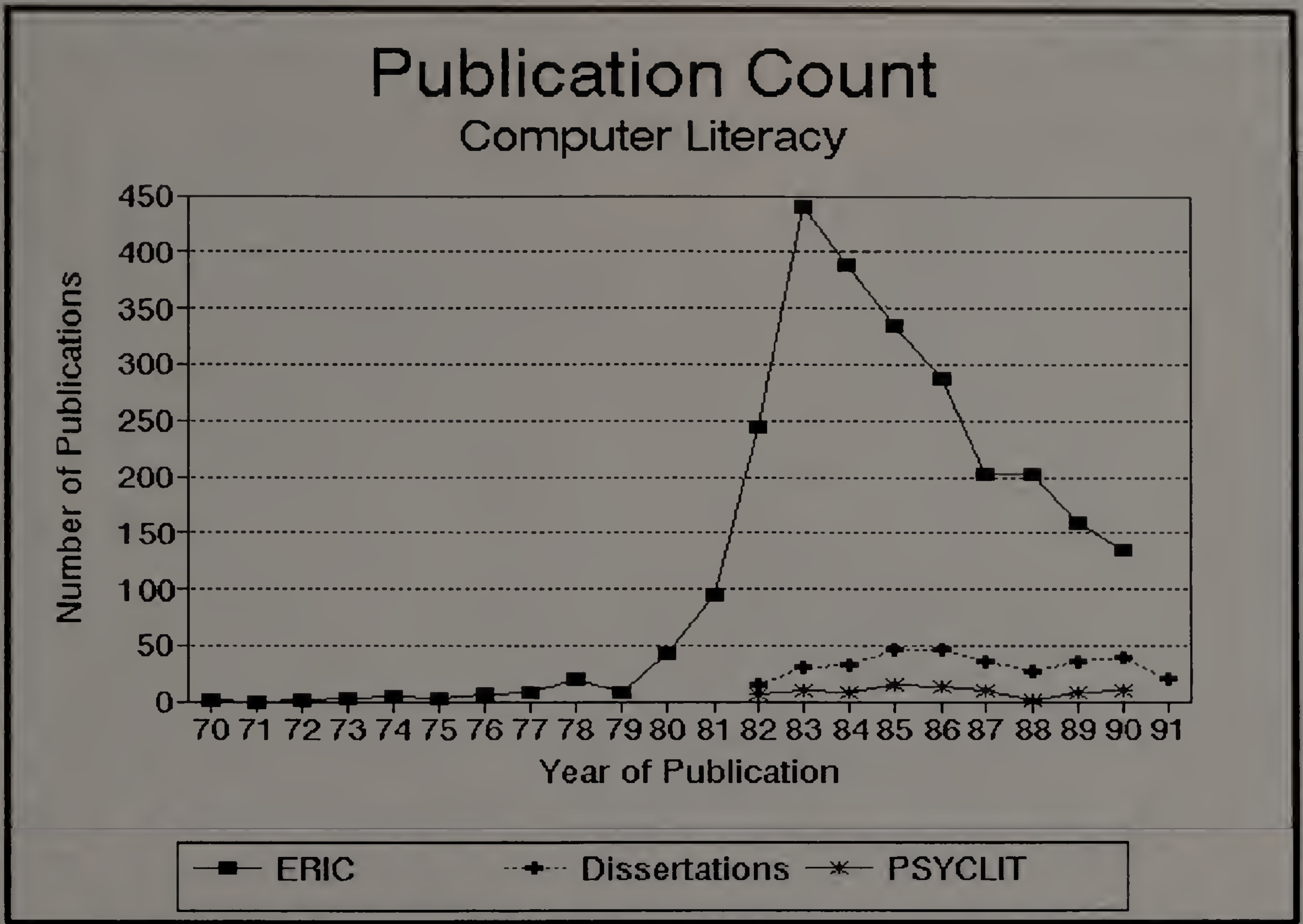


Figure 2.1

Computer literacy research production:
Publication count by year of publication

As can be seen, there is a very pronounced peak in publications, followed by a sharp decline. After a two or three year lag time from the sharp rise in interest in 1980, the academic publications, included in DAO and PSYCLIT, began to publish research in the areas. This peak of activity, 1983-1985 is referred to in this study as the "Golden Age" of computer literacy.

Publications began to decline sharply in 1985, and have continued to decline to this day. The ninth and last computer survey of schools was conducted by Electronic

Learning in 1988 (Bruder, 1989c). Dissertation activity has remained reasonably constant however.

2.1.3 Microcomputer revolution

The decline of interest in computer literacy research seems to reflect the increase in money available for computer hardware. This fact is accompanied by a proportional reduction prices for the power, and quantity, of computers, that could be purchased with the given funds. In effect, the proponents of computer literacy "won" the war of the minds and pocketbooks of the American school system. The "proponent soldiers" were no longer needed.

The first micro-computer appeared in the educational scheme in 1978 (Bozeman, 1988). Late 1981 saw the introduction of the IBM Personal Computer (PC) (Juliussen, 1989, p. 11.6). While microcomputers were available prior to the IBM PC, they were not universally perceived as having the necessary power to make a substantial impact on society. Once they possessed IBM's blessing, another era began (Anderson, 1990, p. 60). Advanced, user friendly, inexpensive, generalized business software was developed for the commercial market (Visicalc, dBase II, Wordstar) (Kershner, 1990, p. 59). The PC provided the mass market entry for commercial software, which in turn justified the mass market for microcomputer hardware. While microcomputer hardware and software were developed for the commercial market, they were general enough to be used by education. This adoption of a commercial machine by the educational community market was the beginning of a convergence between educational and commercial views of computer literacy. Computer educators now had the means, the desire, the expertise, and the financial resources to teach the same material the business community desired of its employees. The explosive growth that followed was without precedent.

From its humble beginning in 1981, there were 40 million personal computers installed by 1989, many of them in schools. (Juliussen, 1989, p. 1.2). This era also brought the development of 4th generation mainframes, the super-computer, the desktop workstation, the graphics-computer, the super mini-computer and the mini super-computer (Juliussen, 1989, p. 1.7). There were approximately 130,000 mainframe computers and 151 Cray super-computer systems in 1989 (Juliussen, 1989, p. 3.4). These numbers are often disputed, but they illustrate the sheer magnitude of computer growth in the last 10 years. The average man would probably never see a Cray, but almost certainly could not escape seeing a microcomputer. The ability to use these numerous computers became a cornerstone of computer literacy in both the commercial and educational worlds.

In the 1985/1986 school year, national spending for micro-computers in the schools was estimated at $550 million for hardware and $130 million for software (Bozeman, 1988).

Computers had become widely distributed, reasonably priced and sufficiently accessible (with respect to power, environment, security, space etc.). People began seriously discussing the direct in-classroom use of the computers (Taylor, 1988). As previously stated, about 250,000 computers were available in schools in 1982. This number had grown rapidly to over 1,000,000 by 1985 (Kurland, 1987, p. 322). This would grow to 1.5 million by 1988 (Bruder, 1988).

Another perspective of the computer growth, was examined by the Census Bureau. In 1984, 28% of the nations students used a computer in school and by 1989, 46% had used one (Census, 1989, pg 3). Interestingly, the percentage of children with access to computers was higher in junior high school (54.6%) than in high school (39.9%). These percentages represent a 50% growth in the 5 years after 1984 (Census, 1989, p. 4).

In the mid 1980s, computer courses were available which contained little or no programming. Their emphasis was on utilizing commercial applications software (Kurland, 1987, p. 324). Text books proliferated with titles such as "Introduction to Computers" or "Introduction to Computer (or Management) Information Systems" (Prentice Hall, West Publishing, Simon & Shuster and Heath Catalogue of academic publications 1990 editions). Computer hardware and software products were flooding society in incredible quantities. One could not pick up a daily paper without seeing a column on personal computing, plus a variety of ads for direct purchase of computer software and hardware.

The concept of computer literacy had became a vehicle to address the desire of many people to use computers as well as the desire of many companies to sell computers. Computer literacy was envisioned as a combination of history, terminology, programming, software use, hardware familiarity and social issues (Bitter, 1982). Computer literacy became a medium for education to solve four major problems:

> First, it answered the call from parents to do something to prepare their children for the world. Second it provided a way for schools to become involved without substantial capital investment. Third, it could be taught by teachers who were computer novices themselves... (fourth) ... by offering a separate course, schools could keep computers neatly compartmentalized and insulated from the rest of the curriculum. Thus, most subject area teachers did not have to learn anything about computers, and none of the regular curriculum had to be altered in any way. (Kurland, 1987, p. 323).

The costs of building a small microcomputer laboratory was comparable to that of a science laboratory. That level of cost could be achieved. The alternative cost of equipping each subject area classroom with enough computers to be effective (2-3 students per machine) could not be so easily absorbed. Expecting all teachers to use computers seemed an impossible task, but a few states have tried, notably New Hampshire (to be documented later) and Hawaii (Hawaii, 1985, 1986).

A few computer laboratories and their small teaching staffs could be centrally managed (Kurland, 1987). This seemed to be the course most states chose. Very little computer integration, with regard to other courses, was detected in the 1986 study (Martinez, 1988). This study detected no change in that situation.

2.1.4 High school assessments

Given the research and interest in computer literacy of the late 70's and early 80's, it would seem natural that a great deal of testing would be done to determine exactly how literate the students were. One of the best computer literacy literature surveys of quantitative studies expressed the situation as follows; "As other reviewers have found in the past, most literature in this area is rich with claims, but poor in actual data" (Roblyer, 1988, p. 86). It is very difficult to tell exactly what students learned from all of this activity, or when they learned it.

Several on-line database searches, as well as manual searches, were made to determine the availability of test results for cognitive computer competency measurements. Some of the results of these searches are listed below.

2.1.4.1 ERIC

A search of ERIC (1991, September), with a qualifier of computer literacy or computer competency yielded 366 headings. Only 44 of them claimed any actual cognitive testing. Of this total, only a very few are of direct interest.

Cheng developed a short test and validated it extensively in one school (Cheng, Plake & Stevens, 1985).

This test focused on programming and computer hardware internals. Applications software or its usage was not included.

The Department of Defense (DOD) had a computer literacy test designed in 1983 to measure the computer competency of the military dependents of the armed forces in schools world wide (Gabriel, 1985). The content description of this test seems to emphasize hardware and programming, but a small segment mentions word processing and databases. A small sociological implications and an applications component was added. In 1983, Gabriel further modified the basic DOD test created a test for seventh graders to measure the cognitive effects of a home computer (Sparks, 1986).

NAEP had previously asked some demographic computer information as part of its 1982 science assessment, but no cognitive items were used. A mix of Gabriel's cognitive items and NAEP's background items were utilized in a California assessment in 1983 (California, 1984). This examination does not appear to have been repeated. California subsequently shifted its computer literacy attention to colleges, and interest in high school assessments waned (Ashley, 1989).

The basic NAEP examination framework utilized in this study is also found in the literature. A contractor for ETS wrote an earlier paper, which describes the basic layout of the 1985-86 NAEP assessment, but apparently never actually gave any examinations (Lockheed, 1983).

To summarize, there were 2,552 references to computer literacy in ERIC. Of this total, nine referred to high school testing. Three of these utilized the Department of Defense Test. Four others examinations predated NAEP, but whose content was directly utilized by NAEP in constructing their examination. Only one reference described the NAEP examination. As stated previously, no new large scale testing has been reported since the 1986 NAEP examination until this study. The NAEP nationwide sample, old though it may be, is the latest information available

2.1.4.2 PSYCLIT

A search of the American Psychological Association database (PSYCLIT) for computer literacy revealed 184 entries, of which only 13 were directed at high school. No high school cognitive or objective tests of computer competency were reported. All thirteen utilized attitude surveys coupled with a student's self-evaluated knowledge of computing or the MCLAA. This area is discussed later in the attitude sub-section of the results section.

2.1.4.3 Dissertations Abstracts Online (DAO)

A search of DIALOGUE dissertation abstracts on-line yielded 466 headings, with only 5 which actually tested students (Hooper, 1984; Ching& Plake, 1985; Strict, 1985; Mathay, 1987; Pish, 1990). Strict tested college students. Mathay tested college students. Pish tested third and fourth grade students. Only Hooper tested high school students.

Hooper and Strict utilized the most current computer competence test available, the MCLAA. Mathay utilized the MCLAA test, which is basically a mainframe testdeveloped in 1979 (Smith, 1992). Mathay did note "a large majority of students ... had experience exclusively with microcomputers...[this] result ... supports their lack of knowledge of larger computer systems". (Mathay, 1987, abstract).

2.1.4.4 Test summary

To summarize, there simply has been very little wide scale cognitive testing done.

Lamar Alexander, Governor of Tennessee, Chairman of the The Governors' 1991 Report on Education, (note: year 1991 part of title), represents the thinking of today's leaders: "The nation - and the states and school districts - need better report cards about results, about what students know and can do" (Governors, 1986, p. 3). This association or correlation is a major proponent of assessment and outcome testing. It is of some interest therefore to quote from their task force on technology.

> "How will we know if we are succeeding?
> This report is based on the assumption that performance-based assessment will be emphasized in our educational system....There are a number of indicators that could be used by any state ...
>
> - Number of districts with formal plans.
> - Number of districts that provide training to help teachers.

- Number of teachers actually integrating machines and technology into their curriculum.
- Significant increase in resources and time spent on instruction and concurrent reduction of resources allocated to curriculum.
- Ratio of hardware to students" (Governors, 1986, p. 134).

This current study represents only the third state to be cognitively tested since computers were invented. It is the first state to be so tested with micro-computers as the prevailing instructional mechanism. It is impossible to extract state data from the NAEP data tapes since responses were coded only to four regional areas of the United States (NAEP, 1988, 1989b). Ashworth of NAEP confirmed that it was not until 1990 that NAEP was permitted, by law, to collect data on a state by state basis. Thus, while the NAEP data provides a national yardstick, the computer competency granularity is no better than the four regions of the country (Ashworth, 1990).

2.1.5 Computer attitude, aversion and competency

Testing in or for "computer anxiety" has been widespread. It is not directly related to this study, but an appreciation of that type of program contributes to some of the confusion in the computer competency area. The basic premise is that a lack of anxiety is somehow related to competency. The most probable cause reverts to the feeling in the mid 1960s to mid 1970s. The reason so many computer systems failed was that the personnel simply felt too uncomfortable with the new technology to properly convert to the "new system." Thus the "failures" were a failure of personnel, not management or technology. Gabriel's work with the Defense Department test originally included an anxiety component (Gabriel, 1985). The MCLAA was based, in part, upon computer awareness (Smith, 1992). Some of the NAEP demographic questions are actually dealing in computer awareness or anxiety. But at the same time as the cognitive practitioners were developing skills tests, another group was developing attitude, anxiety and awareness (AAA) measurements.

The original work in computer anxiety was done in 1980-1981 by Weinberg, English and Mond (Dukes, 1989, p. 195). The term computer phobia was coined and researched by Jay in 1981 (Rossen, 1987, p. 167). References to "computer attitudes and anxiety" testing started during the early 1980s (Collins, 1985; Heinssen, 1987; Meier, 1988; Rossen, 1987). The early tests were developed to quantify the degree of anxiety, to recognize any changes in it, and to validate the findings (Rossen, 168). Since this study is not really trying to assess attitude toward computers, a thorough absorption of this area was not attempted. However, there is a great deal of literature and research in this area. There is just very little that relates this type of study to any measured content knowledge or capability. Virtually all of the hundreds of abstracts reviewed, relied upon subjective evaluation of their own expertise by the test taker.

The literature research indicates a separation into cognitive testing and anxiety testing. The bulk of computer literacy or competency testing has been of the anxiety testing with self-reported computer skills. None of the studies located gave comprehensive cognitive skills and compared those skills to the results of anxiety testing of the same students. This may not be surprising when it is noted that there is very little cognitive computer testing of any kind.

There are some data to indicate the lack of a relationship between skills and feelings. One dissertation demonstrated the shortage of statistical reduction in anxiety after computer classes in programming or operation skills (Andre, 1986). Another study found agreement among various anxiety scales, but "differentiation between cognitive and affective reactions toward computers" (Zakrajsek, 1990, abstract). Finally, the question of whether attitude toward computers can actually help in performance with computers was raised in a research review (Roblyer, 1988). Pinto examined the attitude and anxiety of computer programmers and professional operators of mainframe computers and their performance evaluations and found a correlation to anxiety scores as well as age and sex (Pinto, 1985).

There have been exceptions noted. One is a good attitude and the use of word processing tend to correlate. Another, a good attitude toward computers or lack of anxiety appears to encourage students to feel positively about writing and thus they write more (Roblyer, 1988; Collins, 1985, 1986). This relationship between word processing and computer competence exhibited itself in this study.

2.1.6 Lack of an agreed definition

The concept that all people have different expectations and hence may have differing "literacy" needs dates to an NSF two and a half day workshop in 1980, to determine what constituted computer literacy. No basic agreement between those advocating basic awareness of terminology, those advocating a facility using hardware and software to solve problems, and those advocating the necessity of programming skills could be reached (Gabriel, 1985, p. 153).

These conflicts among depth of knowledge and breadth of knowledge persist to this day. The debate between the theoretical abstractness of "literacy" and the more mechanical aspects of "competency" are still unsettled. Feldman (1987) and Merkle (1990) are perhaps the best advocates of the logical inconsistency of computer literacy in this respect. However, great agreement on the nature of computer competence also exists among many authors (Strict, 1985; Kessler, 1986;Lai, 1986; Carter, 1988; Devoe, 1991).

In 1985, the Educational Testing Service observed in another issue of FOCUS, "Beyond Computer Literacy", that:

> the battle to define computer literacy seems largely irrelevant. A spirit of pragmatism has set in. People seem willing to allow computers to evolve naturally as part of the curriculum rather than imposing an ideological predisposition to their use....For better or for worse, people have satisfied themselves that they think they know what computer literacy is. They would rather do something than labor over definitions, so they've agreed to disagree. (Benderson, 1985, p. 2).

An excellent discussion of the various definitions of computer literacy for this period can be found in Bear's paper (cited in Devoe, 1991, p. 17-19). Feldman (1987) and Merkle (1990) also analyze the definition of a computer in detail. Merkle's paper is particularly interesting in that it provides an excellent description of the abuses, misuses, and lack of evidence that the "promises" or predictions of computer literacy have been fulfilled. Devoe (1991) also provide excellent discussions of the differing views of computer literacy, as well as a bibliography of earlier authors. Benderson (1983, 1985) provides the best survey from a mid-1980's perspective. Sutton (1991), while concentrating on equity issues, nonetheless has a superb literature review and summary.

2.1.7 State survey

As has been shown, there is an interest in having students acquire some sort of computer competency. However, computer literacy is at best defined only in the eye of the beholder. Furthermore, there has been little measurement of this elusive quantity. Nonetheless, some states have implemented computer competency programs of various types.

This section summarizes the research literature in those states. Additional information would be available in unpublished form from the various states' Departments of Education.

Seventeen states have computer competency requirements for graduation. Of these seventeen states, five have a computer literacy course requirement (Michigan, Rhode Island, South Dakota, Tennessee, and Texas). Eight others require their students to demonstrate competency (Arkansas, District of Columbia, Florida, Maine, Nevada, North Carolina, Vermont and Virginia). The remaining four states require both a course and a actual hands-on demonstration of competency (Louisiana, New Hampshire, Utah and West Virginia). (Bruder, 1989b).

Various surveys have been conducted, specifically in state-wide school systems. Twenty-one states have reported studies of some form in research literature. These states are listed below:

- Alaska has conducted questionnaire surveys covering many areas including computer studies (Alaska 1989).
- Arizona reported on the relationships between the high school and college courses in the state. It wished to utilize high school courses to reduce the computer literacy demand on their colleges (Babcock, 1990).
- California has conducted cognitive surveys (California, 1983, 1984).
- The District of Columbia reported upon its educational technology program (DC, 1986).
- Florida has several reports (Broughton, 1991; Still, 1984).
- Hawaii published several curriculum guides for grades K-12 (Hawaii, 1986).

- Indiana has performed four implementation studies of teacher literacy programs (Indiana, 1987).
- Iowa published a general planning guideline for its schools (Iowa, 1986).
- Louisiana performed a resource survey (Louisiana, (1985);Kirby, 1988).
- Maryland utilized a task force study approach (Deasy, 1984).
- Massachusetts (Boston only) surveyed teachers concerning curriculum (Devoe, 1991).
- Michigan has published a study about its plans to implement a study (Lentz, 1986).
- North Carolina published a competency guide for teachers and an status report (North Carolina, 1985, 1984).
- New Jersey also published a status report (Walling, 1984;Wepner, 1986).
- New Hampshire has had a survey, an implementation study and a curriculum study (Rubega, 1989, Carter, 1988; Larracey, 1989).
- Oregon has a pre-implementation study, and one of the early "classical" works on the subject (Neill, 1976). The recommendations were never implemented.
- Tennessee has conducted a cognitive survey (Hooper, 1984).
- Virginia conducted a survey to determine the type of programs required for their schools to meet state graduation requirements (Kessler, 1986).
- Wisconsin's implementation of state mandates were also performed recently (Petric, 1991).

From a study's point of view, it should be noted that the bulk of these studies were published during the "golden years" of 1982 through 1986. Few studies have been published since 1986.

2.2 Assessment instruments

There have been three major scale test instruments that have been developed. Each of these are discussed in the following sections. The first two were developed prior to the introduction of the microcomputer and are exclusively mainframe oriented. The third instrument, the 1986 NAEP assessment, was almost exclusively microcomputer oriented and selected for use in this study.

2.2.1 Department of Defense survey

By 1980, The Defense Department's dependent school systems worldwide developed an idea for a scaled or tiered computer literacy, with a set of educational objectives ranging from "entry" level to "proficient" (Gabriel, 1985, 154). This test was given to Defense Department dependents worldwide in 1982 and 1983 (Gabriel, 1985, 154). This represented the first reported large scale testing of any group of high school students. California utilized the Gabriel material as well as the early version of the NAEP computer demographic questions (discussed later) (California, 1983). Two other reported uses of this "instrument" were located in the literature search (Cheng, 1985; Sparks, 1986).

2.2.2 Minnesota Computer Literacy and Awareness Assessment (MCLAA)

The National Science Foundation (NSF), a branch of the National Academy of Sciences (NAS), has been active in computer literacy since at least 1973. In 1979, NSF funded the Minnesota Educational Computing Consortium (MECC) to develop a test to measure computer literacy. The result was the Minnesota Computer Literacy and Awareness Assessment (MCLAA) (Smith, 1992). It stemmed from the idea that a person's computer literacy was related to his/her personal expectations about computers. Its first use was seen in

1982 (Gabriel, 1985, p. 155). This use marks the beginning of the "golden age" of computer literacy.

The MCLAA was the earliest individual test of the cognitive aspects of computer competency. This test, while available prior to the Defense Department testing, was not utilized on a large scale until after that study.

Based upon a count of (23) appearances in Dissertation Abstracts On-line (University Microfilms International (UMI), 1992), this has been the most frequent instrument utilized to measure computer literacy or competency in the research area. Only three of the occurrences were for high school students; only one of them was directly measuring computer competency for computer literacy purposes. The study was first used in Tennessee to measure computer literacy in 15 school districts (Hooper, 1984). The mainframe orientation of the test could well be a reflection of government's, business's, and industry's concern for obtaining workers for their industrial computers from an educational system moving into micro-computers.

Melanie Smith, the official who is charged with responding to inquiries concerning the MCLAA, described the test in a letter written specifically for inclusion in this study, writes as follows:

> A test was developed with support from the National Science Foundation by a team of people from the MECC and the University of Minnesota in 1979....The test was made available through MECC's catalogue. We have no records of who may have used this before it was discontinued.

> The test is very outdated now as much has changed in computer usage. It attempted to assess the attitudes, experience and knowledge of high school students had regarding computers and how they were used....The content ... included ... how computers operate, the history of computers, and basic programming knowledge. MECC has not updated this tool as computer literacy is no longer part of our focus (Smith, 1992, p. 1).

The test was officially discontinued in the mid 1980's but more specific date is not available. All sales data, copies of the tests and other descriptive literature have been destroyed and copies of that material are not available. Some researchers still have old copies of the test however, and this test is still utilized (Pish, 1990, Mathay, 1987).

2.2.3 NAEP 1986 instrument

In 1984 and 1985, a group of over 70 educators from around the country developed a set of computer competency questions and designed an assessment instrument (NAEP, 1986g). In the spring of 1986, the Office of Educational Research and Improvement (OERI) of the United States Department of Education, surveyed the nation in many subjects. A computer competency assessment of the nation was conducted using this newly developed instrument. This national assessment was the first genuine national test for computer competency given on a large scale. To date, it is the only multi-school test which used a modern micro-computer oriented test instrument. There have been no new assessments planned from now until at least 1994 (NCES, 1998, p. 71). Hence, this is the most current information available. Similarly, there have been no test instruments developed by a group of comparable size or diversity, nor are any planned (Ashworth, 1991).

Specific portions of this assessment are usually referred to in this study as the 1986 Survey, the NAEP data, NAEP test, and NAEP tapes or the National Sample. Since there has only been one national sample, there is no ambiguity.

The NAEP assessment is documented in an executive summary (Martinez & Mead, 1988) and a detailed report (Beaton, 1988). A secured release containing full details of the assessment, copies of the instruments and permission for their use, was obtained through a request to OERI (Askew, 1990). Publicly released data tapes, and their accompanying secured release documentation, were obtained from the NAEP contract administrators, the Educational Testing Service (ETS) in Princeton, New Jersey (NAEP, 1989a, 1989b & 1989c).

Some specific procedures and calculations utilized during this study are discussed in Chapter Three of this study. These results are presented in that section, rather than here, since it is used to compare and contrast NAEP's methodology to the procedures of this study.

Figure C.1 illustrates the organization of the cognitive subject areas of the assessment. Table C.1 and C.2 contain sample sizes and question counts respectively.

Figures C.2 through C.6 contain publicly released sample questions from Martinez (1988).

Some of the demographic questions were carried forward from earlier NAEP surveys, such as the science section of the 1982 national survey (California, 1984). The cognitive questions were all developed specifically for the 1986 survey. Numerous telephone conversations between the study author and various NAEP personnel indicate that this study was only the second time that particular survey had been utilized.

2.3 Discriminators

The definitions, such as there are, and the assessments, what few there are, and the activities of the states have been discussed. This section deals with the research findings of those activities. One of the goals of most computer competency research is to determine discriminators or demographic variables that one can relate to the actual or potential computer literacy levels that a student can or did achieve. These discriminators allow study results to be generalized or correlated with other times and situations to predict the results of future actions, or to explain the results of past actions. This study sought such discriminators. This section of the literature review deals with several discriminators that have been noted in various studies and were subsequently examined in this study.

2.3.1 Attitude

Attitude studies as used in this study include such topics as computer anxiety, computerphobia, computer aversion, locus-of-control and similar types of studies. As a general statement, these studies have sought to relate a person's competency with a computer to their general feelings about their own abilities, feelings or emotions. The general premise is that those who like computers will do better with them, and conversely, those who do well will like computers.

The demonstrated relationship between attitude and competency is ambiguous at best. The repeated use of the obsolete, mainframe oriented MCLAA, as a vehicle for determining computer competency, makes many of its conclusions highly suspect. Where older, mainframe oriented tests were not used, a subject's self-evaluation of his/her ability is often substituted. This study attempts to correlate its quantitative results to one specific attitude type of questionnaire, the locus-of-control. Locus-of-control refers to the ability of a person to feel they have some control over the computer, its actions and results. Generally, the literature research indicated that these tests are used at the college and industry level and rarely at the high school level.

2.3.2 Sex

Sex differences in computer competence have been the most frequently mentioned discriminator in the literature.

Males perform significantly better than females. This study could not locate any studies that indicate the reverse. Studies include Mathay (1987), Cheng (1985), Jones (1983), Levin & Gordon (1989). A search of the PSYCLIT database yielded 10 other citations in several countries which postulated sex differences in computer competency.

Opinions on sex differences are by no means unanimous. Al Arainy (1984) postulated that the amount of computer classes accounted for the majority of differences. Wronkovich (1986) discovered no sex-based differences in grade school students. Arthur & Hall (1990) also reported no differences.

Hall & Cooper (1991) have recently reported that there exist sex differences in attitudes toward computers. Females viewed the computer as a tool, while males perceived it in more personal and broader terms.

Sutton (1991) provides an excellent summary of the literature available, based on sex and ethnic differences in computers in an educational environment. This work contains some interpretations and can serve as a starting bibliographic source in this area.

2.3.3 Computers at home

The presence of a computer at home has also been well documented in past studies. Sparks (1986) and Ching (1986) investigated this area extensively. Dambrot (1985) covered broad areas of inquiry including math anxiety and computers. Shoffner (1990) indicated that computers at home help improve attitudes, but not necessarily performance. Johanson (1985) found a sex-linked difference between computers at home and performance, but the difference was reduced with education.

2.3.4 Computer studies and experience

The literature has been long on extolling the virtues of studying computers and very short on demonstrating that the advertised results have been obtained. Martinez reports an increased score in virtually every category where students are currently studying computers. Sutton (1991, p. 481) reports various studies which indicate a transition from drill and practice to programming, and thence to applications software usage. Benderson (1983 & 1985) also reported upon this trend. However, any quantified analysis of these trends is lacking. The NAEP assessment asked if the students were studying computers, but not what students were studying about computers, or what type of studies they were completing.

Past experience has been frequently mentioned as a predictor of computer competency. In particular, attitude type surveys tend to relate experience to attitude. Lee (1986) and Dambrot (1985) reported on this factor specifically.

Other authors have mentioned sex as a discriminator, but not actually reported upon its quantitative effects. Arthur (1990) who found a relationship between familiarity (usage) and cognitive ability also reported that there was not a sex-based difference when adjustments for familiarity were made.

2.3.5 Other discriminators

As noted in previous sections, there has been very little outcome testing. If fact, only the NAEP has really reported any results with sufficient detail to identify subclasses of students. Appendix D contains tabulated results of these sub-classes from Martinez (1988). These subclasses are reported in this section.

- Public vs private schools: private schools outperformed public schools.
- Community size: high metropolitan performed best, followed by cities, suburbs, small towns, rural, big city and low metropolitan, in that order. These groupings are defined in Appendix D.
- Geographic region: the northeast scored higher than the rest of the country.
- Ethnicity: Asians perform best, Blacks perform lowest in the NAEP assessment.
- Parental education: better educated parents produce better performing offspring.
- Socioeconomic status: computer competency scores roughly proportional to socioeconomic status.

Several subgroups, identified in the national survey, were not examined in this study. These include:

- Race: insufficient diversity throughout state.
- Socioeconomic status: data not collected.
- Region: study designed for a single state.
- Parental Education: data not collected.

The first two items have been researched under the general rubric of equity issues. Sutton (1991) has produced an excellent summary of the literature for these areas. Regional differences have been largely ignored since no regional testing other than NAEP has been done. No other reference to the parental education other than NAEP was located, although some references are found in sections dealing with home computers, along with socioeconomic status.

2.4 The New Hampshire experience

This section of the literature survey reviews the pertinent literature concerning New Hampshire's computer literacy activities from 1983 until the present. While this study is concerned with the outcome of students from a computer competency program, some understanding of the input resources are helpful. Not only does the state require a computer competency course, but as will be seen, it has also developed a relatively complete support environment within which this course could operate.

The documentation of the process by which New Hampshire managed the introduction of computer technology to its schools and students is quite extensive. The documentation referenced not only includes the actual competencies required of students, but also the efforts of the state to furnish schools and teachers with computers, software, training and preservice computer competencies. This study has organized this material into the following categories:

- State computer competency requirements.
- State implementation of the requirements.
- Political backlash regarding the requirements.
- Reaffirmation of the requirements.

Larracey (1989) provided extensive documentation on the "planning for explosive growth of technology in the public schools" (abstract). It Chronicles the efforts of one school district in New Hampshire to change its system in order to accommodate the state requirements. It includes curriculum development, staff training, acquisition, support, evaluation and grants management. This study is of particular interest since Larracey was the superintendent of the school district at the time, and masterfully combines practical administrative experience with educational research techniques.

2.4.1 State computer competency requirements

A National Science Foundation (NSF) workshop was conducted in 1980 to determine what constituted computer literacy. Agreement could not be reached among those advocating basic awareness of terminology, those advocating an ability to use hardware and software to solve problems, those advocating the necessity of programming skills, and those whose viewpoints held a combination of the aforementioned items (Gabriel, 1985, p. 153).

Inspired by this NSF Study, the New Hampshire State Board of Education (NHBOE) began discussing computer literacy. These early discussions included contacting two states that possessed similar programs, the International Council on Computer Education (ICCE) and the National Commission on Accreditation of Teacher Education (NCATE) (Prevost, 1990a). In the spring of 1983 it was recommended that a 1/2 credit (1 semester) course in computer competencies be required of all students for high school graduation. This requirement was codified in the state regulations in September, 1984 (NHSDE, 1984). State school districts were given a time period until the graduating class of 1988 to implement this course into their curricula (Prevost, 1985).

2.4.1.1 NH computer competency definition

Immediately after the adoption of the basic competency requirement, the Commissioner of Education in New Hampshire appointed a committee to develop a method of meeting these requirements (NHSDE, 1984). The committee was aware of the controversy concerning the definition of computer literacy (Carnegie Commission, 1972; National Center for Education Statistics, 1983). New Hampshire chose to avoid the term computer literacy and instead used the term computer competency. The committee felt the lack of a consistent definition of _literacy_ would needlessly confuse people and detract from the purpose of the computer requirement (Prevost, 1990a). The committee issued its draft report containing the specifications of these competencies in January, 1985 (Prevost, 1985). After public hearings, this draft was approved by the State Board of Education on August, 1985.

2.4.1.2 State definitions

The original New Hampshire computer competency requirements were published in 1984 by the State of New Hampshire (NHSDE, 1984). These requirements are contained in Appendix B of this report.

Technically, the _competencies_ are divided into three areas, _awareness_, _operations_ and _programming_. Other groups discussing computer literacy have used similar terms and concepts. For example, the tripartite breakdown of skills (Technology, Applications and Programming) was used by the National Assessment of Educational Progress in their nationwide _computer competency_ survey in 1986 (published in 1988), which is in turn the basis for this assessment (Martinez, 1988, p. 10).

The _awareness_ portion of computer competency is the cultural portion of computer literacy. It includes history, uses, social, economic impacts, moral and ethical issues of computing. Definitions and terminology associated with internal computer architecture, usage, and software are also included within this category. This section is referred to as <u>computer knowledge and attitudes</u> in NAEP terminology, where 40 questions, including one essay, are contained in the survey instrument. The NAEP survey also contained one essay question on a computer copyright legal and ethical issue.

The <u>Operation</u> section emphasizes the use of computers and applications software. The state does enumerate a few specific area within this, including self instruction, word processing, modeling, simulation and decision support (Governor, 1990 and Appendix A). The original 1984 requirements, which are still in force offer some flexibility to the local districts (Appendix B).

NAEP refers to this area as <u>computer applications</u>. The assessment used by NAEP and this study have 43 items in this area, broken down into the same application areas as the state model, but does not include keyboarding. NAEP includes several application areas, word processing, databases, telecommunications, graphics, music, spread sheets, and simulation and modeling.

The <u>Programming</u> section states that a student must be able to state a problem, break the problem into steps, write a program, evaluate the results, and modify the program. While it is often assumed that a classical third generation programming language would be used (FORTRAN, COBOL, BASIC, LOGO), there is no requirement to do so. A creative teacher could use LOTUS 1-2-3 macros, WORD glossaries, or a turret lathe punch tape to accomplish this objective.

NAEP refers to this area as computer science, and the assessment instrument contains 25 BASIC items and 25 PASCAL items. The necessity for programming in a basic competency course is a topic of some dispute, both within the state and on a broader scale. Some national authors feel it should be included, particularly to prepare students for mathematics and science (Wiburg, 1989). Some feel that a failure to learn computer programming leaves them unprepared for college science programs (Milbank, 1990), but the majority do not.

2.4.1.3 General acceptance

There does not seem to be much controversy in New Hampshire about the content of the computer literacy requirements themselves. At four public hearings in April, 1990, there were few comments concerning the content of the requirements (Bourgeois, 1990b). There was discussion during the November, 1989 Computer Teacher Certification hearings about the standards for computer competency teachers (not computer science teachers). It was stated that the competency standards should include more application knowledge, less awareness, and reduced programming knowledge (Baker, 1989b). Carter conducted a thorough study of the computer competency curriculum as implemented in various schools throughout the state. He found agreement pertaining to most areas except that of programming. Data Processing managers in industry throughout the state and mathematical computing teachers wanted more applications and less programming. Business computing teachers felt there should be more computer programming (Carter, 1988).

2.4.2 Implementation

New Hampshire simultaneously pursued several methods for instilling computer competence in its students. The state took a 5 part approach to implementing the desired policies:

- It imposed high school graduation requirements on students.
- It conducted in-service teacher training.
- It required preservice teacher training.
- It tried to establish computer literacy teacher certifications.
- It funded hardware and software acquisitions.
- It fostered integration of computers throughout the curriculum.

2.4.2.1 Student requirements

A computer competence high school graduation requirement was imposed upon students graduating from accredited high schools in New Hampshire. To assist the various school districts in providing the requisite competencies to their students, a primary mechanism and several alternative mechanisms were furnished (Prevost, 1985).

The primary mechanism to achieve competency in these three skill areas is a one semester course, with 3 separate modules of approximately equal class-time distribution. Carter (1988) has studied the components of this course in some detail. In a state-wide sample of schools, Rubega (1989) examined the resources devoted to this course including hardware, software, teachers, teacher qualifications and administrative organization. All schools throughout the state were required to implement this class or provide for an alternative. A transition period of 4 years was allowed from the original mandate (1984). All state school districts, without exception would be in compliance with the mandate by the graduating class of 1988.

The first alternative to the state-mandated computer competency course is a substitute course (Brunelle, 1985). A district may use a locally developed, state approved, junior high school course. High school credit would then be granted to students for successful completion of this optional course. In 1985-1986 there was a flurry of course descriptions sent to the state for approval. There have not been any new districts applying for junior high school course approval for several years (Bourgeois, 1990a; Prevost, 1990a). It was left up to each school district as whether or not to construct and offer such a course. Each district, if it opted to develop such a course, could make it mandatory or optional. If mandatory, then the affiliated district high school would not have to offer such a course.

The second alternative to the mandated and optional course, is to simply pass a test (Brunelle, 1985). Students may learn any way they choose and demonstrate the acquisition of the requisite skills via a state approved, but district developed, examination. This test must have an actual hands-on portion. The required computer skills could have been acquired through integration of computers across a broad range of courses. The acquisition could have been the result of a non-traditional academic program, such as vocational training. The competence could also have been acquired through home tutoring. The option does not specify the manner of acquisition, only that the student demonstrate that he/she possesses the skills.

As with the optional course, there was a whirlwind of applications, and again no activity for the last several years (Prevost, 1990a). It is a necessary mechanism to cope with exceptions and transfers, but otherwise is of minimal importance.

2.4.2.2 Teacher training

The state has had an extensive in-service teacher training program. Utilizing specially appropriated state funds (Meleen, 1989, p. 2), 2500 registered teachers and 325 administrators, from around the state, attended one of a number of one week (40-hour) in-service training programs. At this "conference," they were taught to utilize an Apple IIe computer with "productivity" software (word processors, database, spreadsheets, grade books). Upon successful completion of the program, the registered teachers were allowed to keep the computers and software (Meleen, 1989, p.

5). This works out to one computer for every 4 teachers in the state (National Center for Educational Statistics (NCES), 1989, p. 67).

A different approach to computer literacy education is used for pre-service training all new teachers in the use of computers. New Hampshire is one of 18 states, including the District of Columbia, which requires all of its certified teachers to study computers as part of their preservice training. Another 7 states recommend, but do not explicitly require, such study (Fulton, 1988, p. 32).

This requirement is generally satisfied with a one-credit-hour course which emphasizes computer utilization during training. The 4 week course is typically required of teacher trainees (1 college semester hour). This course generally covers integrating computers in the individual's subject area, not teaching about the computer itself or integrating computer usage by students into the subject area.

Training of computer teachers specifically for computer courses has been attempted with little success. New Hampshire has tried to provide a certification for two classes of computer teachers, computer science and computer literacy. Public hearings were held on these competencies. The NHSDE, the state's top administrative body, formally proposed their adoption (Baker 1990a), to the New Hampshire Board of Education, the states top political body. As yet, these recommendations, for reasons that have nothing to do with computers, have not had a hearing (Bourgeois, 1991).

2.4.2.3 State funding

In 1985, after the passage of requirements for computer education, the State of New Hampshire approved a bill authorizing the budgeting of five million dollars to "enhance excellence in the state's schools." These funds were directed at a specific state program called the Governor's Initiative for Excellence in Education (Meleen, 1989, p. 1). A total of approximately eight million dollars in state money would be spent by the end of 1989 in this program to bring computers to New Hampshire (Vaughan, 1990). There was a local district fund matching requirement of one dollar ($1) of local money for every two dollars ($2) of state money. A grand total of $11 million dollars of state and local money was spent on computers.

The Governor's Initiative also imposed administrative requirements to qualify for the supplemental funds, such as: the establishment of a repair capability, appointment of a support system for software assistance, and a "significant" on-going training component beyond the original group of teachers (Meleen, 1989, p. 5). In effect, the program required the establishment of a cadre of trained users, the creation of a computing environment and the introduction of a large number of machines and software components. The software packages provided were general purpose productivity tools, not specific applications for a single discipline.

The goal of the Governor's program was to instill computer abilities into teachers on a large scale. It tried to make computer users of the teachers themselves. The chosen vehicle was the teacher's own personal productivity. It was not a programmatic goal to retrain the teachers on their own subjects (Vaughan, 1990). It was also not a goal or desire to train teachers to utilize computers in their actual instruction as training aids. Finally, it was not a programmatic objective to train teachers to teach computers.

This program was substantially cut from the state's budget in the 1990 calendar year due to state financial problems. However the program still exists with a small staff. The $8 million over a 4 year period (Meleen, 1989, p. 5) ($2 Million per year average) should be compared with a $38 million per year total state contribution (Digest of Education Statistics, 1989, p. 149). The supplemental funding represented an increase of 5% in total state spending specifically for computers over this period.

2.4.3 Computer integration into curriculum

One of the elusive goals of computer competency has been to have most teachers use computers to teach their subjects more efficiently, and have students learn to use computers as a tool in other disciplines. Some in the state thought that integration had already occurred and therefore, a special computer course was no longer needed for all students. Vaughan, the executive director of the Governor's Steering Committee for Education, believes that computers were integrated into classrooms throughout New Hampshire (Vaughan, 1990). According to statements made at a public hearing in Keene, April 11th, 1989, the Barrett Commission (discussed in a later section 2.4.4) believed these state-purchased computers were integrated into classroom use (Barrett, 1990, p. 6). This section also investigates any literature to support that contention.

In New Hampshire, as with other states, this is still an unproven belief. There are no meaningful statistics on exactly how computers and learning objectives are integrated throughout the curriculum or across the state. The State Board of Education has no consolidated data on what integration does exist on a state-wide basis in New Hampshire or elsewhere (Bourgeois, 1990a; B; Prevost, 1990a). This section reports the results of literature surveys based on the integration of computers into curricula, and the effects on computer competency of that integration.

2.4.3.1 General research literature.

The integration of computers into all facets, across the entire curriculum, appears to be the "Holy Grail" of some computer advocates. Broughton (1991) reports on the successful integration of computers as a component of the biology program. Lentz (1985) reported on Michigan's efforts to integrate computers into their curriculum.Hawaii (1886) has actually published guides describing various methods and lessons to integrate computers into its curriculum, but has not reported on its success. Louisiana (1985) has also taken this approach. North Carolina (1985) also pursues this approach. Nevada attempts to integrate computers into its grade school structure.

All is not necessarily what it seems as concerns integration. Bonner (1986) found a lack of agreement between what principals thought was important and what these same principals reported was happening in the schools in Pennsylvania. Petric (1991) surveyed Wisconsin, where the state mandates the integration of computers into the entire K-12 process, and found very mixed results across the state in terms of compliance. He also reported a the lack of connection between the integration of computers into subjects and any outcome passed onto the students.

The alternative to integration is to provide specialized courses in computers. Luehrmann (1984) was one of the early, and perhaps best known, advocates of teaching computer literacy as a single course, rather than relying upon integration across the curriculum. Several states pursue the separate course mechanism of achieving computer competency. New Hampshire requires a single course to achieve computer literacy. Iowa (1986) seems more interested in separate courses. Neill (1976) reports that Oregon has pursued the special course option. Lucas (1985) reports that Tennessee has little integration, but does have computer courses.

The National Assessment of Educational Progress (NAEP), in their nationwide computer competencies, directly concluded: "Computers are seldom used in subject areas such as reading, mathematics or science. Rather, the use of computers in schools is largely confined to computing classes" (Martinez, 1988, p. 6).

2.4.3.2 New Hampshire computer integration

After expending several million dollars of the Governor's Initiative, some people expected the large group of trained teachers to naturally integrate their knowledge with their classroom activities. The Governor's Committee commissioned a follow-up study to determine the results of the Initiative. This study took the form of a survey. The survey instrument used resembled the Attitude Toward Computers Test (ACT). In effect, computer anxiety of the teachers was measured (Dukes, 1989, p. 196). It reported that the trainees were generally satisfied and happy with their new, free computers. It also found that 52% of the teachers used their computers more than 6 hours per week and that an additional 46% used them between 1 and 6 hours per week (Meleen, 1989, p. 5-6). What the study did not report was when, where or how these teachers used their computers, either personally or in the classroom. It did not address the classroom use of computers. Furthermore, it did not address computer usage by the students.

An analysis of the applications of the state-provided computers reported by Vaughan (1990) yields no surprise.

The computer were used for word processing, databases for students, activities, finances and spreadsheets for statistics and club finances. Uses did not include mathematical applications, science experiments or art development.

New Hampshire School Unit 29, composed of the City of Keene and five of the surrounding towns, performed a follow-up study of each teacher who received a computer under the Governor's Program in 1987 (New Hampshire School Administrative Unit #29, 1987). While the teachers of the district reported great usage, only 39% of the teachers used their computer for anything school related. Fifty seven percent (57%) used it exclusively at home. Individual teacher productivity and computer competency may well have been increased, which was the Governor's Initiative's stated goal. However, it is difficult to integrate a computer at home into student activities in a classroom environment. While this integration was never a stated goal of the Governor's Initiative, it has become a widely assumed implicit goal by many people (Vaughan, 1990).

Most literature has studied making the teachers computer literate. The assumption has been that this is a necessary first step in educating students. From the literature, it is impossible to tell rather or not that the second step has been taken. The transition from teacher computer literacy to student computer competency has been difficult to document. Many authors have commented on the difficulty of achieving computer integration into a subject area, as well as teaching about the computer itself (Bulkeley, 1988; Fulton, 1988).

A computer can be used effectively as a teaching tool without ever exposing the students or teachers to the computer's internal architecture, operation principles or broader social impact of those operations. The widespread use of computers as a drill and practice machine is one example of this type of computer usage (Benderson, 1983, 1985). However, any connection between this application usage and computer competence to utilize even other applications, has been lacking. A simple example will illustrate this point. There is no literature that connects the use of a computer as a spelling and vocabulary drill and practice device, with the ability to use even a closely related computer application such as a word processor.

2.4.4 Backlash

Given the level of investment in computer competency, it was inevitable that some groups would object to that expenditure. Such an objection came in New Hampshire in 1989. It raised all of the objections to the course experienced when the course was first approved, including cost, inconvenience, excluded courses, not enough electives and so forth.

A committee chaired by Roberta Barrett on high school graduation standards was formed in 1989 at the request of the State Board of Education. Additionally, a concurrent committee of the Department of Education Curriculum Supervisors (principals) was also formed. These two groups developed "independently" and "made the joint recommendation" for the :

> ... elimination of the computer education unit requirement for high school graduation. With advancing technology, most students are computer literate by the time they reach the ninth grade. Computers are being utilized as instructional tools across the curriculum and hence there no longer exists a need for a specific unit requirement in this area. The fact that many school districts have requested approval of (a) junior high school courses or (b) successful completion of a computer literacy test supports this recommendation (Barrett, 1989, p. 6).

Extensive public hearings were held throughout the state. In addition to the deletion of the computer competency requirement, the study recommended the deletion of the arts and economics requirements (1 semester each). There were recommendations made to increase the number of periods in a day, and a few other minor recommendations as well. There was virtually no public support for the recommendations except by school district officials who felt that money needed to be saved somewhere. There was a considerable opposition to the removal of any of the courses specified in the recommendations (Bourgeois, 1990; Hogan, 1990; Keene Sentinel, 1990).

2.4.5 Reaffirmation

The Barrett Committee recommendations to delete the computer competency requirements was officially and specifically rejected on May 23rd, 1990 at a meeting of the State Board of Education, and, as a result, the existing requirements will remain unchanged until at least 1995 (Bourgeois, 1990c).

Any desire to reduce the computer competency requirements in the state were further rebuffed in December, 1990. The New Hampshire Governor's task force on education (NH Governor, 1990) reaffirmed the requirements for computer competency and established a performance outcome requirement (NH GOVERNOR, 1990, enclosure, p. 11). The relevant section of that report is contained in Appendix A. In effect in the state of New Hampshire any debate about the definition or desirability of computer competency courses in New Hampshire is purely academic. The governor of the state has confirmed the State Board of Education's definition and programs in this area.

Appendix B documents the specific requirements of the State of New Hampshire. It is extracted from the New Hampshire high school accreditation requirements. In addition to the material to be covered, it provides guidance for class time to be spent upon each subject area. The tripartite subject breakdown will be seen in the NAEP assessment as well. Suggested class activities were provided in the original document, but not included in Appendix B.

CHAPTER 3.

PROCEDURES

3.1 General description of the study

This study sampled New Hampshire students at a sample of high schools throughout the state. These students were administered the NAEP Computer Competency Assessment as well as additional demographic questions relevant to the study. The secured release of the NAEP examinations was obtained (Askew, 1990) for this purpose.

An understanding of the procedures first requires an understanding of the basic instrument, the NAEP 1985-1986 assessment. That section is followed by a description of the basis of selection of the schools which participated in this study. Next, the mechanism for selection of a student for this study is discussed. Finally, a description of the actual assessment technique for a selected student in a selected school is provided.

3.2 Computers uses.

Two types of computers and two different types of computer software were utilized for this study. The public data tape (NAEP, 1989b) received from NAEP was loaded into a Digital Equipment Corporation (DEC) VAX computer. The file was reduced to a micro-computer size and removed from the VAX. The important computer data analysis and storage was done on a stand-alone IBM clone personal computer.

3.3 Software utilized

Three basic types of commercially available software were utilized in this study operating systems, statistical packages and languages. This section discusses those systems to the extent that they could have affected this study's results.

3.3.1 Operating systems

Two operating systems were utilized, the DEC VAX VMS operating system and COMPAQ DOS 3.31. Standard VAX utilities were used to load and reformat the NAEP data tapes. No advanced, new or experimental portions of the system were utilized. There are no known errors in the operating system which would have affected the languages or packages utilized in this study.

3.3.2 Standard software

The actual statistical analysis utilized two commercially available statistical packages. Commercial packages were utilized to minimize the probability of analysis error. Statistics were normally worked on both systems, with only one output selected for presentation. These packages were:

- EXECUSTAT (Strategy Plus, 1991). Execustat was utilized extensively for its excellent logging capability and its superior graphing characteristics.

- MINITAB (MINITAB, 1989).

  MINITAB was utilized due to its length of service and excellent reputation.

Many of the tables and figures of this report were duplicated with the automated logging facilities of these two packages. PCX programs from Genus Software (Genus, 1990) were utilized to import graphics. QUATTRO PRO from Borland Software was utilized to prepare some tables and graphs. Microsoft WORD was utilized to process this study.

3.3.3 Unique programs

The study author developed many programs to manipulate the data received from NAEP and the study results. The author currently teaches computer science at Keene State College. He has over 25 years experience in writing computer programs. Listings of all programs are available from the study author.

Over 50 programs were written for the personal computer for this study. All were written exclusively by the study author. All programs were written in PASCAL utilizing Borland Software's Turbo Pascal, Version 6.0 (Borland, 1991). These programs simply allowed faster data entry, more sophisticated editing, and a display on a formatted screen. The tests were hand entered into the computer. Scanners were not utilized for reasons of convenience. Extensive checking was conducted to insure input was correct.

3.3.4 Computerized scoring programs

Only the actual grading program and files are truly unique and critical to the correctness of the study. The process utilized to check this program is described in the next section. Several variations of this program were utilized to experiment with different weighting and averaging techniques. The result of this program is a text file with a line for each of the 168 students; with a cognitive score, test version, and all demographic questions. Special programs were written to load the file produced by the grading program, and create a separate, compatible file for MINITAB or EXECUSTAT analysis. Many versions of these programs were utilized to provide different sub-sets of the basic data files as needed.

3.4 NAEP Computer competency assessment

This section has two purposes: (1) To demonstrate that the NAEP assessment is really a valid instrument to utilize in New Hampshire as a general procedure and, (2) To demonstrate that this study utilized the NAEP material properly. The details are provided in this chapter rather than the literature review chapter, since at this stage, interest is directed to procedures, data collection details, and analysis mechanisms required.

3.4.1 NAEP assessment appropriateness

The first relevant question is whether the NAEP instrument actually measures what New Hampshire requires of its students. Phrased another way, is it an appropriate examination or assessment of what New Hampshire wishes to teach? The question of whether or not the NAEP study actually measures what it says it does is beyond the scope of this study. But if it does, and it approximately matches what New Hampshire wishes to teach, then it can be utilized to determine if the students are actually learning the material.

Appendix A and B provide a description of the state mandates. Carter (1988) provides even more detailed sample curricula from a curriculum committee of the New Hampshire Department of Education. An examination of the broad cognitive divisions of the NAEP assessment instrument is contained in Figure C.1. Table D.1 lists the sections and scores utilized by NAEP and the corresponding sections of the New Hampshire mandate.

The distribution of questions is illustrated in Table C.2. A more detailed analysis would entail an examination of the 124 cognitive questions versus the elements of the New Hampshire mandate. Such a public comparison is difficult due to the secured nature of the NAEP scores. A general summary would be that the NAEP examination puts more emphasis on programming (46% of questions) than the state time allocations (29% of time allocation recommended). However, Carter (1988) indicated that over half of the computer science teachers felt more programming was necessary in any event.

An examination of the individual questions indicates that all questions asked were within the bounds of the New Hampshire mandate. All areas addressed by the New Hampshire mandate had at least some questions, even such areas as ethics and history. Thus, there are no questions on the

NAEP examination which would be considered "unfair" under the state mandate. To preserve the comparability of results between NAEP and this study, the entire range of questions were asked, and graded utilizing NAEP's answer sheets. Any other mechanism would not permit a valid comparison of New Hampshire to the Nation.

The general NAEP assessment is conducted every other year. NAEP tests some subjects each year, such as reading and mathematics. All subjects are not tested with each general assessment. In particular, computer competency was tested only once, in 1986.

NAEP tests third, seventh and eleventh grade students. The juniors were tested in the spring of their eleventh grade year. This study tested seniors in the fall of their senior year, nominally one semester later than the national sample. It is an assumption of the study that this one semester difference in student ages will not significantly affect the accuracy of the study. Numerous discussions with NAEP indicate that this is not a bad assumption based upon NAEP and ETS testing in other areas (Ashley, 1990).

3.4.2 Relevance of a 1986 survey to today

In the spring of 1986, NAEP conducted an examination to determine computer competence for each of the three grade levels. Only the eleventh grade computer competency portion of the NAEP assessment was utilized by this study.

The objectives of the test, its validations procedures, and 80 participants in its development are documented (NAEP, 1986g). While it might be desirable to have a more recent nationwide survey, as documented in the literature review such a survey does not exist, nor is one planned. This survey is simply the only one available.

It is also worth noting that the 1986 NAEP survey is not as outdated as might be supposed at first thought. The computer mandate in New Hampshire has not changed since its inception in 1984. The graduating class of 1988 was the last class which could have had the computer competency course waived in any district. The transition perturbations should have been completed by this year. The NAEP survey was actually conducted when many of the student subjects of this study were receiving their first (31 of 156) or last (15 of 156) computer classes (Appendix F, NHDQ, Questions 56 and 46 respectfully).

A five year difference between 1978 and 1984 would be significant due to the microcomputer revolution. However, between 1986 and 1991, the types of computer, operating systems, general software packages, communications and storage capabilities have not really changed significantly (Yoder, 1991). Education is still dominated by microcomputers, Apple II, Macintosh or IBM PC (or its clones).

3.4.3 Computer competency assessment composition

The NAEP assessment is actually six different examinations, contained in a secured release document. Each test consists of between twenty and thirty questions taken from a bank of 124 cognitive questions. Cognitive questions are not repeated on each test. The tests have not been scaled or otherwise adjusted. Appendix C contains a description of the cognitive portion of the examination, as well as some sample questions.

In addition to the cognitive portion of the test, a group of 75 demographic questions is contained in the six different tests. Some, but not all, of these questions are repeated in the different booklets. The questions themselves are contained in a NAEP "secured release", and cannot be reproduced in this study. Researchers desiring to obtain copies of the questions can request them from NAEP and upon completion of non-disclosure forms, the questions can be obtained.

A test booklet contains between twenty-six and forty-four questions. They were designed to take 11 minutes each by ETS. In the original NAEP assessment, a student was given a background booklet, and one of 76 different booklets, which contained 3 subject area assessments. Thus one student could receive no computer competency assessments, or one, two or three computer competency assessments. Since one student could receive two or three tests, depending on his 'draw', it could not be said that the results of each test were independent of each other. Further bars to independence were the over-sampling of various ethnic and socioeconomic groups (Beaton, 1988).

Martinez (1988) contains a public description of this examination. Beaton (1988) contains the analysis. The public release tapes and code books also contain a shorthand version of the questions and the correct answers (NAEP 1989a, 1989b & 1989c).

Appendix C contains sample questions taken from Martinez, and a content analysis of these assessment. The secured release of the test can be obtained through NAEP. Martinez contains some, but not many, additional questions.

3.4.4 NAEP sample sizes and raw data

The purpose of this section is to justify the use of Z-TEST type statistical procedures in this study. The large sample size of NAEP essentially allow its results to be considered those of the entire population.

The NAEP 1985-1986 nation wide sample contained 35,000 students. 10,094 students were located who took one or more computer competency assessments. In general, each of the 124 cognitive questions had approximately 2400 responses. The response totals are published by NAEP (1989b).

These totals were utilized to check the counting and scoring programs utilized by this study to count and score the study data.

3.4.5 NAEP grading

The purpose of this section is to demonstrate the NAEP method of grading, and to document the testing of the grading systems and programs utilized by this study.

NAEP utilized a question grading method to determine the outcome of its assessment, where the total correct answers for each question were divided by the total attempts and omitted answers. Questions not reached were not included. Then an average of the average correct responses for the 124 valid questions was calculated.

This study obtained a data tape from NAEP (1989c). Programs were written to calculate the average utilizing NAEP's methodology. They correctly duplicated NAEP's average. A second program was written to determine the average in a more conventional manner, of averaging each participants grades. The answer was identical. Some of the results of the NAEP assessments are presented in Appendix D.

3.4.6 NAEP variances

No real attempt was made to recompute the NAEP variance. Their value of plus or minus 0.6% was simply noted as the population variance. When a subgroup comparison was utilized, appropriate NAEP variances were utilized as published.

The NAEP sample did not utilize independent testing on its questions (i.e. a single student could receive one, two or three booklets), and as a result the tests were not independent. NAEP documentation provides some guidance on the mechanics of conducting this variance calculation, and the tapes provide the 36 weights needed on each of the 10,094 records (Beaton, 1988 p. 273-291).

3.4.7 NAEP comparisons

Several comparisons are made directly with the National sample. When this is done, a 'Z-test' was utilized. That requires only one variance (really the standard error of the mean), namely that of the NAEP population. Only the average scores of the New Hampshire sample were utilized. As shown, that average could be calculated using either student averages or average of the correct response average for each question, since the answers are mathematically identical.

3.5 Study assessment description

This section documents the actual composition of the assessments used in this study. The total assessment used in this study consists of two distinct parts:

- A cognitive portion or test, which was designed by NAEP, and graded using their standards to obtain a computer competency score or grade.
- A demographic portion which was designed for this study in New Hampshire (NHDQ).

The actual contents of the NAEP portion of this assessment has been discussed in previous sections, along with the means used by NAEP to grade their survey. The following sections discuss the grading used in this study, which is different than the NAEP methods.

3.5.1 New Hampshire computer competence score

When the term scores is used in this study without other modifiers, it refers to the average of all of the students' average scores on the cognitive portions of their test booklets.

The following chapter shows the results of computing the average score of the cognitive portions of the study assessment using different averaging techniques. There was less than one-tenth of one percent overall difference in the scores using the different techniques.

3.5.2 Score weighting

NAEP weighted their samples according to a formula based upon the reciprocal of the probability of a student being selected. Essentially, a weight was determined by assigning each student a weight based upon the reciprocal of the probability of selection for each of several dependent variables. The weight was then trimmed, adjusted for "no-shows" and several other factors. The secured release tape user guide describes these procedures in detail (NAEP, 1989a). Telephone discussions with the some of the study authors (Norma Norris, 1991), and a visit with the director of Research (Johnson, 1990) provided guidance on the weighting which should be utilized in studies of this type. This weighting would include the product of three factors:

- The fraction of a selected school tested (i.e. total Keene high school senior enrollment divided by number of seniors assessed at Keene high school).
- The fraction of a sub-group that each school represents (i.e. total large school enrollment divided by Keene high school enrollment).

- The fraction of the total school system enrollment each sub-group represents (i.e. total state enrollment divided total large school enrollment).

The average scores were calculated utilizing both non-weighted and weighed techniques. Questions were further graded utilizing the NAEP method of weighting plus averaging the average of the correct questions rather than the more traditional averaging of the weighted average student grades. The results of these three methods are presented in Table 3.1

Unless otherwise indicated, unweighted scores are utilized in this study. The justification is that when both weighted and unweighted scores are used in comparisons to the national average, the resulting conclusions do not change. The state is remarkably uniform with respect to computer competency, with only small variation in scores between schools. The use of the more traditional average of the average student grade is utilized.

3.5.3 New Hampshire Demographic Questions (NHDQ)

A separate survey of demographic questions was developed for this survey. Originally, thirty-five questions were contained on this survey. An additional five questions were added for later groups.

These questions had several basic goals:

- Determine the mechanism each student utilized to satisfy the New Hampshire computer competency requirement.

- Determine the degree of computer integration into other non-computer courses.
- Determine the students feelings on the usage of computers by themselves, teachers and administrators throughout the school.
- Repeat some questions from an attitude survey for future analysis of the relationship between attitude and cognitive abilities (Kay, 1990).

A complete list of the New Hampshire demographic section is contained in Appendix F. This Appendix also contains the tabulation of responses for each answer, and symbols indicating the statistical significance of each item.

The NHDQ repeated some NAEP demographic questions which appeared to be significant to insure a large, consistent sample. The NHDQ questions are referred to throughout the study by question number. The notation is either NHDQ-x or Q-x, where x equals the question number in the NHDQ, from 45 to 80. Both are interchangeable. MINITAB and EXECUSTAT generally use the shorter 'Q' notation. The test generally uses the longer NHDQ notation. For example NHDQ-52 and Q-52 refer to the identical question, the sex of the student.

Responses to the 75 NAEP demographic questions are presented as needed, but due to their secured nature, the complete set of questions cannot be presented in this study. Furthermore, the demographic questions were scattered throughout all 6 test booklets, so that the sample size is smaller than with the NHDQ. Essentially, a NAEP demographic question will have a sample size one-sixth the size of a

NHDQ question. Thus the sample size is larger whenever the NHDQ can be used. NAEP demographic questions are referred to by their position in a secured listing of demographic questions (1-75), such as NAEP-1 or NAEP-56. Such a notation does not refer to a specific booklet or question number within that booklet. It does not refer to the position in a separate list of cognitive questions (1-125).

3.6 Non-Parametric statistics

The demographic data connected with NAEP average competency scores provide the basis for numerous comparisons. When comparisons are made to NAEP, a Z-TEST was utilized as previously noted. This section documents the procedures utilized when comparing one New Hampshire group to another New Hampshire group. Under those circumstances, neither the NAEP variance nor a standard statistical variance calculated by a statistical program can be used with confidence.

Enough warnings were contained in the NAEP documents that statistical packages did not correctly compute the variance on its process, so that this study decided to avoid use of any statistics that required the use of a variance (NAEP, 1988a, p. 163). Under the assumptions of a Z-test, the only variance needed is that of the correctly calculated NAEP data, and that was assumed to be correctly calculated.

A knowledge of variance is not needed for non-parametric statistics. Therefore, it was decided to avoid the problems that current statistical packages have with variance. Non-parametric statistics, in general, are not as powerful as parametric statistics at detecting small differences. Thus small differences could be missed. That is also an advantage. If significant differences are found with non-parametric means, they will still be significant if more powerful tests are used.

The Kruskal-Wallis test is utilized as an alternative to the usual one way analysis of variance. It will detect a distribution free, significant difference in one or more of many sub-classes of students. The Mood median tests the number of observations above and below the overall median, and uses a Chi-squared test for association, and an Hettmansperger non-linear calculation for confidence limits for each response (MINITAB, 1989, p. 10-4, 10-8, 11-11). Pearsons product moment coefficient, which uses actual data values (a parametric test), and Spearman's rank correlation, which uses the ranks of outcomes, rather than the data itself, are also used (MINITAB, 1989, p. 6-10, EXECUSTAT, 1989, p. 9-3 - 9-5). When these two procedures are used, a pairwise elimination for rows with missing data are used.

Some tests are done to show that the average scores obtained by this study are in fact normally distributed. These were done to illustrate that students' scores rather than question scores, are well behaved, and mean approximately what most readers of this study would expect of such average scores. All findings of this study do not require scores to be normally distributed.

3.7 Sample school selection

There are several possible methods to select the sample of the high schools for the study. This section first discusses the side issues of including schools utilizing different procedures to satisfy the state computer competency mandate, and the inclusion of private schools. The main sample selection is then discussed. The basic selection possibilities considered include the curriculum taught, a balanced geographic sample based upon either area or community size, and finally, school enrollment size.

3.7.1 High school and junior high schools

Whichever method is utilized, it was a study goal to test the effect of local school policy differences. A significant difference is whether a school system chooses to use the primary method of compliance, a high school computer course, or the alternative of using the substitute junior high school course. No state figures were available on the number of students in each category. Approximately one-third of the sample completed their requirements via the alternative junior high school course (Appendix F, Question 55).

3.7.2 Public and private schools

One private nondenominational school and one private parochial school were tested. Private schools were included in the NAEP survey, and to maintain comparability, should be included in this survey. Additionally, one sub-group to be examined is public vs private schools, since this has been previously identified as a discriminator on a national basis.

To compare public and private schools realistically, it was decided to select participants from the larger, better financed private schools. There are only thirteen private high schools (grades 9-12) with over 250 students in this state, of which seven are parochial. One school from each group was selected by random drawing. Each turned out to be schools with academically high admission policies favoring high achievement students.

The study estimates that 52,567 high school students are enrolled in the 43 accredited high schools in the state. The figures reported (NHSDE, 1990) for private schools are a combined K-12 total. Linear interpolation was utilized to estimate the total for grades 9-12.

<u>3.7.3 Curriculum</u>

Rubega conducted a state-wide sample to determine if the schools actually taught the material mandated by the state. "Regardless of size or region, most schools address all the computer literacy objectives recommended by the state ..." [Rubega, 1989, pg 33). This mandate is described in Appendix A and Appendix B. This implies some similarity in course content.

Carter (1988) indicates that there are still some differences in the manner in which schools across the state implement the policy, or how well they feel they achieve the desired goals. Individual schools in this state do vary, since each town or school district is essentially an independent entity. This variance is normally a difference in intensity, emphasis or interpretation.

Such differences are normal and within the scope of academic freedom. The purpose of this study was to determine state averages including the effect of different curricula; and a method more appropriate to a state-wide analysis utilized, namely a selection based upon school enrollments, Rubega (1988), indicates that size is significant. Comparison of the different sub-models throughout the state is a reasonable goal for future analysis, but that is a different study.

<u>3.7.4 Geographic considerations</u>

The ten schools sampled covered the southern tier of the state, from the Connecticut river in the west, to the Atlantic ocean in the east, and from the Massachusetts border in the south, to line from Hanover in the north-west, through Concord in the central portion of the state, and down to Exeter near the Atlantic ocean in the south-east. The western portion of the sample is essentially rural, and Concord, Nashua and Exeter are in the densely populated, industrialized area of the state. Specifically, they cover three of the five regions covered in Rubega's (1989) study which is discussed in the following section.

Five other schools invited to participate in this study would have expanded the geographic area examined somewhat, but did not participate for various reasons. Two schools invited to participate declined the invitation. Three other schools could not schedule the assessment within the study time frame.

3.7.4.1 State description

The total population of New Hampshire is slightly over one million. It is concentrated into an area known as the "Golden Triangle". This is essentially the area from Nashua in the south central portion of the state, north to Concord, approximately halfway up the state, then south-east to the small Atlantic coastline. The majority of New Hampshire industry is also there. It also acts a bedroom community to the Boston area. Five of the ten schools tested were in this industrialized and high population area.

The south-western portion of the state is basically a region of small rural towns, with typical populations of 10,000-25,000. School sizes vary considerably depending upon whether several town formed a school district with a common high school. Five of the ten schools tested were from this region, including the only school of over 1000 students.

The north central portion of the state is primarily lakes, with town sizes similar to the western portions of the state, and little grouping in the districts due to the lake separations. The northern portions of the state are very sparsely populated, either mountainous or cold flatlands of the Saint Lawrence River. No schools were tested from the lakes or northern regions.

3.7.4.2 Resource allocation

The geographic area of the this study is confined to the southern portion of the state. This limited geography can be justified through consideration of other studies that have been conducted within the state, as well as the demographics of the state. This section first discusses the state geography, the geography sampled, the curriculum and geographic sampling methodologies rejected, and finally, the school size methodology utilized.

3.7.4.3 Uniformity of instruction

Rubega specifically tested the hypothesis that differences existed in resources between different geographic areas of the state or of different sized schools. She concludes:

> "Results also show that there is no significant difference among [the high school] computer programs when schools are categorized according to geographic region. Measurements were made in the following: cost per pupil, cost per course, number of courses offered, percent of population involved in computer science and the ratio of students to computers" (Rubega, 1989, pg 33).

3.7.4.4 Effects of community size

A second geographic possibility is to consider the difference between large and small population areas. Actually, in New Hampshire, it is a comparison between small and smaller communities. The NAEP data indicates no significant difference in the types of population areas found throughout the state of New Hampshire. Appendix D, Table D.3 in particular, contains the NAEP results based upon population.

3.7.4.5 Rejection of a geographic based sample

Taken together, the similarity of resources and NAEP scores do not indicate that any differences should be expected across the geographic differences found throughout the state. The final sample contained schools from the rural western portions of the state, and the industrialized eastern portion of the state, but not the northern portions of the state.

3.7.5 School size

It is also possible to balance the school selection based upon enrollment. Previous studies have found differences in computer competency or resources based upon school size.

Rubega did find differences in resource expenditures when schools across the state are compared by enrollment rather than geographic location. She concluded:

> Results show that there is a significant difference among computer programs when schools are categorized by size. These differences are: Small schools spend more per pupil for computer science. This decreases as school size increases. Small schools offer fewer computer courses, this increases as school size increases. Small schools have a larger percentage of the total population enrolled in courses. No significant difference occurs in the amount schools spend per course and the ratio of students to computers (Rubega, 1989, p. 33).

NAEP did not report specifically on school size. However, based upon the findings of Rubega, it was decided to sample the state based primarily upon a school size distribution, rather than geographic distribution. If differences in competency outcome were to be found, they most likely would be found in schools of different sizes, no matter where they were found geographically.

<u>3.7.6 Sample selection</u>

The final sample was based upon school size. The state basically breaks high schools down into five size groups (NHSDE, 1991). This study collapsed the three smallest groups into a single small group, and retained the same state groupings for medium and large schools. A summary of this breakdown, along with enrollments and percentages, is contained in Table 3.1

Table 3.1
Enrollment of New Hampshire high schools

	Enrollment	Number Schools	Total Pupils	Total%
Public				
Small	0 - 500	43	12,098	23%
Medium	501 -1000	18	12,424	26%
Large	1001 -	15	22,575	47%
Total		76	47,097	100%
Private *		18	5,277**	100%
	Private % of Totals Enrollment			10%

* with > 150 students grades K-12 or only grades 9-12 available.

** Linear estimation of grades 9-12 for K-12 schools.

(NHSDE, 1991)

The total enrollment of the sampled schools compared to the state population of schools is contained in Table 3.2.

Table 3.2
Enrollment of Sample Schools

Size		Schools Tested	Pupils Enrolled	Percent of State
Small	0 - 500	3	934	8%
Medium	501 -1000	2	2,141	17%
Large	1001 -	3	3,753	17%
Public		8	6,828	14%
Private		2	1,010	19%
Total		10	7,838	15%

The private schools have been slightly over sampled, but not greatly. The smaller three school sizes have been slightly under sampled, but cumulatively, the lowest three sized schools represent only 25% of the total state student population. One compensation is that the percentage of the seniors sampled in the smaller schools is large.

Table 3.3
Seniors assessed at sample schools

Size		Senior Enrolled	Seniors Tested	Percent of School
Small	0 - 200	494	65	13.1%
Medium	501 -1000	612	73	11.9%
Large	1001 -	1064	30	2.8%
Total		2000	168	8.4%
		Boys	95	
		Girls	68	
		Unknown	5	

3.8 Selection of students within a school

Each school participating in the examination selected students in their own manner. Five schools utilized random numbers and contacted students for the assessments. Two schools utilized non-tracked courses normally meeting at the assessment time. One school utilized 3 different study periods meeting at the assessment time. Two smaller schools simply attempted to use the entire senior class. Approximately one-half of the selected students actually appeared at the assessment room and time. No corrections have been made in this study for no-shows.

The voluntary nature of this assessment could have affected the outcome. At each school, the school officials were queried on their feeling for the appropriateness of the sample. All felt that the students that actually took the assessment were a representative sample. It is an assumption of the study that the sample actually is reasonably representative of the state as a whole.

3.9 Assessment procedures

The selection of the student sample is discussed in the next section. This section discusses selection of students within a school, and the mechanics of administering and grading the assessment.

3.9.1 Assessment duration

The assessment was administered during a single high school period. There are two basic period formats in New Hampshire, a seven period day and an eight period day. The latter has shorter periods. Students in schools with a seven period format had no difficulty in completing the assessment. Students tested during the shorter periods were often rushed in completing the demographic questions.

3.9.2 Answer sheet

A standard computerized answer sheet was utilized (General Purpose NCS answer Sheet). It consisted of an identification section, and 120 questions, each with ten answers, labeled 0-9 and A-J. All identification was left blank. Each sheet was pre-coded with a random number from a theater type ticket, and the test version (1-6) and serial number (1-42).

The answer sheets caused some problems in the New Hampshire Demographic section. The students did not seem to have any problem skipping the first column. In the New Hampshire section, the number 0 was sometimes utilized to allow all 10 choices. Examination of several questions where '0' was not coded, such as sex and school grade indicated that some students marked '0' for '1' and '1' for '2'. Answers that were not within the legal ranges were treated as blank answers.

3.9.3 Test envelope

Each student was given an envelope containing:

- A consent form (Appendix E).
- A computerized answer sheet. Pre-coded with random number and test booklet code.
- One blank sheet of paper for essay questions.
- An instruction sheet.
- A theater-type ticket with students random number for them to retain.
- One NAEP computer competency booklet.
- One New Hampshire demographic question booklet.
- A pencil.

These envelopes were shuffled prior to the students arrival. As students arrived at each school, they drew an envelope. The number of each type of NAEP booklet at any particular location was a random event. No two schools had the same test booklet distribution. While individual schools should not be compared, a valid state sample was obtained.

3.9.4 Preliminary directions and consent form

The general purpose of the test was explained. Students were asked to participate, and the voluntary nature of the test was explained. If they desired to participate, they were requested to sign the consent form. Directions were briefly given, and the students took the test. While they were taking the examination, the consent forms were collected and placed into a separate envelope. The class was queried to identify any students who were not seniors, and insure that their tests were not included in this sample. This process usually consumed 5 minutes.

3.9.5 Examination

The first students were usually finished with the assessment in approximately 20 minutes from the start of the examination. The last student usually finished in 40 minutes. Few students did not finish at all.

At the completion of the test, the student kept the theater ticket, and put all material into the envelope. All answers were put onto the computerized answer sheets except essay questions. The essay questions were answered on a separate piece of paper. This additional paper was placed into the envelope along with the answer sheet.

3.9.6 Post Examination

The envelopes were opened, answer sheets removed, and newly coded sheets and tickets were placed into the envelopes to allow reuse of the test materials. All answers were entered by hand into a computer utilizing a special data entry program developed for this study. Throughout the entire process, the examinations were handled only by the study author. The school officials did not participate in the actual testing portion of the assessment. They were notified of their individual scores, and kept abreast of the study findings.

3.9.7 Answer sheets.

In the NAEP assessment the answers were written directly into the test booklet, and machine scored from special scanners. ETS statisticians were queried, and indicated that they had data that indicated that, at the twelfth grade, the use of a computerized answer sheet would be a source of minimal error (Johnson, 1990). This study utilized standard computer answer sheets. It is an assumption of the study that this difference did not materially affect the results of the assessments.

3.9.8 Creation of computer file

Two data files were obtained from NAEP with the questions and their categories. A third file was created with the correct answers for each of the questions. The answers were taken from the Public Data Tape users manual (NAEP, 1989a). These answer file and question categories were electronically merged into a cognitive question file, which contained the correct answers, as well as the question description and category.

3.9.9 Correction procedures

A scoring program was written for this study, utilizing the answer file developed. To check the correctness of the scoring mechanism, of both the scoring subroutine and the answer file, a procedure was written to load the answer file and grade an examination. Another program was written to utilize this procedure to grade the known NAEP survey data. The scores obtained were identical to the scores published in the data tape user manual (NAEP, 1989a) and the management survey (Martinez, 1988). The same grading subroutine was copied into the other programs utilized in this study.

As an additional check, a sample of 20 study assessments were hand corrected and compared to the computer program results. The results were identical in all 20 assessments.

3.10 Data preparation for analysis

Several programs were written to output the scores and demographic data in several ways, for the two statistical packages, MINITAB and EXECUSTAT and the spreadsheet QUATTRO. The two statistical packages were utilized for output. The spreadsheet was utilized to print results in a formatted manner for return to the participating schools. Special programs were written as needed to convert or select data as needed for the statistical packages.

Non-parametric statistics were utilized for all important conclusions in order to eliminate any errors which could be caused by incorrectly calculating the variance.

3.11 Security

There are three types of security issues in this study, protection of student identities, protection for the schools participating in the assessment and protection of the secured release examination.

3.11.1 Student identification security

Each examination was pre-coded prior to giving it to the student. The student number was a number drawn from a pool of numbered theater tickets. A second number was used to indicate the examination type (1-6), and the serial number of the particular copy of the examination utilized with that answer sheet (1-42).

There were no names on the examination. The theater ticket was placed in the envelope along with the answer sheet. The student was instructed to keep the ticket to locate his score when it was returned to the school. Informed consent statements were collected separately from the examination to prevent their being associated with a particular examination. There have never been lists correlating individual tests with names. This procedure was explained to both the schools and students at the beginning of the assessment.

3.11.2 Participating school security

This study objective was to assess the average competence of the state as a whole, not to compare one school to another. Schools participated upon the basis that while they would receive their score for their own internal use, they would not receive other schools' scores. Individual school scores are not published. Each school has been made aware of these restrictions.

Several study procedures actually invalidate school comparisons. These include:

- A random draw of test booklets by students. Each school did not have the same mix of test booklets. There are statistical differences in the average scores of the various test booklets.
- The student selection mechanism differed at each school. This would not affect state-wide assessment, but does preclude valid school to school comparisons.

3.11.3 Assessment instrument security

The secured release request stipulated that the secured information in the assessment remain in the sole possession of the study author. The study is to remain locked while not in the immediate possession of the study author. While others may examine the material, no copies, notes or written records are permitted. These requirements have been followed.

The code books, tape layouts and secured documentation have not left the possession of the study author, and are kept in a locked filing cabinets at his home or office. They were not transported to the school sites.

The assessment instruments were transported to the participating schools on the day of the assessment by the study author. The assessment was supervised by the study author. The assessments were removed from the school by the study author.

All secured material was serialized. Counts of the material were made before and after each assessment. All tests were accounted for.

CHAPTER 4.

PRESENTATION AND ANALYSIS OF DATA

4.1 Analytical goals and objectives

This study has five major objectives which are enumerated below:

1. Locate significant differences among types of school throughout the state, if any.

2. Compare the state of New Hampshire schools to the nation as a whole.

3. Identify differences, if any, in computer competency outcome attributable to different local school policies.

4. Discover discriminators, if any, which are attributable to student demographics or curriculum choices.

5. Discover demographic characteristics which have been identified in the research literature, but do not make a significant difference in New Hampshire at this time.

These items form the basis for the major research questions in this chapter, whose numbers correspond to this sequence. Prior to addressing these questions directly, a basic understanding of the characteristics of the raw computer competency scores is presented. This computer competency score is used as the yardstick by which the various demographic factors are correlated.

Unless otherwise noted, all statistical tests use a two tailed, 95% confidence level significance criteria. This level was selected due to its prevalence in educational and psychological scenarios. A two tailed analysis was utilized since it is more stringent than a single tail evaluation (Pillemer, 1991, p. 16). It should be noted that the use of a 99% confidence level would not significantly change the outcomes, conclusions or recommendations of this study. Correlations obtained high.

4.2 Question 0: Sample characteristics

This section deals with a description of the computer competency scores. It does not correspond to one of the study objectives. A knowledge of the scores is necessary to address the desired questions. Hence, it is question number 0. Table 4.1 contains the traditional, unweighted statistical description of the cognitive scores of the 168 students sampled.

As referenced in Chapter 3, the weighted scores are virtually identical to the unweighted scores. The weighted student average and the NAEP weighted question average should be identical, and indeed, when computed, they were. Most of the statistical packages available to researchers, particularly at the K-12 level, have difficulty with weighted averages. To assist future users in comparisons with this study, unweighted data is presented. Weighted averages were computed as checks, but they never changed the results obtained using unweighted averages.

Table 4.1
Summary of computer competency scores

	Score
Sample size	168
Mean	52.3635
Median	52.38
Mode	61.9
Geometric mean	49.2671
Variance	292.806
Std. deviation	17.1116
Coeff. of variation	32.6784
Std. error	1.32019
Minimum	14.29
Maximum	100
Range	85.71
Lower quartile	41.18
Upper quartile	62.5
Interquartile range	21.32

Average scores using different techniques

Non-Weighted student average = 52.38
Weighted student average = 52.30

NAEP weighted question average = 52.30

National Results

NAEP weighted Question Average = 46.2 ± 0.4

4.2.1 Question 0a: Normality of scores

One implication of the Central Limit theorem is that the distribution of average scores for individuals will be normally distributed. This theorem should apply to a student's overall average on his/her test, even if the scores of individual tests are different. Many statistical tests assume a normal distribution. While this study normally uses non-parametric statistics, it is of some interest to know if their use is an absolute necessity. This forms the basis of the following hypothesis:

> Hypothesis: The distribution of the average cognitive score represents a random sample of data from a normal distribution with a mean of 52.36 and a standard error of 1.32.

> Null Hypothesis: The distribution of the average cognitive score does not represent a random sample of data from a normal distribution with a mean of 52.36 and a standard error of 1.32.

Several standard statistical tests were performed. The results are illustrated in Table 4.1 below. Since all probabilities are greater than 0.05, the null hypothesis that the scores were not drawn from a distribution other than a normal distribution is accepted. In more positive terms, the hypothesis that the data represents a random sample from a normal distribution is accepted.

Table 4.2
Test for average score normality

Computed Shapiro-Wilk's W statistic	= 0.979298
P value	= 0.3326
Standardized skewness	= 0.853494
P value	= 0.3934

To visually illustrate the distribution of scores, a distribution of average scores obtained in this study was constructed utilizing a histogram, with a normal curve whose mean and variance was estimated utilizing the sample data. The results are in Figure 4.1

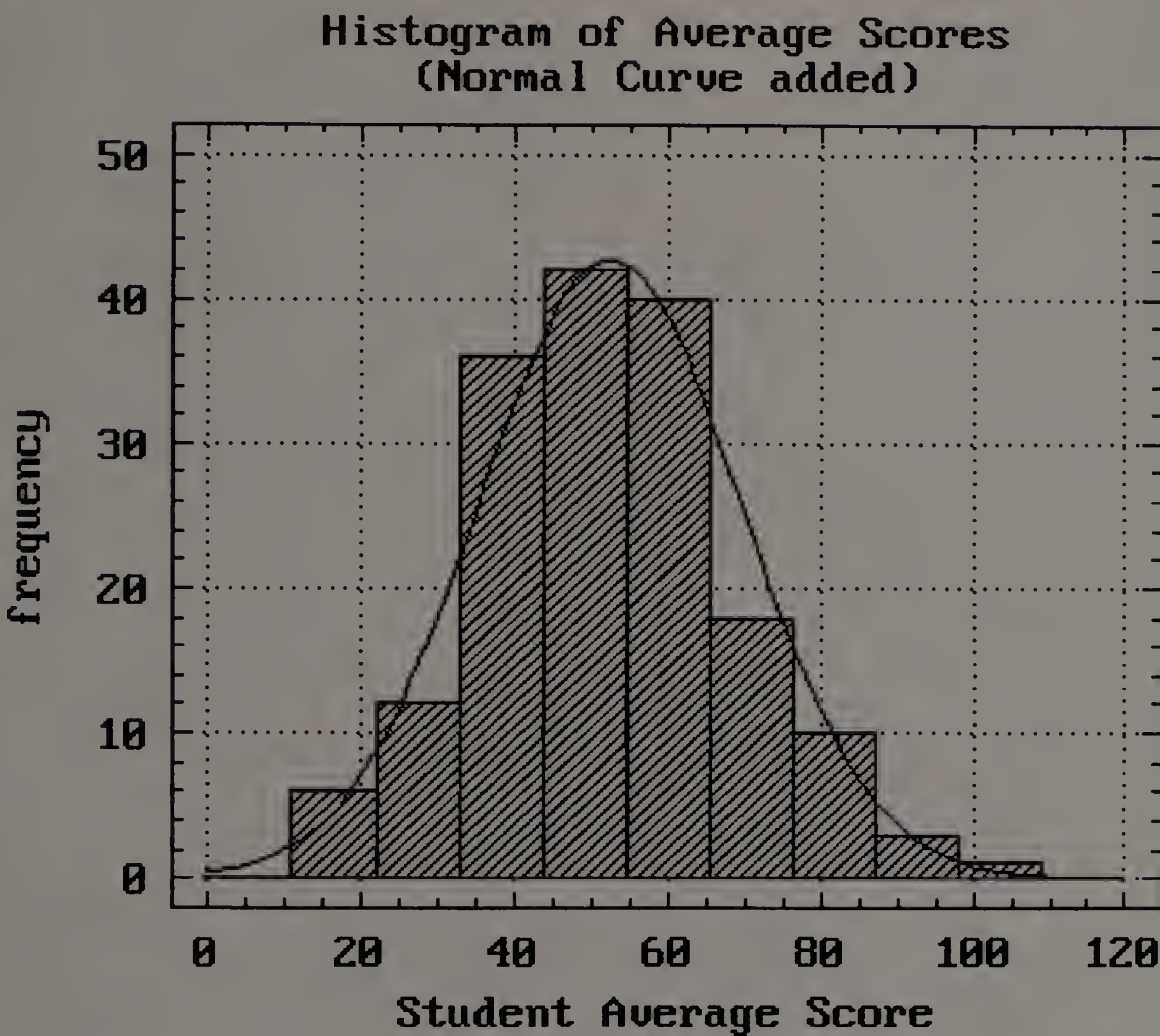


Figure 4.1
Histogram of average competency scores

4.2.2 Question 0b: Test booklet number differences

The NAEP examination consists of six different examinations with totally different cognitive questions. At each school, the students were uniformly and randomly assigned a booklet from this set of books. Thus each school did have a different mix of test booklets. The question then becomes, was the version of the test itself a discriminator for the score? If the test books used were a discriminator, then schools should not be compared that did not have a similar distribution of test books. The analysis utilizing both a parametric analysis of variance and a non-parametric Kruskal-Wallis yielded the same results.

Table 4.3 indicates that there is a variance in both the means (Analysis of Variance P = 0.0005) and the analysis of medians (Kruskal-Wallis, P = 0.0003) indicates that at least one difference in test number outcomes exists.

The pairwise differences indicate which 5 pair combinations of all possible combinations, have significant differences:

- Test 1 results are different than Tests 3, 5 & 6. As shown in figure 4.2, the average of test 1 is higher.
- Test 2 results are different than Test 3 & 6. As shown in figure 4.2, the average is higher.

Appendix K provides an annotated box and whisker chart similar to Figure 4.2 illustrating all of the features of the particular type of EXECUSTAT presentation used in Figure 4.2 and other similar graphs in this dissertation.

The net effect of these differences is that a given school score can vary significantly with the test booklets used. In this study each school had a random draw, without replacement, from a pool of forty-two booklets (seven copies of each of the six tests) of booklets. No attempt was made to control the booklet drawing to permit a fair comparison between individual schools with each other. The method does permit a fair state-wide sample to be obtained however.

Table 4.3
Test booklet number significance

Class	Value	Sample Size	Mean	Standard Deviation
1	1	25	63.672	12.586
2	2	31	55.9132	18.2343
3	3	32	46.745	14.5014
4	4	23	55.1183	20.2447
5	5	32	48.5669	15.9311
6	6	25	46.1704	15.1743

Analysis of Variance

Source of Variation	Sum of Squares	D.F.	Mean Square	F-Ratio	P Value
Between groups	6192.49	5	1238.5	4.70	0.0005
Within groups	42706.1	162	263.618		
Total (corr.)	48898.6	167			

Parametric Pairwise Differences - Comparison by 95% LSD Intervals
Pairs for which difference is insignificant removed by study author

	Contrast	Difference	+-LSD	Significant
1	-3	16.927	8.55826	Yes
1	-5	15.1051	8.55826	Yes
1	-6	17.5016	9.06855	Yes
2	-3	9.16823	8.07993	Yes
2	-6	9.74283	8.61859	Yes

Non-Parametric Kruskal-Wallis Test for Differences in Location

Value	Sample Size	Average Rank
1	25	117.42
2	31	94.7097
3	32	66.6406
4	23	94.1087
5	32	75.6094
6	25	64.32

Test statistic = 23.4321
P value = 0.0003

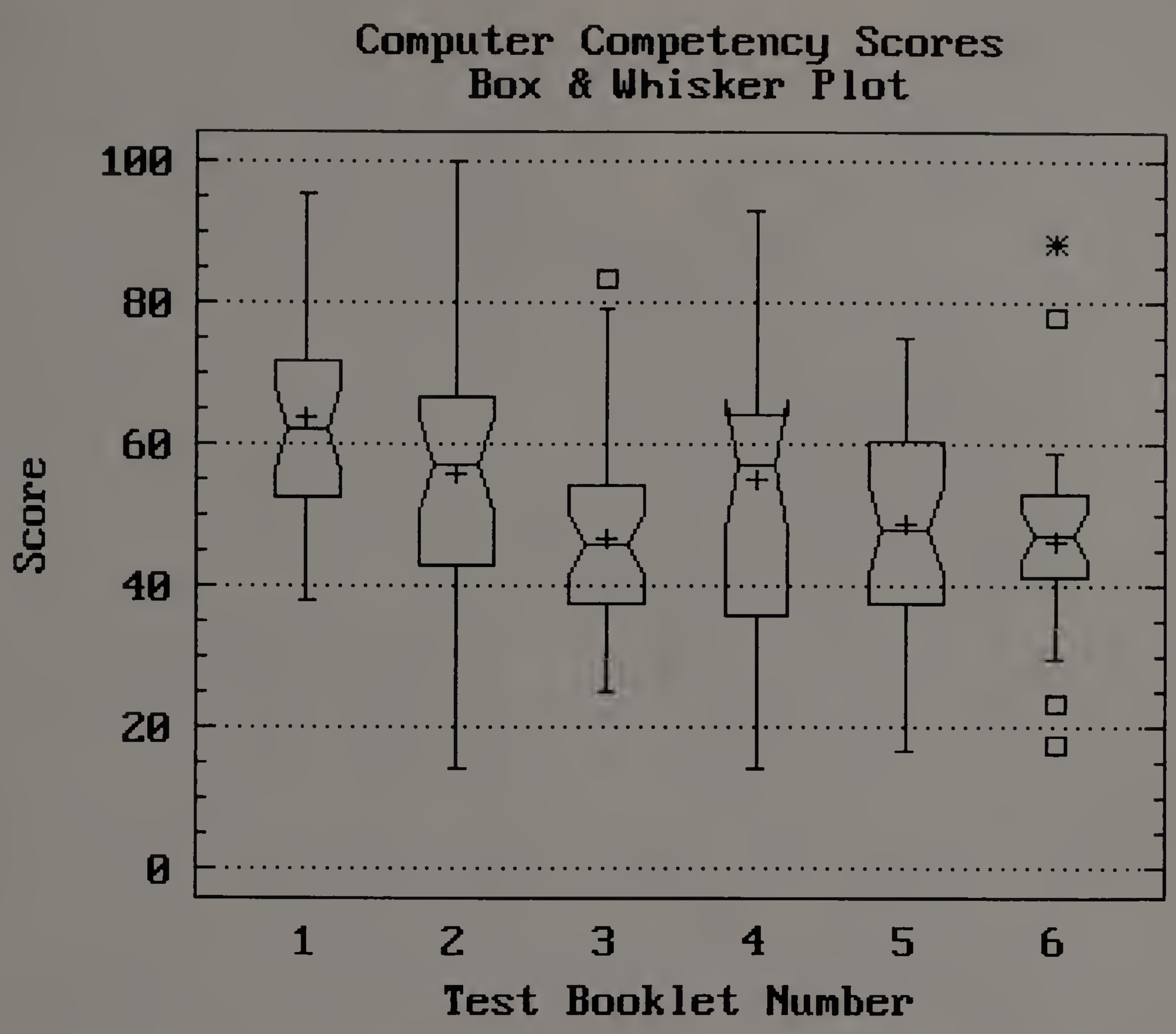


Figure 4.2
Score vs. Test booklet number

4.3 Question 1: School factors

Despite having said that schools could not be fairly compared, the study author was asked by each school to identify where they stood with respect to the state. In the analysis that follows, the school identities are concealed and all identifying marks removed.

> Question 1: Are there any statistically significant differences between the competency scores of the schools sampled throughout the state?

This question is addressed in three parts. In addition to comparing schools to each other, there are two sub-classes of schools that should be examined, public/private and a stratification based upon school size. Each of these three groups is examined in the next sections. This analysis was performed. The school locations were randomized in the table and graphs, with all identifying marks removed. There are two views of this. One is that there is no difference. The second is that the state is relatively uniform in its policies, procedures and resources, and achieved fairly uniform results. Differences may exist, but they will not be so large that they cannot be attributed to chance.

4.3.1 Question 1a: Differences in sample schools

At the specific and explicit request of the schools, the individual schools are compared anonymously. Table 4.4 presents both a parametric and non-parametric results of the following hypotheses:

> Hypothesis: there are differences in computer competency outcomes between the individual schools tested.

> Null Hypothesis: there are no differences in computer competency outcomes between the individual schools tested.

Table 4.4
Sample school comparison

Parametric

Analysis of Variance

Source of Variation	Sum of Squares	D.F.	Mean Square	F-Ratio	P Value
Between groups	2672.62	9	296.958	1.02	0.4303
Within groups	46226	158	292.57		
Total (corr.)	48898.6	167			

The analysis of variance table decomposes the total variability in Score into two components: one due to the differences between Loc means, and the second due to other factors (error). The mean square between groups estimates the variance of the error to be 292.57. Since the P value of the F-ratio is greater than or equal to 0.05, there are not statistically significant differences between the means at the different levels of Loc.

Non-Parametric

Kruskal-Wallis Test for Differences in Location
Individual School data intentionally deleted

Test statistic = 8.37145
P value = 0.4972

The Kruskal-Wallis test compares the differences between the medians of Score at the 10 levels of Loc by ranking the combined samples, and computing the average rank at each level. Since the P value is greater than or equal to 0.05, there are not statistically significant differences between the medians at the different levels of Loc.

The similarity of the scores is demonstrated graphically in Figure 4.3. Three other non-parametric tests were run, including all possible pairwise differences with the same result, and the null hypothesis that there is no difference cannot be rejected.

The conclusion is that there is no statistically different between computer competence scores at the high schools within the state of New Hampshire. In attempting to meet the state mandate for computer competence, high schools have achieved a remarkable uniformity of results considering the differences among schools tested.

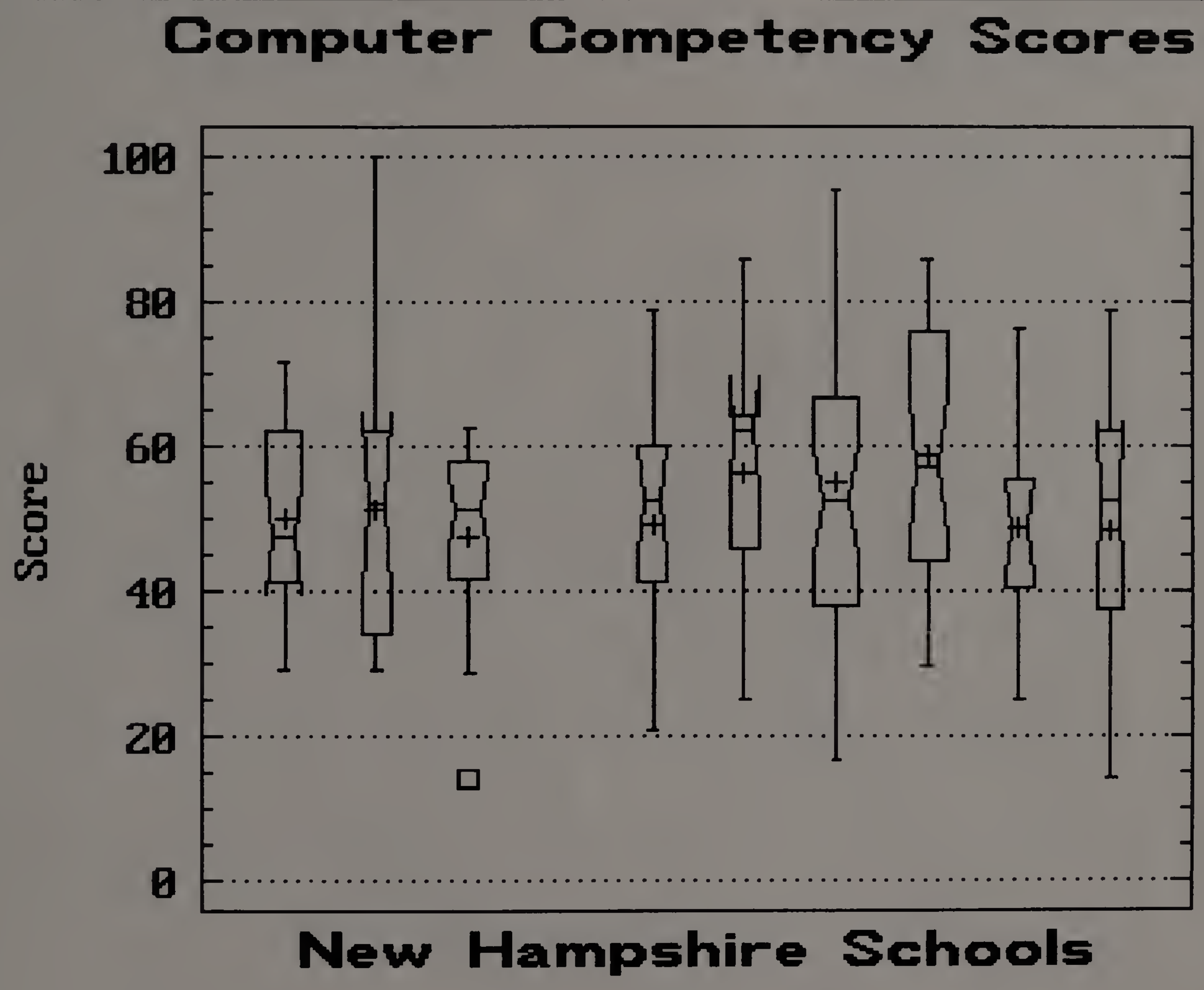


Figure 4.3
School competency scores
(School names and identifiers concealed)

Figure 4.3 has intentionally removed identifying characteristics of the school, and randomized the order in which each school is presented. The conclusion is that there is no statistical difference between the ten individual schools tested throughout the state of New Hampshire.

4.3.2 Question 1b: Public and private schools

Just as there was no difference between all of the schools, if the number of schools is reduced to two, public and private, the null hypothesis "There is no difference between public and private schools" cannot be rejected.

The private schools selected were chosen from the private schools in the state with greater than 250 students in total. This selection criteria would insure that the schools had sufficient funding to equip computer laboratories, and hire special computer teachers. The two schools randomly selected from the qualifying group are both known for their very restrictive admission policies and high academic standards.

One of the private schools tested was a "boys only" school. The second private school only had three girls in the test sample. It is a predominantly male school currently trying to become co-educational. Since a student's sex has been identified as a discriminator, a data file was prepared with a program written for this study that contained only males, and coding the schools into just public and private schools. The resulting analysis contained in Table 4.5, does not permit rejection of the null hypothesis. The conclusion is that there is no difference in computer competency based upon control of school, public or private.

Table 4.5
Public and private schools

Males Only — Two Sample Analysis — Males Only

	P	V	
Sample size	66	30	
Mean	55.0126	58.1007	diff. = -3.08809
Variance	312.774	298.047	ratio = 1.04941
Std. deviation	17.6854	17.264	

95% confidence intervals
mu1 - mu2: (-10.7638,4.58759) assuming equal variances
mu1 - mu2: (-10.7576,4.58142) not assuming equal variances
variance ratio: (0.538591,1.89465)

Hypothesis Test - Difference of Means

Null hypothesis: difference of means = 0
Alternative: not equal
Equal variances assumed: yes

Computed t statistic = -0.79882
P value = 0.4264

The computed t statistic tests the null hypothesis that the difference between the means of the populations from which the two samples come is equal to 0, against the alternative hypothesis that the difference is not equal 0. Since the computed P value is greater or equal to 0.05, we do not reject the null hypothesis.

Males only analyzed due to small female sample at private schools.

4.3.3 Question 1c: School size.

The third possible discriminator is school size. Rubega (1989) reported that there were differences in costs for these schools, but that all of the schools seemed to be expending the necessary resources to meet the state mandate. A computer file was generated using a special program to code the schools into school three sizes:

- <u>Large</u>: more than 1000 students, representing 43% of the state enrollment. 47% of states students.

- <u>Medium</u>: 500 to 1000 students, accounting for 29% of the total enrollment. 26% of states students.

- <u>Small</u>: fewer than 500 students. It accounts for 28% of the total students. 47% of states students.

The <u>large</u> and <u>medium</u> sizes corresponds to the state size groupings. The <u>small</u> group was pooled from the three smallest size groupings of the state. Tables 3.1 through 3.3 summarize the states and samples student population based upon these three size categories.

The following hypotheses were tested using these three size breakdowns:

> <u>Hypothesis</u>: there is a difference between computer competency results based upon school sizes.
>
> <u>Null Hypothesis</u>: there is no difference between computer competency results based upon school sizes.

The analysis, as shown in Table 4.6 does not permit rejection of the null hypothesis. While only the parametric results are shown, non-parametric results are similar. The conclusion is that there is no difference in average computer competency scores based upon school size within the state of New Hampshire.

Table 4.6
School sizes

Analysis of Many Samples

	Class	Value	Sample Size	Mean	Standard Deviation
Parametric	1	Large	54	53.565	16.6867
	2	Medium	49	54.1614	19.8266
	3	Small	65	50.01	15.1431

Parametric Analysis of Variance

Source of Variation	Sum of Squares	D.F.	Mean Square	F-Ratio	P Value
Between groups	596.382	2	298.191	1.02	0.3634
Within groups	48302.2	165	292.741		
Total (corr.)	48898.6	167			

The analysis of variance table decomposes the total variability in Score into two components: one due to the differences between Loc means, and the second due to other factors (error). The mean square between groups estimates the variance of the error to be 292.741. Since the P value of the F-ratio is greater than or equal to 0.05, there are not statistically significant differences between the means at the different levels of Loc.

4.4 Question 2: National comparison

The second purpose of the study is to analyze whether or not the efforts of the state of New Hampshire have achieved any improvement over the national average, as measured by the NAEP assessment. The following hypothesis is tested:

> Hypothesis: "That the students of the state of New Hampshire have significantly different average computer competence scores than those measured by the NAEP 1986 survey".

Null Hypothesis: "That the students of the state of New Hampshire do not have significantly different average computer competence scores than those measured by the NAEP 1986 survey".

4.4.1 Question 2a: National averages.

In this case, both groups are essentially the same population, upper-class senior high school students. Thus a T-Test or a Z-Test is appropriate. This study utilized a Z-Test since the variance of the Null population is assumed to be the NAEP nation-wide survey. A one-tail test is utilized, since it is desired to test whether on not the state has improved upon the nation.

The assumption of normality required for the Z-Test was discussed in section 4.3.3. In addition to the expectation provided by the central limit theorem, a direct test for normality could not reject the hypothesis that this sample was from a normal distribution.

Recalling that NAEP utilized the weighted average of the scores of the correct answer, the following analysis is provided:

NAEP μ=42.6 SE=0.6 Study μ=51.1

Z_{obt} = (51.1 - 46.2) / 0.4 = 12.25
Z_{crit} (1 tail, α = 0.05) = 1.645
Z_{crit} (2 tail, α = 0.05) = 2.01

Since $Z_{obtained}$ is larger, in fact substantially so, than the critical value, the null hypothesis, that there is no difference, is rejected. The alternative hypothesis is accepted.

The conclusion is that the New Hampshire test scores are significantly better than those of the nation as a whole, as obtained upon the national sample.

4.4.2 Question 2b: Different national subgroups

The state computer competency scores as a whole were significantly higher than three national subgroups reported. Essentially, the whole state, girls and boys, scored better across the nation. New Hampshire was also significantly higher than the Northeast as a whole, and better than comparable communities sizes across the nation.

	NH	Nation	S.E.	Zobt	Group
Z_{obt} =	(56.2	- 47.6)	/ 0.6 =	14.33	Boys
Z_{obt} =	(46.8	- 44.8)	/ 0.3 =	6.67	Girls
Z_{obt} =	(51.1	- 48.7)	/ 0.7 =	3.43	Northeast

Z_{crit} (2 tail, $\alpha = 0.05$) = 2.01
Z_{crit} (1 tail, $\alpha = 0.05$) = 1.65

Each of the above three scores exceeds $Z_{critical}$, which would enable the rejection of a suitable null hypothesis asserting that there was no difference for national boys, the Northeast, and community size respectively.

4.4.3 Question 2c: Similar national subgroups

There are several areas in which the state of New Hampshire is not significantly better than the national average as reported by Martinez. These are listed below:

	NH	Nation	S.E.	Zobt	Group
Z_{obt} =	(51.1 -	52.3) /	1.4 =	-0.86	Family owned computer
Z_{obt} =	(51.1 -	50.2) /	0.7 =	1.29	Both parents graduated from college
Z_{crit} (1 tail, $\alpha = 0.05$)			=	1.645	

Each of these two areas is less than $Z_{critical}$, which would not allow rejection of a null hypothesis that the state as a whole possessed higher scores than the nation as a whole for families that owned computers and families across the nation where both parents were college graduates.

The conclusion concerning these two groups where the state as a whole did not do significantly better is as follows:

- The state school system has essentially provided sufficient access to computers to overcome the advantage of a student's family owning their own home computer on a nation-wide basis. This conclusion is tested within the state sample in a later section.

- The state system, as a whole, has not yet overcome the educational advantages of both parents possessing a college degree. The scores were better, but not significantly. This study did not gather data to directly compare student groups based upon parental education.

The collection of data on parental status was beyond the scope of this study. This study limited itself to those characteristics that a school system can control, such as mandates, regulations, course work and curricula. It is recommended that any future studies in this area obtain data on parents education, occupation and family income.

4.5 Question 3: School policies

There are several areas where district school policies could directly impact the outcome of the computer competency educational process. The purpose of this section is to investigate those issues. These are distinguished from question 5, which deals with choices made primarily by an individual student.

> Question 3: What differences, if any, in computer competency outcome are attributable to different local school policies?

A school district has essentially three areas subject to its local discretion: (1) whether it offers the mandated course in high school or junior high school; (2) the degree to which they achieve integration of computer competency subjects into other courses throughout the curriculum; (3) the emphasis and implementation details of the general curriculum guidelines provided by the state. Other areas identified by this study and literature research are more dependent on student demographics and choices, which are largely beyond the school district policy domain.

4.5.1 Question 3a: High school vs junior high school

A school in the state of New Hampshire has three means of satisfying its computer competency mandate, a high school course, a junior high school course, and an examination. A school district could by policy or procedure, adopt any one of these mechanisms. In effect, which of the three means is used to satisfy the state mandate is a matter of local school choice. This question examines the effect of that choice.

Three high schools utilized the primary high school course. Three high school utilized the junior high school course. Only one private school utilizes examination to satisfy the state mandate. The specific hypothesis tested can be stated as follows:

> <u>Hypothesis</u>: There is a difference between students depending on the mechanism chosen by the school district to permit achieving computer competence.

> <u>Null Hypothesis</u>: There is not a difference between students depending on the mechanism chosen by the school district to permit achieving computer competence.

The analysis is presented in Table 4.7, and is displayed in Figure 4.4. The null hypothesis cannot be rejected. The conclusion is that it makes no difference which implementation policy a school utilizes to meet the state mandate. But a word of caution is in order. As will be seen in the section dealing with the results of students rather than schools, the number and timing of courses does matter. This analysis deals only with the average end results of various school policies, not how well individual students perform.

Table 4.7
Competency Mechanism (NHDQ-55)

Based upon School District Policy for each School assessed

Analysis of Many Samples

	NHDQ-55 Class	Value	Sample Size	Mean	Standard Deviation
Parametric	1	Examination	14	56.2921	17.4957
	2	High School Course	123	52.3151	16.8773
	3	Junior High Course	31	50.7813	18.1424

Pairwise Differences - Comparison by 95% LSD Intervals

	Contrast	To	Difference	+-LSD	Significant
Parametric	Exam	-High School	3.97702	9.55843	No
	Exam	-Junior High	5.51085	10.912	No
	High School	-Junior High	1.53383	6.81036	No

The above table shows the estimated differences between the means of Score for all 3 pairs of different Loc values. Alongside the estimated means are the Least Significant Difference (LSD) intervals, which are separate 95% confidence intervals for each difference. 0 pairs, indicated by a "Yes" at the far right, show statistically significant differences.

Non-Parametric

Mood median test of score

Chisquare = 3.17   df = 2   p = 0.206

```
                                                Individual 95.0% CI's
           method   N<=    N>   Median   Q3-Q1  --+---------+---------+---------+----
High School     1   66     57    52.4    20.8             (-------+-)
Junior High     2   16     15    52.4    26.6     (---------------+---------)
Examination     3    4     10    61.9    22.3           (---------------------+---)
                                                --+---------+---------+---------+----
                                                42.0      49.0      56.0      63.0
```

Overall median = 52.4

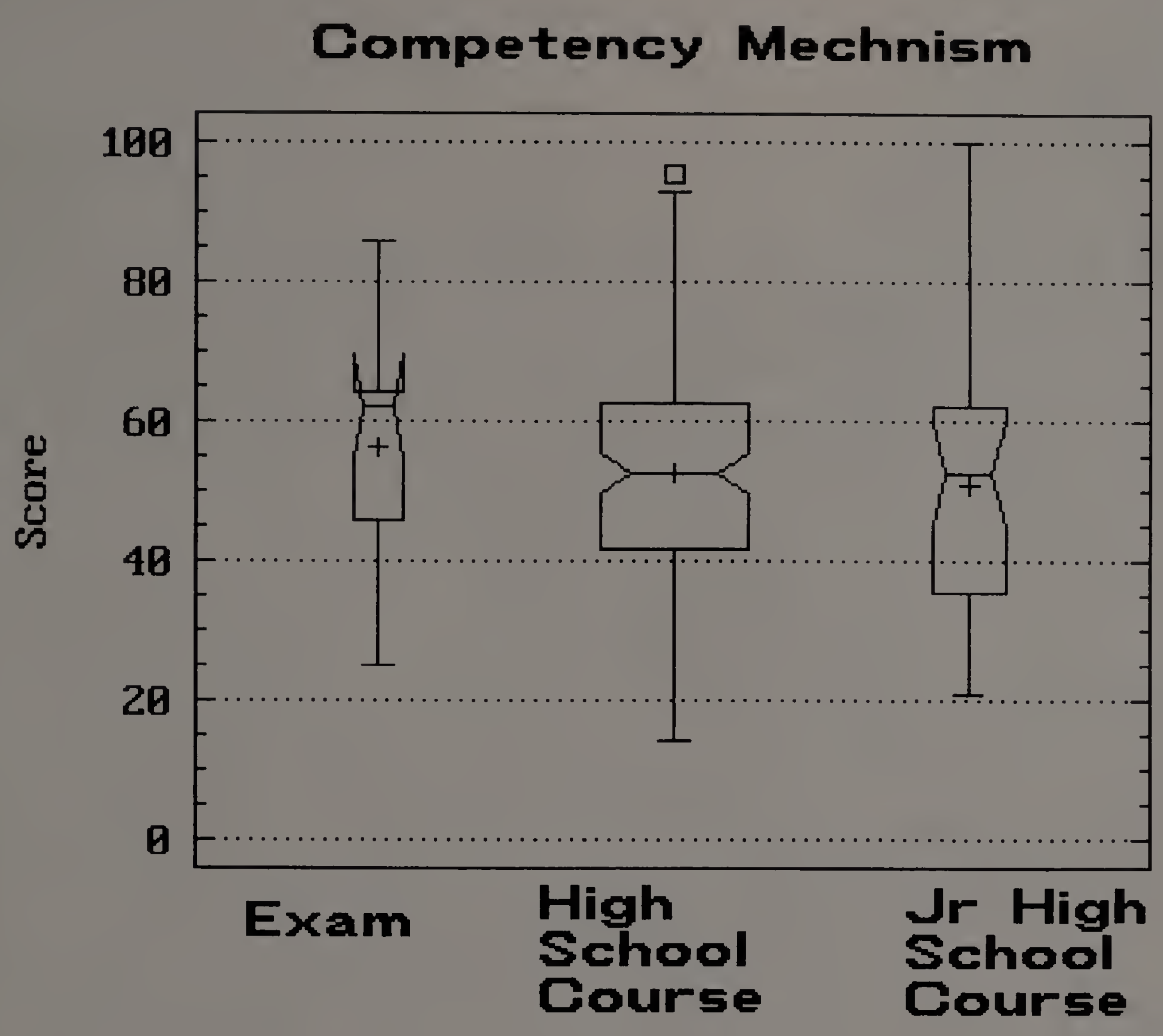


Figure 4.4
Competency mechanism (NHDQ-55)

Thus, even though it does not matter which system a high school uses, as will be shown later, it is significant that more courses are available. It is not sufficient to offer only a junior high school course. All high school districts sampled which utilized the junior high school option offered additional, follow on computer courses in high school. As will also be shown later, while it does not matter how early the first course is taken, it does matter how late that course is taken. That choice is usually a students scheduling choice, rather than an a school policy choice.

4.5.2 Question 3b: Integration into other classes

There have been proposals over the years to integrate computers into the classroom throughout the curriculum. This study tried to determine if that was happening, and wether it affected computer scores. This question can be framed into the following hypotheses:

> Hypothesis: Student usage of computer in outside, non-computer courses affects their overall computer competency outcome.
>
> Null Hypothesis: Student usage of computer in outside, non-computer courses does not affect their overall computer competency outcome.

There are several questions that attempt to obtain information on this subject. The NAEP demographic questions provided some information, and the NHDQ provided other information.

Appendix H contains various data tables for several different courses. The following results can be summarized as follows; based upon the NHDQ data in questions NHDQ-61 through NHDQ-65, the use of computers in English, Mathematics, Social Studies and Science all showed a significant relationship to computer competency scores at the $\alpha=0.05$ significance level. This permits the rejection of the null hypothesis, and acceptance of the alternative hypothesis. However, these questions really address what a computer was used for in various subjects. They do not address how often they were used. In particular, the most popular answer was word processing, where the student and not the teacher can bring the skills and knowledge into the homework process. Realizing this, further analysis must be done.

The mere usage of computers does not in itself guarantee computer competence. The NAEP examinations asked several questions that are indicative of computer usage. These are tabulated in Table H.5. That data indicates a much higher usage of computers than was present in the national survey. It also indicates that mere usage was not significant. In short, these questions asked if a computer was used at all, not how much it was used, or for what purpose. Unstructured, occasional usage does not seem to help competency scores.

The resolution of the apparent discrepancy between the result of Table H.1 through H.4 and H.5 was investigated further. Table H.6 shows the results of four other NAEP data questions which dealt with how often computers were used in the same subjects. The results indicate that in mathematics and English, the number of people who never used the computer was essentially the same as in the 1986 national sample. Only in science and music do the results appear different. That increased degree of computer usage did not make a significant difference as indicated by the probability (p) which is larger than the desired alpha of 0.05.

The ambiguous results of this analysis is subject to various interpretations. The study concludes that the difference is one of perception. Teachers are not using computers in class for the most part. Those students who utilize computers on their own, primarily for word processing, achieve sufficient reinforcement for their computer skills to achieve higher outcome scores. In effect, if students use a computer, even for just word processing, their overall computer competence will rise. Occasional use by occasional teachers throughout the curriculum simply does not help students, on the average, raise their computer competency scores.

4.5.3 Question 3c: Computer competency curriculum

Computer competency courses can be of many types: a simple typing or keyboarding course, a mixture of applications, or computer programming. As noted in the literature research, this topic has been studied in terms of desired curriculum, but has never been studied in terms of computer competency outcome. This leads to the following testable hypothesis:

> Hypothesis: The content of the first computer course does make a difference in the outcome of the assessment.
>
> Null Hypothesis: The content of the first computer course does not make a difference in the outcome of the assessment.

There were no NAEP questions that addressed this issue, even indirectly. The New Hampshire Demographic Questionnaire (NHDQ), question 57 asked for a student evaluation of their competency course. An analysis of the responses are presented in Appendix J. The analysis done there indicates that the null hypothesis can be rejected. Figure 4.5 illustrates the results.

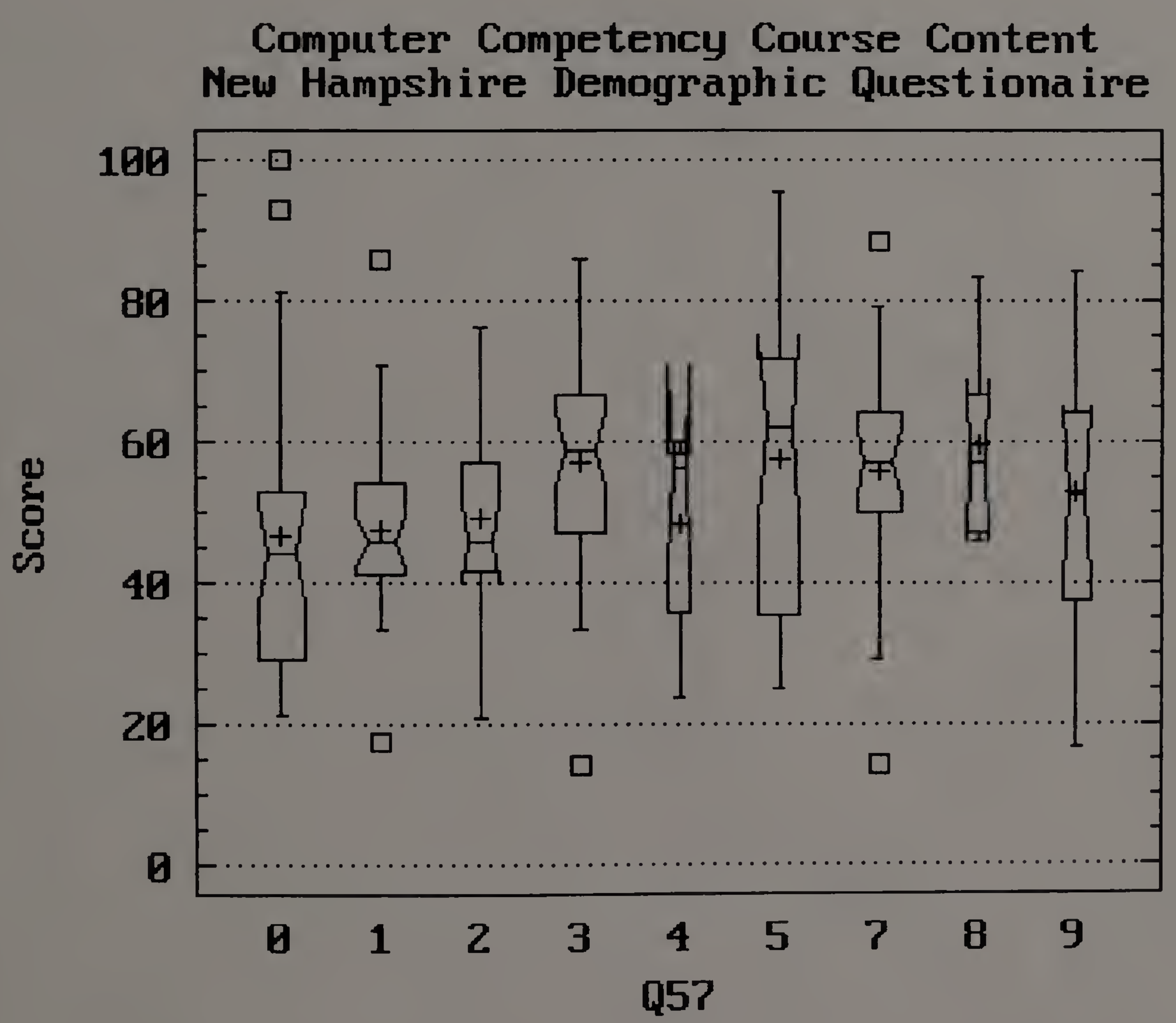


Figure 4.5
Computer competency curriculum (NHDQ-57)

The conclusion is that it does make a difference what the content of a computer competency course is. Judging from the data, a mixture of material, including terminology, operations, applications and programming, such as New Hampshire mandates indeed does produce the highest scores on the NAEP outcome assessment.

4.6 Question 4: Discriminating factors

The demographic questions in the New Hampshire Demographic Question (NHDQ) supplement were examined utilizing MINITAB and its non-parametric MOOD comparison of medians. Questions were also examined with a regression analysis. There are 5 closely related factors:

1. Sex.
2. Time since first computer course
3. Years experience.
4. Semesters studied.
5. Programming course.
6. Word processing.

Items 1 through 4 were analyzed using both a parametric Pearsons Product Moment Correlation (Table G.1) and a non-parametric Spearmans Rank Correlation (Table G.2). These results are contained in Appendix G. This section presents the results of single Mood Median tests to illustrate the general form of the data. Word Processing is also discussed and analyzed separately.

4.6.1 Question 4a: Q-52: Student's sex

The literature review indicated that the sex of the student was the most often reported and agreed upon discriminator of computer competency scores. The 1986 NAEP survey also reported similar results (Martinez, 1988). This study found similar results for the hypothesis:

Hypothesis: The sex of a student does make a difference in computer competency scores.

Null Hypothesis: The sex of a student does not make a difference in computer competency scores.

Table 4.8 presents the result of a non-parametric analysis of medians. As it shows, the boys score significantly better than the girls.

Table 4.8
Student sex (NHDQ-52)

Non-Parametric

Chisquare = 10.87 df = 1 p = 0.001

	q52	N<=	N>	Median	Q3-Q1
Unknown	0	0	1	83.3	Not used
Boys	1	38	57	57.1	23.8
Girls	2	45	23	47.1	21.9

```
Individual 95.0% CI's
-----+---------+---------+---------+-

                          (--------+------)
 (-------+----------)
-----+---------+---------+---------+-
    45.0      50.0      55.0      60.0
                 Median
```

Overall median = 52.4

Parametric

Comparison of New Hampshire Boys and Girls to NAEP assessment Boys and Girls
ROWS: q52

		COUNT	score N	score MEAN	score SEMEAN	NAEP MEAN	Zobt	Zcrit	Significant
Unknown	0	1	1	83.330	--				
Boys	1	95	95	56.216	± 1.79	47.6 ± 0.6	14.20	1.65	Yes
Girls	2	68	68	46.769	± 1.77	44.8 ± 0.3	5.00	1.65	Yes
	ALL	164	164	52.464	± 1.33				

A 'Z-test' comparison was performed to compare boys and girls to the NAEP assessment, and the results are shown at the bottom of Table 4.8 Both boys and girls do significantly better than their corresponding sex performed in the NAEP study, as indicated in the bottom section of the table, although the effect is more pronounced with men.

This test indicates that the null hypothesis should be rejected, and the alternative hypothesis accepted. A visual picture of this outcome is contained in Figure 4.6. Boys do significantly better then girls.

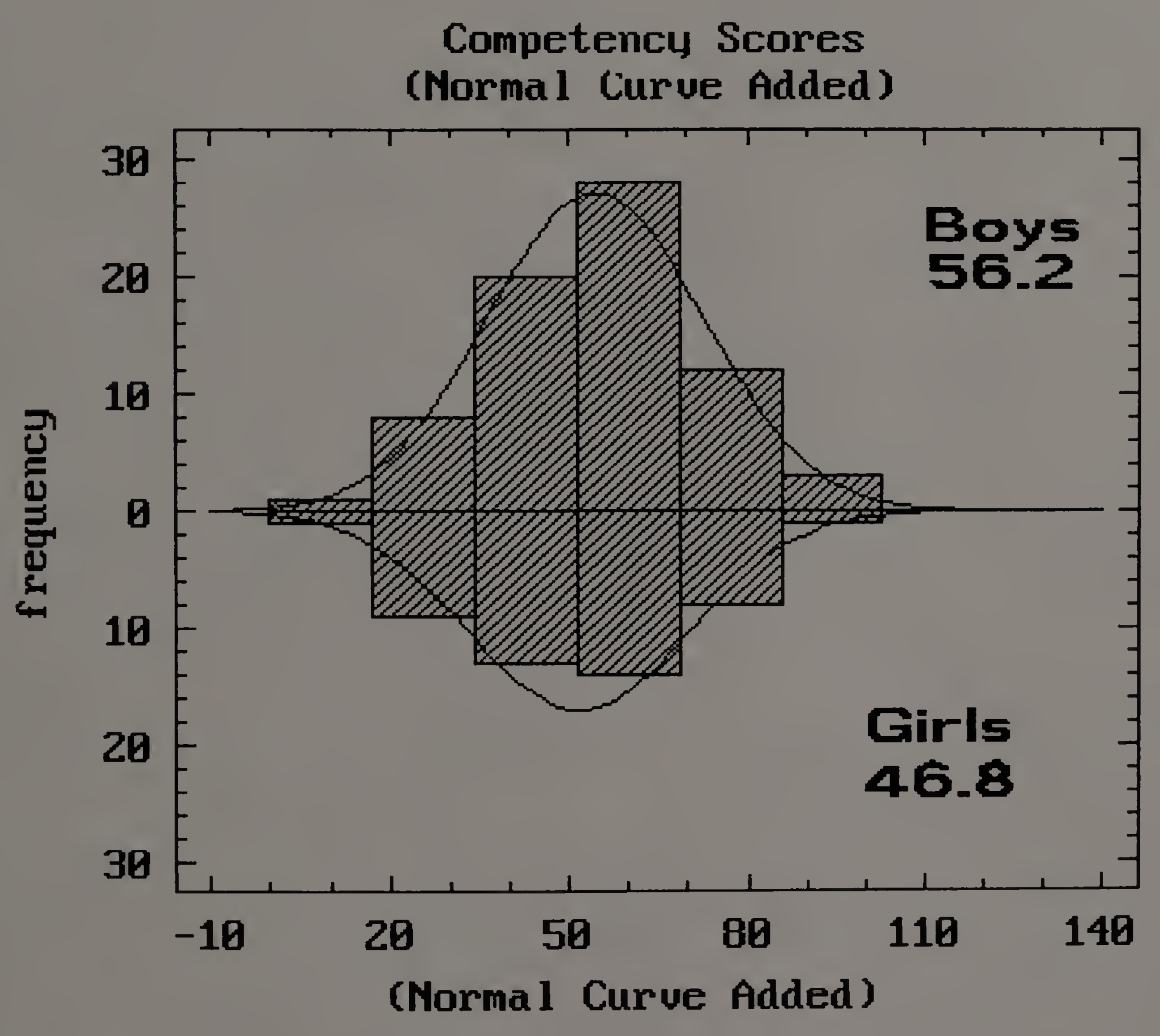


Figure 4.6
Histogram of scores by sex

A multivariate analysis of various potential discriminators, including sex, is contained in Appendix G.

and supports this conclusion. That analysis also indicated that experience is a second factor, and that programming classes and semesters of classes are related to each other, if not directly to competency score. Table 4.9 contains a tabulation of student sex versus experience, showing the counts and average scores of each combination. As can be seen, boys score higher than girls for most experience columns. Girls outscored boys for exactly 2 years experience, which was the lowest boys score obtained.

Table 4.9
Student sex (NHDQ-52) vs. Years experience (NHDQ-58)

Non-Parametric

ROWS: sex COLUMNS: experience

		0 years	1 Year	2 Years	3 Years	4 Years	>4 Years
Coded answer		1	2	3	4	5	ALL
Boys	1	4	10	5	11	65	95
Average Score		49.432	42.704	56.548	50.093	59.723	56.216
Girls	2	5	10	7	9	37	68
Average Score		37.142	46.761	39.346	39.484	51.249	46.769
Combined		9	20	12	20	102	163
Average Score		42.604	44.733	46.513	45.319	56.649	52.275

CELL CONTENTS --
COUNT
Computer Competence score : MEAN

A popular belief for this difference would be that girls continue to use computers, but do not go on to take other computer courses. Figure 4.10 was prepared to investigate this belief. It illustrates that girls move on to further courses in computers at appropriately the same rate as men. A popular belief is that while girls do move on to other courses, they do not take the more "rigorous" programming courses, and this lack of programming training would explain lower scores on a assessment that tests programming competency.

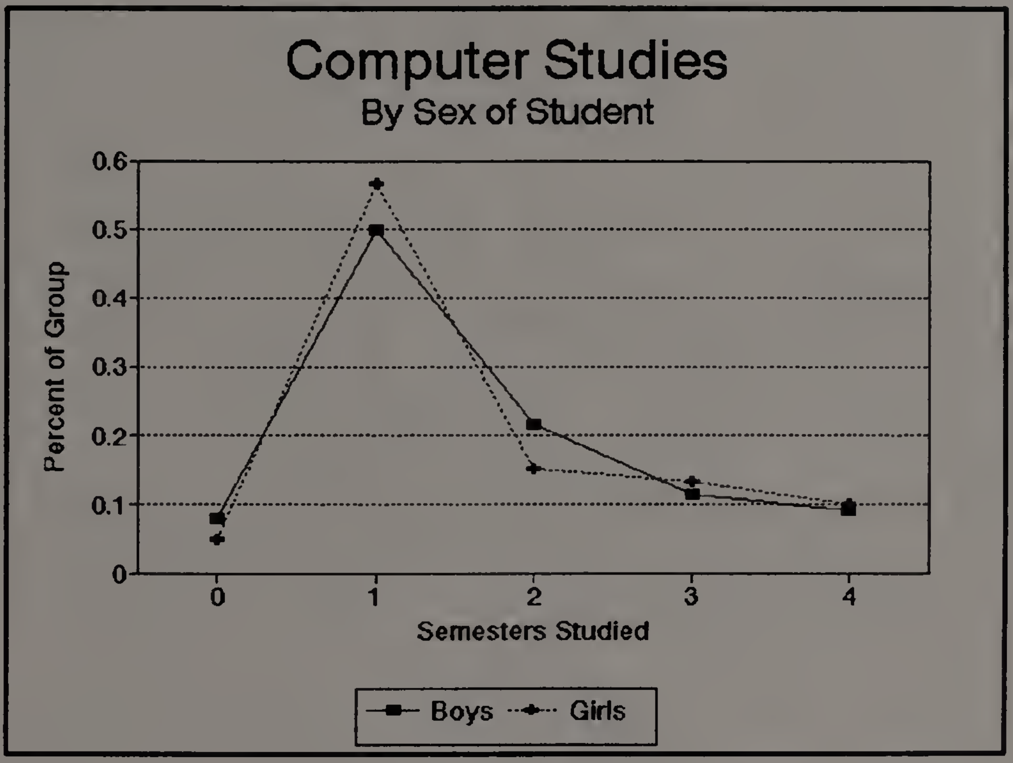


Figure 4.7
Student sex vs Semesters of computer study

Table 4.10 is the result of this examination. As can be seen, boys score higher than girls in each category of programming courses.

It should be noted from figure 4.5, that approximately 50% of the students take only the mandated course. Significantly, approximately 50% of the students take more than the required course. Corresponding information from the 1986 survey is not available.

Table 4.10
Student sex (NHDQ-52) vs. Programming courses (NHDQ-49)

ROWS: sex   COLUMNS: programming courses

Non-Parametric

		Yes 0	No 1	ALL	
Boys	1	31	39	70	Count
Average Score		55.372	59.923	57.908	Mean Score
Girls	2	35	13	48	Count
Average Score		46.379	47.155	46.589	Mean Score
Combined		66	52	118	Count
Average Score		50.603	56.731	53.304	Mean Score

CELL CONTENTS --
COUNT
Computer competency score:MEAN

From an examination of Figure 4.6, one could suspect that just as many girls go on to further computer studies as boys. The question is do their scores improve equally with that of boys? Table 4.11 contains a table of sex versus the number of semesters of computer studies. Again, boys generally outscore girls.

In analyzing this data on sex differences, some care must be taken. The total sample was of a reasonable size. When this sample is divided one by sexes, and then each sex is divided into several groups, some very small sample sizes are the result. The results are valid as far as they go, but more study in this area, with larger samples are needed before too many conclusions are drawn.

Table 4.11
Student sex (NHDQ-52) vs Semesters studied (NHDQ-60)

ROWS: sex (Q52) — COLUMNS: Semesters of computer Study (Q60)

		None	One	Two	Three	>=Four		
		1	2	3	4	5	ALL	
Boys	1	7	48	21	10	8	94	Count
Boys Scores		38.281	54.577	63.619	54.545	66.219	56.371	Mean Score
Girls	2	3	39	10	8	6	66	Count
Girls Scores		55.357	47.458	46.726	42.639	48.102	47.181	Mean Score
Combined	ALL	10	87	31	18	14	160	Count
Combined Scores		43.404	51.386	58.170	49.253	58.454	52.580	Mean Score

CELL CONTENTS --
COUNT
score:MEAN

As shown in the various figures and tables, girls' scores are less than boys' for essentially all groups of experience, semesters of school or whether or not programming was studied. Essentially the popular beliefs based upon boys take more semesters of courses on the subject are false. With equal preparation, girls still score less than boys. The real reasons for this difference, or corrective action for the difference are beyond the scope of this study, but the difference does appear to be real, and not imagined.

4.6.2 Question 4b: Q-56: Time of first course

A second significant factor is the timing of the first course. A simple one factor correlation does not indicate this. This leads to the statements:

Hypothesis: The number of years since the first computer class has an effect on computer competency scores.

Null Hypothesis: The number of years since the first computer class does not have an effect on computer competency scores.

Table 4.12 contains a Mood median test from MINITAB. Based upon that analysis, this factor should be rejected. However, as shown in both figures G.1 and G.2, the probability of obtaining the calculated Pearson Product Moment (0.1636) was 0.0370 and the probability Spearmans Correlation Coefficient value (0.1550) was 0.0485. Both of these probabilities are below the critical value of 0.05. Based upon that more powerful analysis of APPENDIX G, the null hypothesis is rejected. It should be noted that there are several small samples for "over 5 years". These could be pooled, but the resulting conclusion would not change. It does not matter how soon the first course was taken, but it does matter how late the first course was taken. If the first course was taken in the last year or two, outcome scores will be lower. This is probably related to years experience, which is the subject of the next section.

4.6.3 Question 4c: Q-58: Years experience

The second highest correlation factor (sex is the highest) occurs with reported computer usage. There is no information available for the NAEP test, but NHDQ-58 directly addressed this. The following pair of hypotheses were tested:

Hypothesis: The students' reported years of computer experience affect computer competency scores.

Null Hypothesis: The student' reported years of computer experience do not affect computer competency scores.

Table 4.12
Years since first computer course (NHDQ-56)

56. If you took a computer competency or computer literacy course, how long ago was your first such course?

Non-Parametric

Mood median test of score vs Years Since First Computer Course

Chisquare = 12.18 df = 8 p = 0.145

	q56	N<=	N>	Median	Q3-Q1	Individual 95.0% CI's
						--------+--------+---------+--------
Never took course	0	16	6	44.3	33.5	(---+---)
Within last year	1	13	9	47.1	22.2	(--+------)
Within last 2 years	2	17	18	54.2	19.0	(--+-)
Within last 3 years	3	14	22	54.2	15.5	(+--)
Within last 4 years	4	12	9	47.1	19.3	(--+----)
Within last 5 years	5	7	6	45.8	38.7	(-----+-----------)
Within last 6 years	6	1	4	58.8	24.3	(----------+---------)
Within last 7 years	7	1	4	61.9	39.7	(-----------+------------)
More than 7 years	8	1	3	69.1	41.4	(---------------------+---)
						--------+---------+---------+--------
						40 60 80

Almost two-thirds of the students reported themselves as having at least three years experience (102 of 164 students). Experience of over 3 years was not requested. Future research should have a larger span of years. However, using the data available, a MOOD test is illustrated in Table 4.13. As shown, the MOOD, Pearsons correlation and Spearmans rank all indicate that the null hypothesis should be rejected at beyond the 99% confidence level.

Table 4.13
Years Experience (NHDQ-58)

58. How long have you used a computer?

Non-Parametric

Mood median test of score vs Years Computer Experience (Q58)

Chisquare = 22.09 df = 4 p = 0.000 N=164

	q58	N<=	N>	Median	Q3-Q1	Individual 95.0% CI's
						-+---------+---------+---------+-----
Never used	1	8	1	42.9	11.0	(--------+---)
Less than 1 year	2	15	5	47.1	13.9	(-----+----)
Over 1 year	3	9	3	47.3	30.4	(----------------+-----------)
Over 2 years	4	12	7	50.0	18.9	(-----------+---)
Over 3 years 62%	5	33	59	57.7	20.8	(--+---)
						-+---------+---------+---------+-----
						30 40 50 60

Overall median = 52.4

Pearsons Product Moment Correlation p = 0.0001 (Table G.1)
Spearmans Rank correlation p = 0.0000 (Table G.2)

The results are shown graphically in Figure 4.8. This data supports the rejection of the null hypothesis, that the years of computer experience makes no difference is rejected. The alternative hypothesis, that there is a difference in computer competency scores depending upon years of computer experience, is accepted. This dependence upon years of experience indicates that students should not wait until their junior or senior to take their computer competency course and become a computer users.

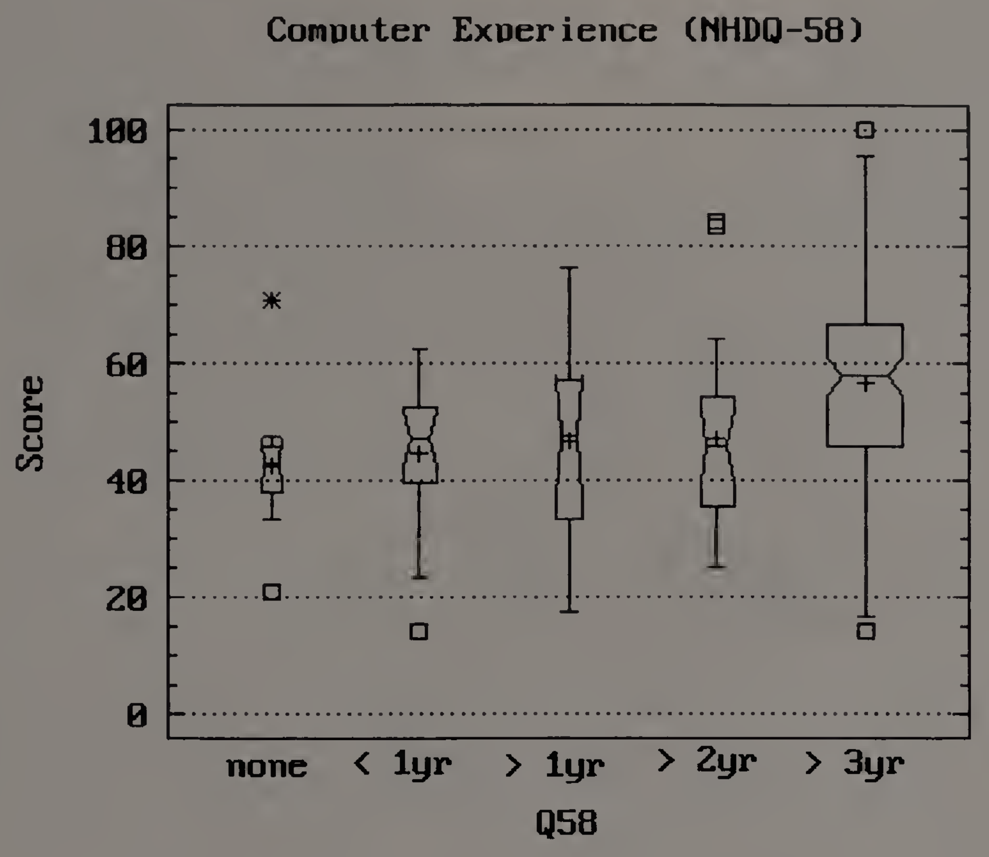


Figure 4.8
Score vs years of computer experience

4.6.4 Question 4d: Q-60: Semesters studied

Another factor under student control is the number of semesters that they choose to study computers. This question was not addressed in the NAEP study, but was directly asked in NHDQ-60. The Hypothesis:

> Hypothesis: The number of semesters that a student has studied computer studies correlate with their competency score.

> Null Hypothesis: The number of semesters that a student has studied computer studies does not correlate with their competency score.

The resulting non-parametric analysis is contained in Table 4.14. The results confirm rejecting the Null Hypothesis. Tables G.1 and G.2 contain the Pearsons correlation and Spearman Rank correlation. The results are identical. This information is shown pictorially in Figure 4.9.

Table 4.14
Computer semesters studied (NHDQ-60)

Mood median test of score vs Semesters Studied (Q60)

60. How many computer courses have you had in school, including any courses you might have had for computer literacy or computer competency?

Chisquare = 6.69 df = 5 p = 0.246

	q60	N<=	N>	Median	Q3-Q1	Individual 95.0% CI's
						`-----+---------+---------+---------+-`
Miscode	0	2	0	32.6	18.1	`  (-----+-----)`
None	1	7	3	41.4	31.1	`   (----------+---------)`
One Semester	2	44	43	52.4	20.2	`                  (--+--)`
Two Semesters	3	11	20	61.9	30.2	`                (----------+---)`
Three Semesters	4	11	8	47.1	26.8	`           (-----+-------)`
Four Semesters	5	7	7	54.8	26.5	`                 (-----+----------)`
						`-----+---------+---------+---------+-`
						`    30        45        60        75`

Overall median = 52.4
* NOTE * Levels with < 6 obs. have confidence < 95.0%

A complete set of tests was run on all NHDQ's. One surprising result was that a correlation was found on Q-50, which questions the amount of word processing used in all subjects, throughout a student's high school career. The following hypothesis was tested:

<u>Hypothesis</u>: The amount of word processing influences a students computer competency score.

<u>Null Hypothesis</u>: The amount of word processing does not influences a students computer competency score.

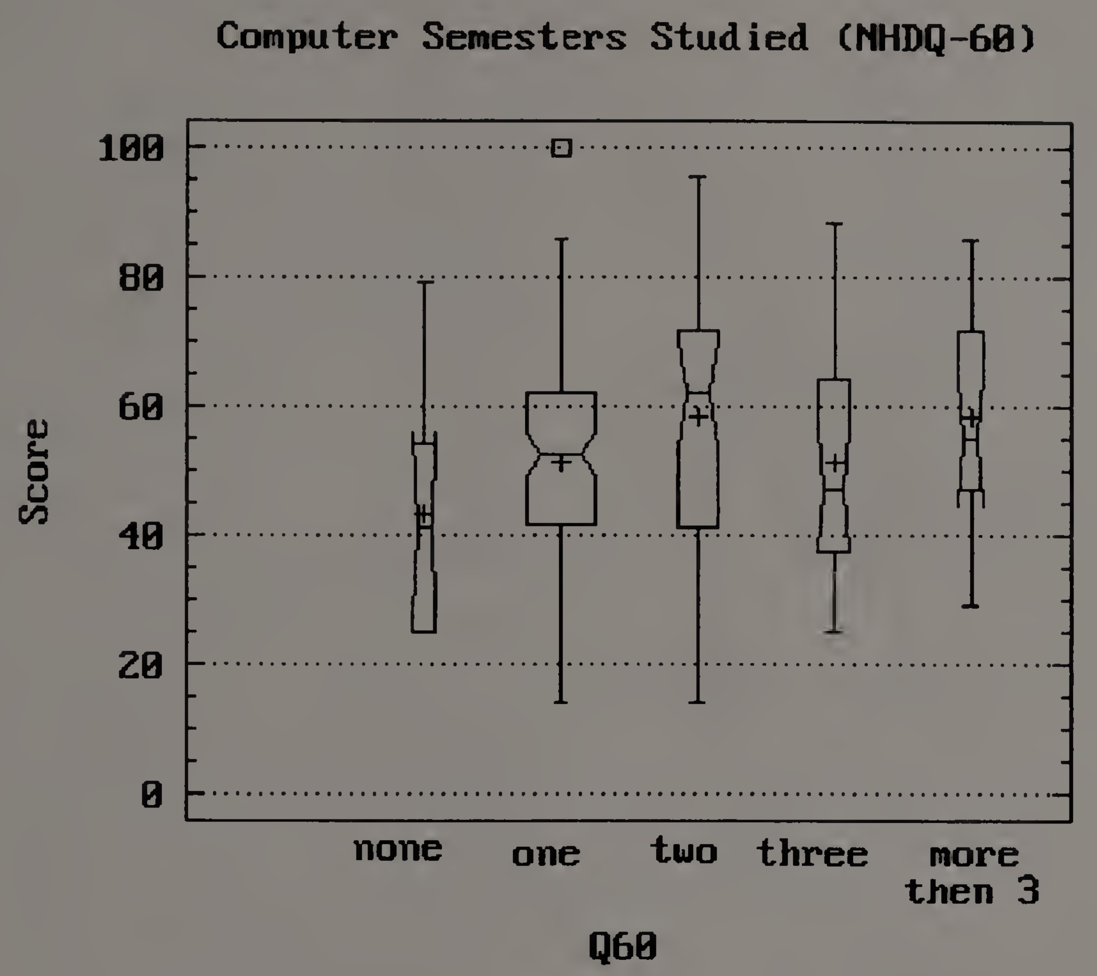


Figure 4.9
Computer semesters studied

The relevant analysis is contained in Table 4.15. Since a p = 0.033 is less than the desired 0.05, the null hypothesis is rejected, and the hypothesis is accepted. Further support for this can be found by an examination of Appendix H, and the discussion found under Question 4b, Course Integration in School Policies. Virtually all of the usage of computers outside of computer class was for word processing. The word processing experience also correlated with computer competency scores.

Table 4.15
Word processing usage (NHDQ-50)

---

50. Best description of your use of a word processor throughout your high school career including all of your subjects?

Non-Parametric

```
          Mood median test of score

          Chisquare = 11.06   df = 6   p = 0.088

                                                     Individual 95.0% CI's
                      q50  N<=    N>  Median   Q3-Q1  --------+---------+---------+--------
No, can't use           0    6     3    41.2    31.4  (-----------+----------------)
No, no computer         1    6     3    45.8    24.4        (--------+-----------)
No, Can't type          2    5     1    48.5    19.9     (-------------+---------------)
No, Teachers object     3    5     1    45.8    17.3          (------+---------------)
Use < ½ time            4   15    17    54.0    36.3                (------+------)
Use > ½ time            5   14    15    57.1    27.0                (---------+---)
Use all the time        6    9    19    60.1    24.6                      (----+----)
                                                    --------+---------+---------+--------
                                                           36        48        60

          Overall median = 52.9


         Recoding 0, 1 & 2 to 0 = Did not use.
 MTB > code (0:2) 0 c10 c10

          Mood median test of score

          Chisquare = 10.56   df = 4   p = 0.033

                                                     Individual 95.0% CI's
                    q50  N<=    N>  Median   Q3-Q1  ----+---------+---------+---------+--
                      0   17     7    46.4    22.9    (---------+--------)
                      3    5     1    45.8    17.3   (---------+---------------------)
                      4   15    17    54.0    36.3             (----------+--------)
                      5   14    15    57.1    27.0            (--------------+-------)
                      6    9    19    60.1    24.6                       (-------+------)
                                                    ----+---------+---------+---------+--
                                                      40.0      48.0      56.0      64.0

          Overall median = 52.9
```

4.7 Question 6: Non-discriminating factors

There were 35 demographic questions asked of all students. These covered most of the areas over which school systems have some control. Areas such as parental education that are really beyond the control of the public school system were beyond the scope of this study. These questions are presented in Appendix F. Special symbols after the question number indicate a 95% confidence of at least one response being a discriminator.

A few questions are worthy of special discussion. They address areas that have been previously identified in the literature research as making a significant difference in the computer competency of students. This discussion is contained in the following sections.

4.7.1 Question 5a: Attitude

Due to the extensive literature produced about computer attitude, it was decided to test cognitive computer competency against an attitude survey. Kay's study (1990) was selected for several reasons:

- It is very recent.
- He has been active in the field.
- He published all of the "attitude" questions he asked on his survey (Kay, 1990. p. 467).
- He published the "cognative" questions for the computer competency area. (Kay, 1990. p. 468).

Kay's 10 question survey (1990, p. 467) was reproduced on the New Hampshire demographic portions of this test as questions 71 through 80. The cognitive items were divided into roughly the same basic skill areas as the NAEP survey and the state mandate (Awareness, Basic Skills, Application Software, and Programming). He utilized a seven point Likert scale for both the cognative and attitude portions of his study. This dissertation converted that scale to a five point Likert scale, where the "mildly agree" and "mildly disagree" items were deleted.

Kay's study was concerned with a Locus-of-Control. An operational definition for purposes of this dissertation would be the confidence of an individual to control his/her actions so as to get the computer to perform in a manner necessary to accomplish his/her function. It roughly corresponds to the older computer literacy definition of being able to use the effectively computer in one's educational or employment goals.

In Kay's experiment, the subjects rated their ability on a second seven point scale from "Very unsure" to "very confident" (Kay, 1990. p. 467). He then performed various cross item correlations between the various ability items and his locus of control. Kay concluded that "correlations between locus of control and [computer skills] ... were all significant ($p < 0.001$) (Kay, 1990, p. 470). It should be noted that Kay studied adult graduate students ages 21 to 51, and hence his results may not be directly comparable to this study. Nevertheless, it is instructive to replicate a portion of the experiment for internal comparison with the results of this study.

This study attempted to correlate directly with the cognitive score and the 10 Kay questions. It did not attempt to repeat the in depth psychological analysis that Kay performed. However, as the literature research for this study found and as Kay reported, "Previous research was ambiguous in demonstrating the relationship between computer literacy and locus of control" (Kay, 1990. p. 472).

> Hypothesis: There is a correlation between locus of control as measured by Kay and computer competency scores as measured by the NAEP assessment on this study.

> Null Hypothesis: There is not a correlation between locus of control as measured by Kay and computer competency scores as measured by the NAEP assessment on this study.

It is assumed that no significant difference will occur from changing from a 7 point Likert scale to a 5 point Likert scale. This assumption was confirmed during a telephone conversation with Kay (1992, Feb. 11). The results of the analysis are contained in Table 4.16. As shown, only five of the ten items correlate to score (probability < 0.05, marked with '*'). Only five of the ten questions had any significant difference in outcome between any pair of answers. Alpha (α) is the probability of rejecting the null hypothesis when it is true. Thus, if Kay's locus-of-control questions should have correlated about 95% of the time or better. One can use a binomial density to calculate the probability of 5 or fewer successes out of 10 tries with a 95% success rate. The probability is essentially 0 to four decimal places. This means that is highly unlikely that 5 questions would not have correlated with measured score by accident. Hence the null hypothesis cannot be rejected. When high school students are asked to self evaluate themselves about their computer competence or literacy, they do not do a very reliable job. At the bottom of Table 4.16, the actual Pearson's moment is given for those items. As shown, even for those items where the probability that a correlation did not occur by accident, the strength of the correlation is quite weak. The questions average approximately 5% of the variance in computer competency score. The next logical step is an item analysis, and multivariate analysis. Such analysis is beyond the scope of this study. A significant amount of additional analysis to determine a valid standard deviation to support an in depth parametric analysis would be required. From the data discovered in this study however, it can be concluded that any correlation between locus-of-control or other psychological factors, and actual cognitive knowledge cannot be assumed.

Table 4.16
Locus-of-Control (NHDQ-71 - NHDQ-80)

Probability of achieving the calculated Pearson's Product-Moment Correlation (not shown)

Parametric

	Score	Q71	Q72	Q73	Q74
Score		0.1285	0.0862	0.0725	0.0073*
Q71	0.1285		0.0014	0.0000	0.0009
Q72	0.0862	0.0014		0.0000	0.0000
Q73	0.0725	0.0000	0.0000		0.0003
Q74	0.0073*	0.0009	0.0000	0.0003	
Q75	0.2164	0.0000	0.0000	0.0000	0.0001
Q76	0.0033*	0.0053	0.0001	0.0001	0.0000
Q77	0.0301*	0.0000	0.0004	0.0000	0.0115
Q78	0.0178*	0.0060	0.0000	0.0002	0.0014
Q79	0.0008*	0.0000	0.0130	0.0000	0.0608
Q80	0.1282	0.1628	0.0001	0.0200	0.0024

	Q75	Q76	Q77	Q78	Q79	Q80
Score	0.2164	0.0033*	0.0301*	0.0178*	0.0008*	0.1282
Q71	0.0000	0.0053	0.0000	0.0060	0.0000	0.1628
Q72	0.0000	0.0001	0.0004	0.0000	0.0130	0.0001
Q73	0.0000	0.0001	0.0000	0.0002	0.0000	0.0200
Q74	0.0001	0.0000	0.0115	0.0014	0.0608	0.0024
Q75		0.0000	0.0000	0.0003	0.0000	0.0039
Q76	0.0000		0.0000	0.0000	0.0012	0.1091
Q77	0.0000	0.0000		0.0001	0.0000	0.0470
Q78	0.0003	0.0000	0.0001		0.0118	0.0000
Q79	0.0000	0.0012	0.0000	0.0118		0.9442
Q80	0.0039	0.1091	0.0470	0.0000	0.9422	

The table shows the and two-tailed Probability value of obtaining the calculated Pearson's product-moment correlation by chance alone.

The correlation coefficient measures the strength of the linear relationship between two variables on a scale of -1 to +1. The P value is used to test whether the coefficient is significantly different from zero.

The following pairs of variables are significantly correlated at the 5% level (Correlation Coefficient also shown as an indication of the strength of observed correlation):

	Correlation	% of Score Predicted by Question	P value
Score with Q74	-0.2214	4.9%	0.0073
Score with Q76	-0.2434	5.9%	0.0033
Score with Q77	0.1796	3.3%	0.0301
Score with Q78	-0.1959	3.8%	0.0178
Score with Q79	0.2748	7.5%	0.0008

One final check was made. Attitude surveys usually relate to the concept of 'like.' NHDQ asked the question of whether or not the first computer course improved a students attitude toward computers. NHDQ-47 and NHDQ-70 asked for a graduated like/dislike evaluation. Q-47 covered the overall 4 years of high school and Q-70 covered just the first computer competency course. An analysis of the responses two these two questions will permit some indication of the association between "like" and "retained capability". Recall, that high seniors are being tested, generally several years after their first computer course. It is possible that they did like computer at that time, but no longer do so. It is also possible that the like comptuers, and once did well, but have subsequently forgotten the details. Nonetheless, the state's objective is to produce high school graduates with computer capabilities, and it is not unreasonable to judge attitude and ability as close as possible to that graduation.

Table 4.17 contains the correlation presentation. This table is broken up into three parts, a parametric product-moment analysis, and two non-parametric tests, a Spearman's Rank Analysis for dual correlating and a Mood median single elements tests. They test the following hypotheses:

> Hypothesis: There is a correlation between liking computers or computer studies and the computer competency score.

Null Hypothesis: There is not a correlation between liking computers or computer studies and the computer competency score.

Table 4.17
Attitude (NHDQ-47 & NHDQ-70)

Part I of III Pearson's Product-Moment Correlation Analysis

47. Which state best describes your overall, 4 years of high school computer class experience or impressions (terrific [1] to awful [5])?

70. I found my first high school computer course improved my attitude toward computers (strong disagreement [1] to strong agreement [5])

Parametric

	Score	Q47	Q70
Score		-0.0222 (120) 0.8102	0.0448 (148) 0.5884
Q47	-0.0222 (120) 0.8102		-0.0046 (105) 0.9627
Q70	0.0448 (148) 0.5884	-0.0046 (105) 0.9627	

The table shows Pearsons product-moment correlation (sample size), and two-tailed P value.

The correlation coefficient measures the strength of the linear relationship between two variables on a scale of -1 to +1. The P value is used to test whether the coefficient is significantly different from zero.

The following pairs of variables are significantly correlated at the 5% level:

Correlation P value

<none>

Continued next page

Table 4.17 (Continued)
Attitude (NHDQ-47 & NHDQ-70)
Spearmans Rank Analysis

Part II of III

47. Which state best describes your overall, 4 years of high school computer class experience or impressions (terrific [1] to awful [5])?

70. I found my first high school computer course improved my attitude toward computers (strong disagree [1] to strong agreement [5])

Non-Parametric

Spearman's Rank Correlation Analysis

	Score	Q47	Q70
Score		-0.0143 (120) 0.8759	0.0535 (148) 0.5168
Q47	-0.0143 (120) 0.8759	3	-0.1258 (105) 0.1994
Q70	0.0535 (148) 0.5168	-0.1258 (105) 0.1994	

The table shows estimated Spearman rank correlation (sample size), and two-tailed P value.

The correlation coefficient measures the strength of the linear relationship between two variables on a scale of -1 to +1. The P value is used to test whether the coefficient is significantly different from zero.

The following pairs of variables are significantly correlated at the 5% level:

Correlation P value

<none>

Continued next Page

Table 4.17 (Continued)
Attitude (NHDQ-47 & NHDQ-70)
Mood Median Tests

Part III of III

Non-Parametric Q-47 Chisquare = 3.03 df = 4 p = 0.554

	q47	N<=	N>	Median	Q3-Q1	Individual 95.0% CI's
						----+---------+---------+---------+--
No Courses	0	8	6	46.8	33.6	(------+--------)
Terrific	1	3	6	78.6	43.5	(---------------+------)
Good	2	18	12	51.2	29.3	(--+---)
Neutral	3	26	31	54.2	24.4	(--+-)
Bad	4	5	4	52.4	20.2	(---+--------)
Awful	6	0	1	61.9	Not used	
						----+---------+---------+---------+--
						40 60 80 100

Overall median = 52.7

Chisquare = 1.76 df = 4 p = 0.780

	q70	N<=	N>	Median	Q3-Q1	Individual 95.0% CI's
						-----+---------+---------+---------+-
No courses	0	1	0	45.8	Not used	
Terrific	1	5	5	54.8	21.6	(-------------+------)
Good	2	16	11	45.8	33.3	(----+--------------------)
Neutral	3	28	28	52.7	24.7	(-----+----)
Bad	4	21	22	52.9	20.2	(---+---)
Awful	5	4	7	61.9	35.5	(-------------------------+--------)
						-----+---------+---------+---------+-
						40 50 60 70

Overall median = 52.4

Neither of the two 'attitude oriented' questions correlated with the actual competency score. Interestingly, but beyond the scope of this study, they do not correlate with each other. This check confirms that the null hypothesis cannot be rejected. The conclusion is that some attitude tests may not correlate with actual measured competency scores using a comprehensive instrument to perform the scoring.

4.7.2 Question 5b: Self assessment

Most of the computer attitude studies reviewed relied upon a self assessment of abilities. It is instructional to determine how well students can assess their own skills, as compared to those skills demonstrated on this outcome assessment. It is true that few of the attitude studies reviewed were performed on twelfth graders, thus the analysis in this study may not be transferable to older or younger people. The requisite hypotheses can be stated as follows:

> Hypothesis: There is a relationship between a students assessment of their own computer skills and their actual measured skills.

> Null Hypothesis: There is no relationship between a students assessment of their computer skills and their actual measured skills.

There are several approaches to analyzing this question. NHDQ-59 directly asked for just such a student's assessment of him/her selves. Table 4.18 present a non-parametric analysis of a student's overall assessment of themselves and their computer competency score. This analysis would indicate that the null hypothesis should not be rejected. The conclusion is that students cannot evaluate how competent they are in computers.

Table 4.18
Self described computer expertise (NHDQ-59)

```
---------------------------------------------------------------------------------------------
59. In your use of computers, as compared to others you know of your own age
    and grade level, do you consider yourself to be:
---------------------------------------------------------------------------------------------
Non-Parametric
             Mood median test of score

             Chisquare = 6.19   df = 4   p = 0.186

                                                     Individual 95.0% CI's
                  q59  N<=    N>  Median   Q3-Q1  ---+---------+---------+---------+---
Invalid               0     1      0    45.8  Not used
A non-user            1    12      5    42.9     26.8    (-------+-----------)
A novice              2    22     15    50.0     20.7            (-----+----)
An intermediate user  3    35     46    54.2     22.6                  (--+---)
An expert             4     3      5    67.9     28.4               (-----------------+------)
An ex-user            5     4      4    52.7     15.3              (-----+--------)
                                                     ---+---------+---------+---------+---
                                                       36        48        60        72
             Overall median = 52.

Note: ex-user one who used to use computers, but not currently.
      Non-user never used computer at all.
```

A second analysis was conducted using a question on the NAEP demographics asking the student to evaluate how good a programmer he/she thought he/she was. Table 4.19 contains the data for a students self evaluation of his/her programming expertise with his/her scores. As shown in the two largest groups, those who rated themselves as poor outperformed those who rated themselves as good. Since this question is contained only on one test booklet, the sample size is small. The result and conclusion are the same as determined in from the NHDQ analysis, not rejecting the null hypothesis.

Table 4.19
Programming ability (NAEP-Q31)

NAEP Q-31. How good are you at programming a computer?

Analysis of Many Samples for Score

	Class	Value	Sample Size	Mean	Standard Deviation
Very Good	1	1	4	80.95	16.0325
Good	2	2	3	49.2067	23.4896
Fair	3	3	8	51.1888	20.4794
Poor	4	4	11	58.0082	11.2312
Never	5	5	4	42.8575	7.7771

Kruskal-Wallis Test for Differences in Location

Non-Parametric Value	Sample Size	Average Rank
1	4	151
2	3	71.1667
3	8	89.5
4	11	103.636
5	4	52.5

Test statistic = -380.87
P value = 1.0000

4.7.3 Question 5c: Home computer

Martinez and others have identified family ownership of a computers as helping cognitive computer scores. This question was specifically addressed in NHDQ 45. The results are shown in Table 4.16.

Hypothesis: A family owned home computer helps computer competence scores in New Hampshire.

Null Hypothesis: A family owned home computer does not help computer competence scores in New Hampshire.

The results of a comparison of medians is illustrated in Table 4.20. As can be seen, the null hypothesis cannot be rejected.

It is the conclusion of the author of this study that the availability of computers throughout the state school system has nearly overtaken the advantage of those students nationwide that own their own home computers.

Table 4.20
Home Computer Ownership

Non-Parametric

Chisquare = 0.57   df = 1   p = 0.450

	q45	N<=	N>	Median	Q3-Q1
Have a Home Computer	1	34	38	54.2	24.8
Do not have a Computer	2	25	21	51.2	24.0

```
Individual 95.0% CI's
------+---------+---------+---------+
           (---------+-----------)
 (------------+--------------------)
------+---------+---------+---------+
     48.0      52.0      56.0      60.0
```

Overall median = 52.7

A 95.0% C.I. for median(1) - median(2): (-6.0,10.1)

4.7.4 Question 5d: Timing of last computer course

Martinez (1988) reported that the number of years since a student took his/her computer competency course will ultimately affect his/her computer competency score. In effect, it questions whether the beneficial effects of having more years to use the computer overcomes the detrimental effect of having more years to forget the material learned.

This question is similar to study Question 4, whether the school policy on the timing of the computer competency course made a difference. This question is based upon when the student reported taking the competency course. Even in a district where the course was offered in high school, a student could elect to take the course in their ninth, tenth, eleventh or twelfth grade. The hypotheses are:

> <u>Hypothesis</u>: There is a difference in computer competency outcome depending upon how long ago a student took their first computer competency course.

> <u>Null hypothesis</u>: There is no difference in computer competency outcome depending upon how long ago a student took their first computer competency course.

The requisite analysis is shown in Table 4.21. As shown, the null hypothesis cannot be rejected. From a examination of the data, it appears that the optimal time to complete a computer competency course at least two or three years ago. There is an exception of students who report their first course over 6 years ago. This group must have learned in grade school. The students studying within the last year also perform less well. The implication is that some computer usage gestation time may well be required to fully develop the skills. However, the probability of 0.18 does not support rejecting the null hypothesis.

Table 4.21
First Computer Course (NHDQ-56)

---

56. If you took a computer competency or literacy course how long ago was your first such course?

```
        Mood median test of score

          Courses over 6 years ago folded into 6.
          Students never haven taken course eliminated.

        Chisquare = 7.61    df = 5    p = 0.180

                                                    Individual 95.0% CI's
                      q56   N<=    N>   Median    Q3-Q1  -+---------+---------+---------+-----
within last year        1    14     8     47.1     22.2      (----+------------)
Within last 2 years     2    17    18     54.2     19.0           (-----+---)
Within last 3 years     3    17    19     54.2     15.5               (-+---)
Within last 4 years     4    13     8     47.1     19.3       (---+--------)
Within last 5 years     5     7     6     45.8     38.7  (--------+--------------------)
6 or more years ago     6     3    11     62.2     28.4                (-------+-----------)
                                                         -+---------+---------+---------+-----
                                                         36        48        60        72
        Overall median = 53.8
```

4.7.5 Question 5e: Computers in non-computer courses

This question is similar to question 4c in that it attempts to examine computer usage outside of computer classes. The difference is that question 4a considered such integration as a matter of school policy. This question examines the integration as a matter of student preference. For example, students could utilize their skills in an appropriate manner in spite of the teacher, rather than because of the teacher.

A relatively small percentage of students did utilize a computer in other classes, for word processing or anything else. The question is, did those students who reported computer usage do significantly better than those who did not? This leads to the following hypothesis:

> <u>Hypothesis</u>: The usage of computers in schools as reported by students was sufficiently effective that student scores would be improved over those students who did not report computer usage.

> <u>Null Hypothesis</u>: The usage of computers in schools as reported by students was not sufficiently effective, on average, that student scores would be improved over those students who did not report computer usage.

Table H.5 contains the responses to six NAEP questions concerning computer usage. They indicate that computer usage in various subjects areas has increased in New Hampshire as compared to the nation in all six subject areas questioned. Table H.6, which illustrate how often computers were used in four subject areas does not show increased usage in mathematics and English, but do show an increased usage in science and music. Tables H.5 and Table H.6 do not show a single significant relationship between the responses in those subject areas. The sample sizes are small because the questions did not appear in all booklets. Based upon just the NAEP questionnaire, the null hypothesis cannot be rejected.

In the New Hampshire Demographic Questionnaire (NHDQ), Question 66 was directly asked to provide a larger sample, and the results are shown in Table 4.22.

Table 4.22
Computer curriculum integration (NHDQ-66)

```
-----------------------------------------------------------------------------------------------
66. Taken as a whole, how would you best describe how computer were used and/or discussed in
your
    high school years (Do not count actual computer classes)
-----------------------------------------------------------------------------------------------
Non-Parametric

           Mood median test of score

           Chisquare = 5.14   df = 4   p = 0.274

                                                    Individual 95.0% CI's
                  q66   N<=    N>  Median    Q3-Q1  -----+---------+---------+---------+-
Almost all courses  1     1     3    75.0     45.5   (-----------------------------+----)
Most of courses     2    14    11    50.0     29.0             (---+-------)
Some of courses     3    16    17    52.9     24.4               (---+-----)
Few of courses      4    24    32    54.2     22.7                 (--+---)
None of courses     5    24    14    46.4     19.1            (--+------)
                                            -----+---------+---------+---------+-
                                                32        48        64        80
            Overall median = 52.4
            * NOTE * Levels with < 6 obs. have confidence < 95.0%
```

The analysis indicated that the null hypothesis cannot be rejected. The degree to which computers were integrated into classes, as sensed by students, did not significantly affect computer competency scores. Some caution is required, since those students who use computers in class do have a significant advantage. This can perhaps be explained by the difference between the teacher integrating computers into subject classes versus a student independently integrating computers into his/her school work, which is the subject of other questions.

Further study is recommended into this area to resolve the differences between student reports of computer usage, student reports of their own computer usage and computer competency outcome assessments.

4.7.6 Question 5f: Computer programming course

If a student had what they classified as a programming course in some language, would a student do significantly better on their computer competency score. This question was directly asked in NHDQ-49, leading to the following hypothesis:

> Hypothesis: Taking a programming course in high school makes a difference in computer competency scores.
>
> Null Hypothesis: Taking a programming course in high school does not make a difference in computer competency scores.

First, a MOOD median test of the entire range of answers was conducted. No statistical significance was found. The answers were collapsed into just two responses, the student did not take programming for any reason, or the student did take a program for some reason. A Kruskal-Wallis test was then run. The results are illustrated in Table 4.23 and indicate that the results are not statistically significant at the 95% confidence level. There is a difference in the score, as would be expected with a test containing programming questions, but the difference was not sufficiently large to be significant.

Table 4.23;
Computer programming course (NHDQ-49)

```
-----------------------------------------------------------------------------------------
49.  Have you taken a computer programming course in high school?
-----------------------------------------------------------------------------------------
Non-Parametric

            Mood median test of score

            Chisquare = 8.57    df = 9    p = 0.479

                                                                Individual 95.0% CI's
                    q49   N<=    N>   Median    Q3-Q1   ---------+---------+---------+--------
No, didn't want to   0     22    14    47.1     27.7          (-----+----)
No, lack prereq.     1      2     2    59.5     31.8             (--------+-------)
No, Not offered      2      3     1    43.8     16.7         (----+----)
No, Schedule Conflict 3     6    11    61.9     19.9                  (----+---)
No, but plan to      4      4     1    35.7     35.6    (----+------------------------)
Yes, hated           5      1     2    61.9     14.3                  (----+-)
Yes, disliked        6      1     4    61.9     12.8                 (-----+----)
Yes, ok              7     10    13    57.1     36.9               (------+---)
Yes, liked           8      7     7    53.1     30.0             (------+----)
Yes, really liked    9      4     4    52.3     48.1          (--------+----------------)
                                                        --------+---------+---------+--------
                                                                40        60        80
```

As illustrated, the results are ambiguous. To examine if the number of answers had an effect on correlation, the answers were recoded into a YES/NO. The results are shown pictorially in Figure 4.10. Several statistical tests then were utilized, and the results are shown in Table 4.24. The Mood and Kruskal-Wallis test are over the desired $\alpha = 0.05$, and do not support rejecting the null hypothesis.

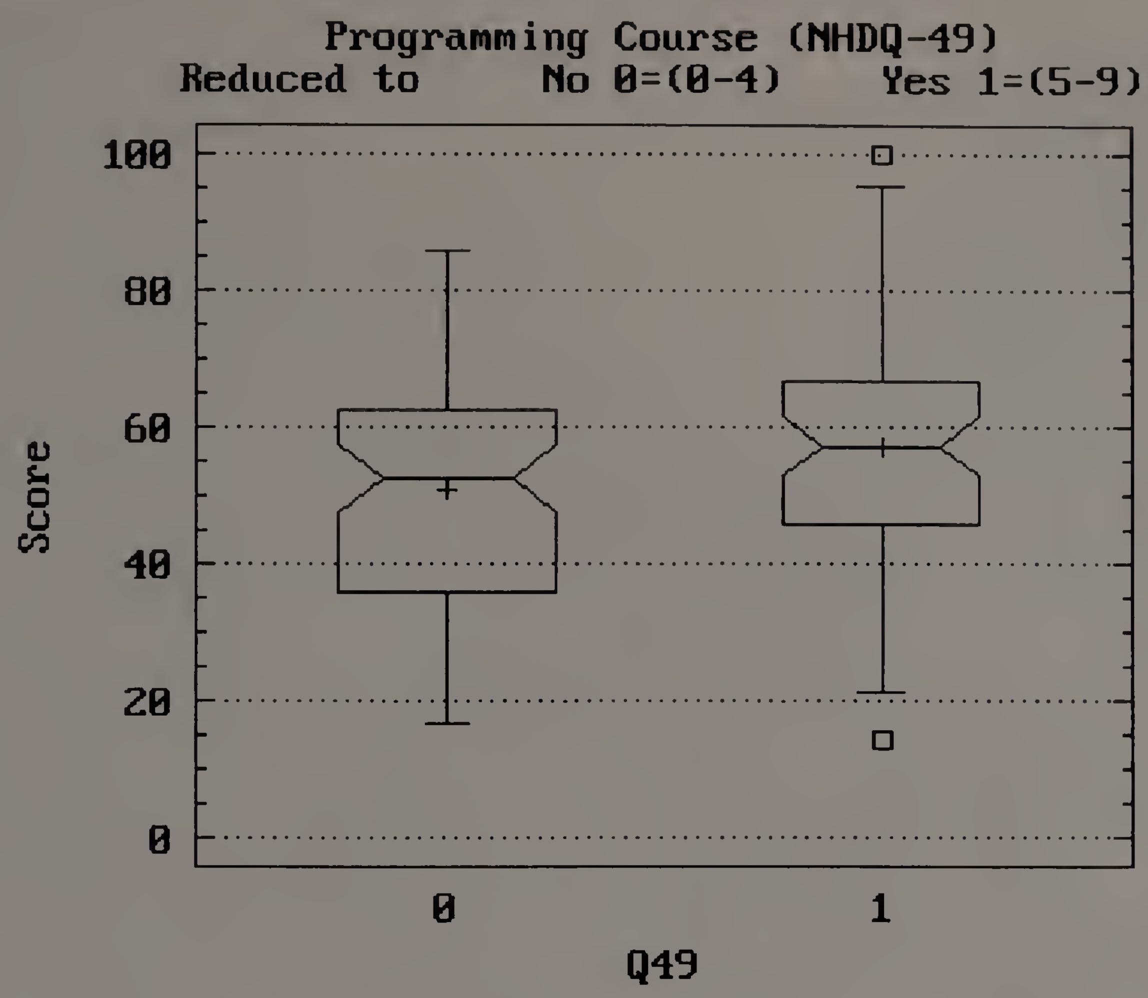


Figure 4.10
Programming course

Since the P value appears to be borderline, and the results of the test seem counterintutive, a further check was made utilizing the NAEP demographic data. A MINITAB Two Sample Ttest (TWOT) was run which assumes that the test scores are normally distributed. The result was an α = 0.051, greater than the critical value of 0.050. Again, the more powerful parametric test supports rejection of the null hypothesis, but only if the sample is parametric and the variance is correctly calculated, which, as previously documented, it may not be. To attempt to resolve this difference, and having exhausted other possibilities, the data available from the NAEP portion of the test was examined. NAEP did not specifically ask if a programming course was taken. However, one exam booklet number did ask a few questions that only people who had written programs were likely to answer positively. One example is "Have you tested or debugged a program" (NAEP, 1988b. p. 213). Since only one test contained this type of question, the sample size of this study is small (23). Several tests were run, both parametric and non-parametric, but the results are not shown in this report. The resulting "P" values were approximately 0.400, depending upon which statistical test was utilized. This is quite a bit greater than the critical value of 0.050

A more complete multiple parameter analysis is contained in Appendix G. The mixture of computer programing, student's sex, years of computing experience, and number of computing courses are compared with computer competency scores.

This study concludes that the null hypothesis cannot be rejected. The relationships are very complex, and the literature survey indicates that they are not well understood. All of the items analyzed in Appendix G are inter-related. The evidence simply is not strong enough to accept the conclusion that taking a programming course significantly increases computer competency scores. There is too much evidence that while taking such a course is a factor, it is not, in itself, a significant factor.

Table 4.24;
Recoded programming course (NHDQ-49)

```
-----------------------------------------------------------------------------------------------
49.  Have you taken a computer programming course in high school?
-----------------------------------------------------------------------------------------------

            Mood median test of score

            Chisquare = 1.89   df = 1   p = 0.170
Non-Parametric
                                                     Individual 95.0% CI's
                 q49   N<=    N>   Median    Q3-Q1  ---------+---------+---------+-------
Yes (0-4)          0    37    29     52.4     27.3   (------------+--------)
No  (5-9)          1    23    30     57.1     24.7          (-------------+----------)
                                                    ---------+---------+---------+-------
                                                          50.0      55.0      60.0
            Overall median = 52.9

            A 95.0% C.I. for median(0) - median(1): (-14.8,2.4)

Non-Parametric
            Kruskal-Wallis

              119 CASES WERE USED
               49 CASES CONTAINED MISSING VALUES

            LEVEL     NOBS     MEDIAN  AVE. RANK   Z VALUE
No  (0-4)        0       66     52.38       55.0     -1.76
Yes (5-9)        1       53     57.14       66.2      1.76
            OVERALL    119                  60.0

            H = 3.08  d.f. = 1  p = 0.079
            H = 3.09  d.f. = 1  p = 0.079 (adj. for ties)
```

Computer courses do increase computer competency scores. However, computer courses which concentrate on subjects other than programming may work just as well as programming courses. The effects of different curricula in a second, third or fourth computer competency courses is an area deserving of future study. No studies in this area were located in the literature review.

CHAPTER 5.

SUMMARY, CONCLUSIONS & RECOMMENDATIONS

5.1 Summary

This study performed a computer competency outcome assessment of 10 New Hampshire high schools. The enrollment at the schools sampled represented approximately 15% of the state's public school enrollment, and 19% of the private school enrollment. Approximately 8% of the seniors at the participating schools were sampled. 168 students were sampled, 95 males, 68 females and 5 unknown.

The method of assessment was to repeat the National Assessment of Educational Progress (NAEP) 1986 computer competency survey (Martinez, 1988). The survey consisted of 124 cognitive items and 75 demographic items. An additional 35 demographic items, designed for this survey, were administered. The 1986 NAEP survey is the most current large scale sample available. It is possible the nation as a whole has improved its computer competency, but there is no quantitative information to support that contention.

The study was limited to schools in the state of New Hampshire. Within New Hampshire, it concentrated on those demographics most likely to be affected by town and state school policies. Factors beyond the control of these agencies were ignored.

The study examined 22 major hypotheses, and the null hypothesis was retained in 9 of those. Furthermore, 5 subgroups identified by NAEP were examined, and the state exceeded the national outcomes in 3 of those groups.

A summary of the five general questions put forth in the introduction, and a necessary data prerequisite, "question 0", are summarized below:

0. Identify sample characteristics.

   (1) The average scores are normally distributed.

   (2) The test booklet number used by a student significantly affects the score.

1. Locate significant differences among types of schools throughout the state, if any.

   (1) There were none. The state is remarkably uniform.

   (2) There is no difference between public and private schools.

2. Compare the state of New Hampshire schools to the nation as a whole. The five comparisons are listed below with their results:

   (1) The state student scores are significantly better than the best national sample available.

   (2) The state performed better than the northeast national sample. This is true for the total population as well as for boys and girls individually.

   (3) There is no difference between large and small schools or city and rural schools.

   (4) There is a no difference in state scores based upon ownership of a home personal computer.

   (5) There is no difference between the state as a whole and those students nationally whose parents are college graduates.

3. Identify differences, if any, in computer competency outcome which could be attributable to different local school policies. The factors analyzed are indicated below:

(1) There is no difference in outcomes depending on the school district's choice of using a high school or junior high school course.

(2) There is little indication of integration of computer skills into non-computer classes has been effective. The degree of integration was not high enough to affect computer competency scores significantly.

(3) There is a difference in outcomes depending upon the curriculum used in a computer competency course. A balanced curriculum as recommended by the state achieves better scores.

4. Discover discriminators, if any, which are attributable to student demographics or curriculum choices. The demographic characteristics that did make a difference in outcome are enumerated below:

(1) Student's sex. Boys' outcome is higher than girls', for essentially all experience and semesters studied levels.

(2) A <u>first</u> computer course no later than the junior year to allow time for practice and reinforcement.

(3) Increased years of computer experience.

(4) Increased semesters of computer studies.

5. Discover demographic characteristics which have been identified in the research literature, but do not make a significant difference in New Hampshire at this time. These areas are are listed below.

(1) Attitude or locus-of-control as used by many psychological testing studies.

(2) Self assessment of a students knowledge.

(3) The years since the <u>last</u> computer course.

(4) The use of computers in non-computer courses.

(5) A computer programming course.

(6) Home ownership of a computer.

5.2 Conclusions

Based upon individual hypotheses tested, which are summarized above, and the authors experience with computers in general, some conclusions can be drawn.

5.2.1 Required computer course

One major conclusion of this study is that the resources, programs, curriculum requirements and teacher preparation required by the state of New Hampshire are improving state wide computer competency outcomes. The computer competency outcome scores of the state sample are significantly above the national norms. By inference, a state policy of requiring a computer competency course does, over time, improve computer skills significantly beyond a general mix of elective courses found nationwide.

5.2.2 Local school autonomy

The state dictates computer competency policies, principally requiring a course of its students, teacher training, and assistance in purchasing many computers for students, faculty and administrators to use. Nonetheless, school districts still have great freedom in implementing these polices. The final outcome assessment showed a remarkable degree of uniformity across the state school system. There was no difference on how early the mandated course is taken (there is a difference on how late it is taken), junior high school or high school, whether the schools are public or private, whether the schools are large or small, or in urban or rural areas. All of the states students are offered equal opportunities to learn computer competencies, and they achieved more retention than the nation as a whole.

It should be noted, that there is a relationship between the number of semesters computer are studied and outcome assessment results. To achieve higher outcomes, high schools should offer follow on courses to the first computer competency course independent of when the first course is taken. The policy of creating a large demand competency course seemed to have the effect of creating a pool of teachers, laboratories and interested students to staff and fill these courses.

A policy of requiring a substantial portion of papers or reports to be prepared using word processors, independent of the subject, and without each instructor teaching word processing, appears to have great promise for increasing outcome scores. Such a policy implies that students are taught to type early in their school career, and that computers are available before, after and during school for students to use for homework. Such a policy in itself would not necessarily improve outcomes, but it is an excellent reinforcement mechanism for knowledge gained in a computer competency course.

5.2.3 Student discriminators

Statistically significant discriminators were sex, years of computer experience, curriculum content and word processing usage.

A student's sex was the single largest discriminator. Boys did better than girls. This was true at all levels of experience, study and computer usage. This study made no attempt to investigate any reasons for this finding.

Computer experience was the second largest discriminator. Number of semesters studied and amount of computer usage in non-computer subjects were in turn correlated with the years of computer experience. This sex difference was true at all levels of experience, further confirming the first discriminator.

The type of curriculum provided in the first computer course also significantly affects computer competency outcome. The best results were obtained with a multi-subject mixture of material, topics, applications, typing, and programming. A simple word processing or keyboarding course or a complex programming course achieved a statistically lower outcome than a multi-subject course.

When the first course was taken was significant. While it makes no difference how early the first course is taken, it does make a difference how late the first course is taken. It should be taken before the junior year of high school for optimal results. This permits at least a few years of computer using experience prior to graduation. This experience can be obtained simple word processing usage.

The amount of word processing significantly affects outcome results. Individual students who learn word processing and typing, as well as taking a broad based computer competency course will outperform most other students. Those students who studied several semesters of computers and used word processing will tend to score highest.

5.2.4 Student non-discriminators

There were several demographic characteristics that have been mentioned in various studies that were found not to have been significant in this study. These include home computer, whether a computer programming course was taken, when the last computer course was taken, and the degree to which computers were integrated into other classes.

The lack of significance of having a home computer is perhaps the most surprising finding. This can be ascribed to sufficient availability of school computers to provide the needed access to develop and maintain computer skills. Computer access is the key to improved outcomes, not where the computer is found. The state schools have sufficient computers now to overcome much of the advantage of a home computer (12 students / computer).

When the last computer course was taken was not as important as the continued use of a computer. It is the continued use of a computer that affected outcome. Use of a computer needs a reason and taking a computer course apparently is a good reason to use a computer, but not the only reason. Word processing seems to help this usage, and consequently computer competency outcomes.

5.2.5 Computer integration into courses

Direct determination of computer usage in non-computer courses, and its effects on competency outcome was ambiguous. When asked if computers were used at all, students in the state showed significant advances over the national sample. When asked how much the computer was used rather than if it was used at all, no improvement was found in total time spent using a computer. When asked how much computers were used throughout their high school experience outside of computer classes, the majority of students reported essentially no usage. The majority of those that did report usage reported self-starting areas such as word processing where no teacher participation was necessary.

It does not appear that integration is happening as many educators assumed or wished. What integration there was did not teach students about the computer or how to use them. Computer competency, like English or mathematics, is best done in a course designed for that purpose. Computer integration into other courses does serve to reinforce computer knowledge, but such integration does not instill this original knowledge. Given a starting knowledge, computer usage is primarily in word processing and other computer courses.

There was sufficient use of computers by teachers and administrators to provide role models for students throughout the school system. Role models of computer usage by teachers and administrators were noticed by almost all students. They, plus the course work, are succeeding in motivating students. Students seem to genuinely want to learn more about computers.

If the state intended to increase the computer skills of students through computer integration into subject areas, there is no indication of success, and some indication of failure in this study. There was very little reported computer usage by students in classes other than computer courses. This study did not address if computer usage helped learn other subjects, but students who reported such usage were no more computer competent than other students, even though both groups have had at least one computer competency course. Computer integration into courses, even if accomplished, does not appear to be a replacement for specialized computer courses. Such usage might help individuals, but not on a large enough scale to affect the average scores of a large group of students. This conclusion does not mean that computer integration does not help learn a subject such as science, geography or history. It simply means that such integration is an inefficient means of learning about computers, and how they are used in a more general sense. Such integration usually fails to address the historical, social, ethical and literature issues that are important in any discipline, including computers.

5.2.6 Student desires for more computing

Students were overwhelming in expressing their desire for more computing in high school. The majority found computer studies interesting (Table I.1). They felt that the school was teaching them the computer skills they needed (Table I.2). They also felt that not enough computer usage was included throughout their curriculum. Forty-two of the students went on to study more than the single required computer course (Table 4,14).

5.2.7 Computer attitude studies

The most important of these findings from a research point of view is the lack of correlation between a students actual cognitive score in a large examination, and his/her self reported abilities or feelings. A less comprehensive test or self evaluation is typically performed in computer attitude or locus of control investigations. Apparently, seniors in high school do not have a very good self concept of their abilities. Those who know something have begun to learn how little they know. Those who know little feel that amount is sufficient. Students who do not particularly like computing seem to be able to master elementary skills and knowledge as well as students who like computing. Some students who really like computing seem to have no developed or measured ability for computers. On average, these differences cancel each other out. The net effect does not favor those who think they know computers and like them. This finding casts some doubt on much of the testing that has been done in the computer competency area over the last 10 years, at least with respect to teenagers.

<u>5.2.8 Outcomes assessments feasible</u>

One conclusion of this study is that other researchers can replicate assessments of a similar size and scope. This study, as well as the NAEP data can be used as a basis of comparison for other large, multi-school groups, such as large cities, states, counties and regions of the country. As such, it can provide a yardstick to measure the success of various computer competency policies (including no policy). The test instruments are reasonably up to date. They are available by special request, from NAEP in Washington, DC or at ETS in Princeton, NJ. The national sample is superbly documented. A medium scale survey such as this can be replicated in different areas at a relatively low expense and effort. This study was done by one person, with no external or special funding or support beyond the normal resources of the university available to any graduate student, and a good dissertation committee for advise, and the assistance of NAEP and ETS personnel.

<u>5.3 Recommendations</u>

This study has five basic recommendations. These are enumerated below.

<u>5.3.1 Required computer competency course</u>

The state of New Hampshire should continue its computer competency policies and programs. They are working. While these policies will certainly change with time and circumstances, the commitment of a required course of some type should not be reduced without strong evidence that the new policies are really an academic content replacement, and not simply an administrative replacement of the existing system.

Computer literacy courses should be structured approximately as recommended by the New Hampshire model, with a mix of applications, literacy, programming, and operations. There should be follow-up courses in programming, operations, networking, writing, graphics or any other area desired. It is not necessary or desirable to concentrate follow-on courses in just programming. These courses should be available on an elective basis available for students who desire them.

5.3.2 Word processing and keyboarding

It is the study author's opinion that typing and keyboarding should be conducted as early as possible. All students should have had a typing or keyboarding course prior to their second year of junior high school. This course should concentrate on typing skills, not computer literacy or writing. Those mechanical competencies should then be brought forward into both writing and computer competency courses.

It is recommended that, as a matter of school policy, students should be required to submit a percentage of all written work for each course using a word processor. Perhaps 50% would be a good goal. The teacher should require correction and resubmitting of some of these papers. To implement this recommendation, a word processing laboratory is needed at schools. This laboratory needs to be available to students before, during and after school. The English laboratory seems to be the next computer laboratory of choice for some schools. One school actually offers an English / Word Processing laboratory as an elective course. This recommendation simply suggests that its use should be encouraged by policy, and not left to chance.

5.3.3 Improving performance of girls

Additional study is certainly indicated into the areas of sex differences in computer assessment outcomes. The gap between males and females was larger in this study than in the national assessment. Some girls do quite well, but on average, they do not score as well as boys. Research is required to determine why this occurs, find a solution, implement it, and show by assessment, that this new solutions does indeed works. Without some solution to this problem, girls may find themselves at a serious disadvantage in tomorrow's job markets.

5.3.4 NAEP update

It is the study author's opinion that the NAEP instrument should be reviewed and updated. This does not mean that new questions necessarily need to be added. It means that it should go through the normal standardized test processes of standardization. This would result in a test that can be given to smaller groups, without the problems of six significantly different test booklets. Such a test is needed if teachers and administrators are to have any quantitative yardstick with which to measure results.

The questions in the assessment should be reviewed, and perhaps updated. While there have not been a lot of changes in computers, there have been some. The four areas that come to mind are:

- Communications and networks, including quasi-public networks such as Internet and Compuserv, electronic mail and special interest mailing lists such as Kidsnet.
- Graphics, including animation. This could be expanded to include multi-media, computer photography and real-time photography.
- Databases, including CD-ROM's, library catalogues and public (not necessarily free) databases such as Dissertations Abstracts On-line.
- Desktop publishing where text, tables and graphics are integrated.

These technological changes are still in their infancy, but adjustments do need to be made.

Finally, NAEP should consider conducting another national assessment in 1996. The assessment of computer knowledge once per decade seems reasonable. It is the study author's opinion that it is time to see if the nation as a whole has improved its computer competency.

5.3.5 Further surveys

Finally, and perhaps most importantly, other state and large scale outcome assessment surveys should be conducted.

Computers and automation represent a significant investment by government and industry. The research for this study indicates that computers and automation are areas with a surplus of opinions and a shortage of hard data. There are few areas where investments of such magnitude are essentially unmonitored.

5.4 Speculations

This study did not really look into the future directly. It only attempted to measure what competencies exist now. But in the process of doing that assessment, the literature survey that accompanies it, and the general experience of the author (6 years military, 14 years commercial data processing, 7 years college computer science teaching), some observations and speculations were obtained.

5.4.1 Employment training

Computers are a fact of life in the work place. It is doubtful if they will simply go away. This country needs skilled workers, who must be able to utilize those computers effectively. Since the adoption of the IBM PC (and Apple Macintosh) by schools, a congruence of interests of schools, students, parents and business has occurred with respect to computer skills. To the extent that the congruence lasts, there will be a great deal of support for computer courses. To the degree that they diverge, with school interests and business interests separating, no matter which one "advances" and which "remains stationary", the strong support of all parties will evaporate, along with the resources that schools have acquired for computers. High schools need to closely match the portion of a students time devoted to "skill acquisition" to the employment and advanced education skills needed by industry and higher education. Such "skill transference" is one of the missions of the public education system.

5.4.2 Classical educational benefits

Computer competency can be viewed in essentially two manners, education and training. If computer competency courses are viewed as a mechanism to teach employment skills, they have been successful for the most part. If computer competency is viewed in the light of the general educational mission of schools, with its goal of higher academic and cognitive skills, it is doubtful if such a broad based computer course has been very successful for all, or even most students. The course has certainly has been effective for some students. It could be forcefully argued that it has been a waste of time for other students. For most students, it was probably neither, just another course. Unfortunately, this dissertation could not locate any research which would allow those three groups of students to be identified before, during or even immediately after their first computer course.

5.4.3 Pressure for change

Computer literacy or competency has changed its meaning over the years. It will continue to change. Any attempt to predict this change has a high potential for error. Predictions also have an attempt to be dated quickly. However, from studying, teaching, working in industry and conducting assessments in the area of computer competence, the study author cautiously makes the following predictions in future directions. These changes will be driven by several non-coordinating and random factors.

5.4.3.1 Ability tracking

The basic computer competency course is already ability "tracked" in New Hampshire in some districts. Potential science majors in higher education need different skills coming out of high school than other majors. Non-college bound students may need different skills. In the past, it was thought of as one set of skills for students of all abilities and interests. Early experience in grade school and junior high school improve non-uniformly. High school courses will upgrade themselves for better prepared students while maintaining the basic courses for other students.

Schools will change naturally, as typing skills are learned in grade schools, and word processing in junior high school (K-8). High schools will find may students wanting more from their first course at the 9-12 level than those schools are currently offering. What the new offerings will be is problematic. It will often depend as much on the talents of individual teachers and the availability of equipment money and grants as any master plan this study could propose.

5.4.3.2 Technology changes

Technological changes will also necessitate some changes. For example, the changes in wide area, telephone based networks and bulletin boards may require some changes in the way communication, both computer and personal, is taught. Inexpensive wide area communications will encourage electronic mail systems. These will require different work habits, typing skills and computer competencies than stand alone units.

Graphics power is just being opened to virtually everybody. This not only includes the classic business graphic systems, but the thousand color, high resolution picture systems. The full meaning of scanners, direct digital imaging, animation and extensive graphical capability of many software packages could have a large impact on business communications. "Writing" pictures that tell a story is a vastly different skill than "writing" words to tell the same story.

5.4.3.3 Industry demands

Industry will also impose its demands on tomorrows high schools. The full and expanding range of personal productivity equipment, such as facsimile machines, and their interface with word processors, scanners, communications and other computer equipment may also need to be taught to some fraction of students. Todays highly automated telephone systems are also devices that could easily require some training. Industry is already adopting desktop publishing extensively. Those systems require a knowledge of word processing, layout, graphics and artistic sensibilities not generally learned by accident.

5.4.3.4 Higher education desires

Higher education will also insert its demands into the situation. They are finding "Introduction to Computers" an expensive course to offer for many reasons. Increasingly, more colleges are ceasing to offer large numbers of sections of such courses. To date, colleges have poorly vocalized what computer skills they wish of entering freshman. This will probably change in the future. When and if higher education does decide to express such an opinion, what specific skills they will want collectively is unknown.

The most common desire currently voiced by higher education is to require a student's ownership of his/her own computer. By extension, high schools should spend some time on how to select the proper computer and software, plus purchase them wisely. Installation and maintenance of both the hardware and software, plus the basic operations of those systems would probably be demanded by students, parents and higher education administrators.

5.4.4 Future directions

The future of computer comptency education will be a reaction to all of the pressures discussed plus many others. The previous sections provides a partial listing of the various groups which will demand more computer education. The outcome of just those pressures is difficult to predict.

In all probability, the next real change to computer comptency education will be caused by a computer hardware which will revolutionize hardware as the Apple II or IBM-PC did in its day. But then it could be changed by a software, just as spreadsheets changed the perceived utility of computers to business groups. It could also be caused by the gradual usage of computers in all subjects because the newer teachers experienced extensive pre-service usage of computers in their college education. The most little noticed change is the increasing presence of small, inexpensive machines that perform single functions, such as the pocket sharps machines with word processors and spread sheets built in, along with communications abilities to microcomputers. While the machines may be small and inexpensive, their use is non-trivial.

All this dissertation will predict is that change will occur. The concept of computer literacy or computer competency school courses has been in a constant state of change for at least 40 years. There is no force on the horizon which will slow that change. This study indicates that some skills are gained by requiring such a course specifically designed to teach computer skills. As groups learn that these types of courses do indeed work, they will want them. States will compete to provide the "best trained" workers, and the change will continue. Parents will want their children to have all the advantages possible. Business will wish for better trained workers.

Industrial designers will automate more functions to reduce costs and compete internationally. Politicians will promise that America's children will have the highest computer competency in the industrial world. Educators will have no choice but to respond. As shown in this study, requiring a course in computer competency does, on a broad average, increase competency in this area. Few other disciplines can demonstrate as much a gain from a single semester course.

APPENDIX A

GOVERNOR'S TASK FORCE DEFINITION

New Hampshire
Student Outcome Performance
Computer Competency

From
Governor's Task Force on Education
December 1990.

The following section is an extract from an insert into the Governor's Task Force on education, the <u>Student Performance Outcomes</u>. Section IX is quoted in its entirely.

"IX. COMPUTER COMPETENCY
In this information age, computer literacy is an essential element of learning. Without computer skills will be unable to manipulate the vast amounts of information that will be presented to them throughout their lives. Although it is included here as an academic competency, it is really a tool to be used in all the other skills areas. Computer competency is inextricably integrated throughout all of the academic skills.

- Demonstrate awareness of when and how computers may be used in the academic disciplines and various fields of work, as well as in daily life.
- Understand the problems and issues confronting individuals, and society generally, in the use of computers, including the social an economic effects of computers, and the ethics involved in their use.
- Demonstrate a basic knowledge of how computers work and of common computer terminology.
- Use computers and appropriate software for:

    - self instructions.
    - collection and retrieval of information.
    - word processing (including development of keyboard, composition and editing skills).
    - modeling, simulation and decision making, and

- problem solving - both through the use of existing programs and through experience with developing one's own programs."

(NH Governor's, 1990, Enclosure, p. 11).

Additional information is available on the details of implementation of these general guidelines in the Standards for the Approval of New Hampshire Public High Schools, Grades 9-12. (NHSDE, 1984).

APPENDIX B

STATE COMPUTER COMPETENCY DEFINITIONS

"New Hampshire State Department of Education
Student Competencies
for
Computer Education

Awareness

The committee recommends that a minimum of 10 days, and a maximum of 20 days be devoted to this section.

The Student will

Know the history of computers:
- Identify the characteristics of each generation of computers....
- Identify key individuals in the development of computers....
- Describe the historical development of the computer as a whole.

Identify major uses and careers:
- Describe common uses of computers.
- Identify major computer-related occupations.
- Identify tasks which are not suited to computers.

Understand the social and economic issues:
- Describe the economic impact of computers on New Hampshire.
- Identify at least three ways in which computers affect his/her life.

Recognize the ethical and moral issues:
- Identify at least three major issues of concern regarding the ethical use of computers.
- Discuss the issues of computer crime, software protection, and copyright laws.
- Discuss the issues of privacy, depersonalization and impact on employment opportunities.

Suggested activities ...

Operation

The committee recommends that a minimum of 45 days and a maximum of 55 days be devoted to this material.

The Student will

<u>Recognize</u> the makeup of a computer:
- Demonstrate proper procedures in the handling and basic care of computers.
- Identify the basic components of a computer.
- Recognize and use appropriate computer vocabulary.
- Distinguish between software and hardware.
- Classify peripheral equipment as input or output devices....
- Describe how data is treated by the computer: (Input - Process - Storage - Output)
- Demonstrate the proper procedure for operating a computer by logging on, loading a program, interacting with it and logging off.

<u>Use</u> proper keyboarding skills:
- Identify and use letters and numbers on a keyboard.
- Identify and use common special-purpose keys.
- Demonstrate proper keyboarding skills in entering data into a computer.
  - <u>Note</u>: It is not intended that this be a typing course. However, some attempt should be made to enable students to enter data efficiently.

<u>Demonstrate</u> the appropriate use of software:
- Identify the different types of software: operating system, programming languages and application software.
- Demonstrate the use of drill and practice <u>or</u> a simulation package.
- Given a simple software evaluation form, use and evaluate at least one software package (e.g.: a game, drill pack, word processing program or test review software).
- Use a software package to create, edit and print a document which is approximately one page in length.
- (Optional: time permitting) Demonstrate the use of a database or spreadsheet program

Suggested activities ...

Programming

The committee recommends that a minimum of 20 days and a maximum of 30 days be devoted to this topic.

The student will

<u>Program</u> the computer to solve a given problem:

State the problem clearly.

"Fill-out" the problem - specify what information is needed.

Develop a problem solving plan or algorithm.

Identify sub-problems and tasks, deal with them individually, and relate them back to the central problem.

Use an appropriate language or computer-based system for solving the problem.

Write the necessary code or data-entry instructions.

Correct errors in logic and debug errors in coding.

Look back, determine whether or not the question was answered and consider alternative solutions.

Modify a program

Suggested activities ..." (NHSDE, 1984; from a extracted copy provided to this study author. Circular numbered p. 1-3).

APPENDIX C

NAEP ASSESSMENT DESCRIPTION

This appendix contains a generalized description of the total assessment bank of six assessment instruments from the NAEP study by Martinez (1988). NAEP reports, findings, objectives, frameworks and figures are public domain and not copyrighted. They are open to public use, and may be copied. Some material is secured release, and requires non-disclosure forms. No secured material is contained in this section.

A visual representation of the makeup of the cognitive portions of the assessment is contained in Figure A.1. The division into the three content areas follows the divisions used in the New Hampshire mandated contents. The New Hampshire content areas was presented in Appendix A and Appendix B.

The NAPE heading of Applications contains all of the various applications of the New Hampshire Operation section. While the New Hampshire specifications on applications are vague, they permit expansion into virtually any area a teacher could desire. Thus, they may be expanded into networks, telecommunications and CD-ROM data bases without having to change the regulations. NAEP did not have the luxury of imprecision, since they had to specify the applications in common use in 1986 to generate the specific test questions.

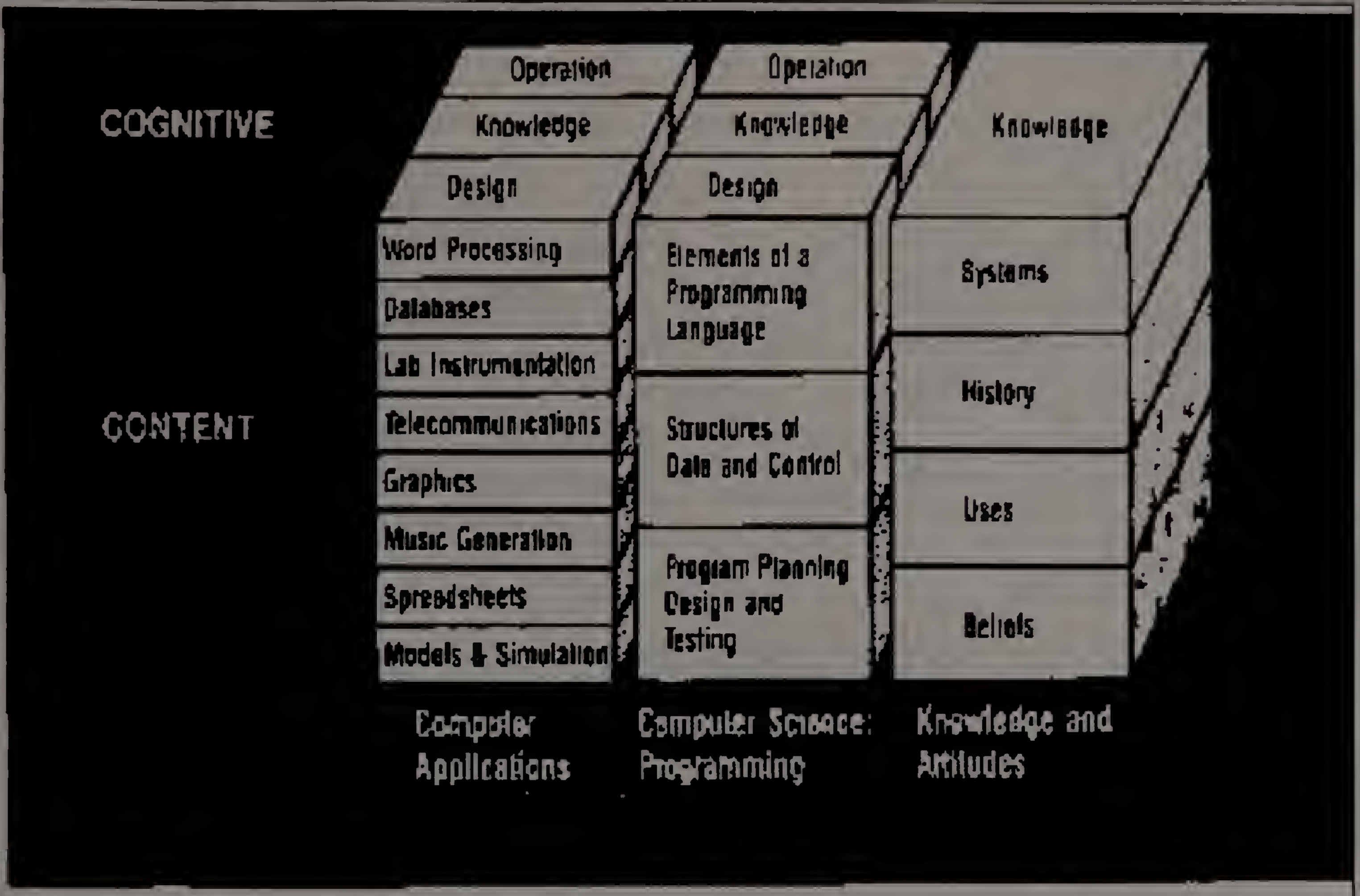


Figure C.1
Computer competence categories:
Cognitive and content areas
(Martinez, 1988, p. 76)

The New Hampshire sections under Operations relating to hardware, operating systems and keyboarding are tested under the NAEP Knowledge section, systems subsection. The Programming sections are similar in interpretation, as practiced in New Hampshire today.

The depth dimension of the NAEP categories, Design, Knowledge and Operation corresponds to the New Hampshire competencies of Know, Recognize or Understand, and Demonstrate or Use. These New Hampshire terms were explained in Appendix B under each of the major knowledge area competencies.

Table C.1 contains the sample sizes of the Public Release data tape. The total size is published in the NAEP codebook (1989a, p. 2). The computer competency record count was derived from programs written for this study.

Table C.1
NAEP sample size
Grade 11 and/or Age 17

Total Students tested =	39,753 students
Computer Competency Sample =	2,433 students

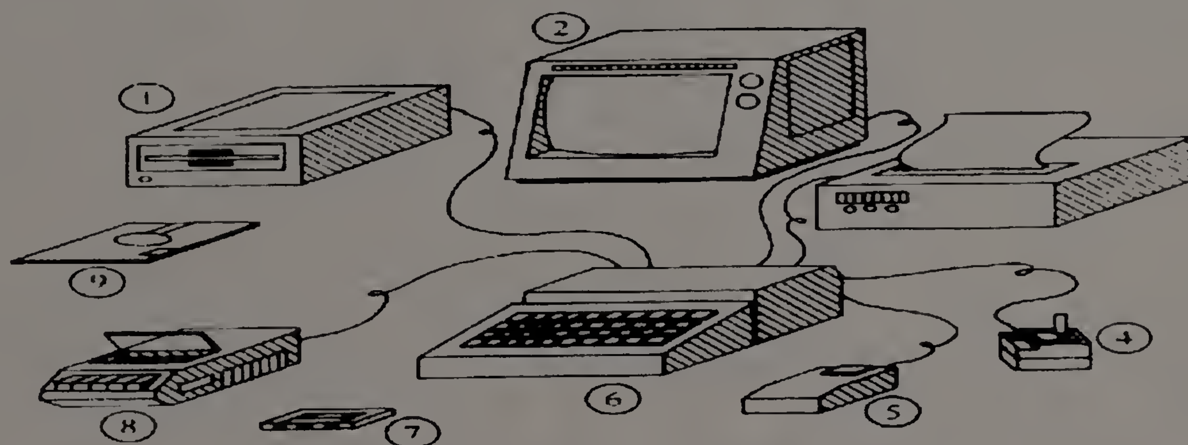
Table C.2 lists the number of background and cognitive questions in each of the 6 booklets (NAEP, 1988, p. 35). Two cognitive questions were subsequently disqualified due to printing errors, leaving 124 valid questions. The number of computer programming questions are listed in parentheses after the total cognitive questions. Programming questions represented 46% of the total questions. Cognitive questions were unique to each booklet. Background questions were not unique.

Table C.2
NAEP question block composition

Block Number	Background Questions	Cognitive Questions	Open End Questions	Total Questions
c1	21	23 (11)	2	44
c2	15	21 (10)	3	36
c3	4	24 (9)		28
c4	23	17 (8)		40
c5	20	24 (10)		48
c6	19	17 (9)	1	36
Total Unique	75	126 (57) [124 (55) valid]		

(Programming Questions in parentheses)

Figures C.2 through C.8 are copied from the public release portion of the examination (Askew, 1991). The captions also show the Martinez (1988) page numbers for these same documents. The actual document contains other sample questions. The examinations themselves are part of a government secured release from NAEP. These questions were selected to illustrate the types of questions found. They do not represent the general ratio between application areas.



1. Which picture shows a keyboard?

Picture 1	Picture 2	Picture 3	Picture 6
○	○	○	●

2. Which picture shows a disk drive?

Picture 1	Picture 3	Picture 8	Picture 9
●	○	○	○

3. Which picture shows a joystick?

Picture 4	Picture 5	Picture 7	Picture 9
●	○	○	○

4. Which picture shows a display screen or video monitor?

Picture 1	Picture 2	Picture 3	Picture 6
○	●	○	○

5. Which picture shows a floppy disk?

Picture 4	Picture 5	Picture 7	Picture 9
○	○	○	●

6. Which picture shows a printer?

Figure C.2
Sample knowledge questions
(Martinez, 1988, p. 11)

Put dough in a piy dish. Grese piy dish. Open can of cherry piy filling and pour it in piy dish. Bake at 350 degrees for 45 minutes and left cool.

1. "Pie" is spelled wrong four times. What is the best way to fix this problem?

- ● Search and Replace
- ○ Move (or Cut and Paste)
- ○ Insert
- ○ Delete

Put dough in a pie dish. Grese pie dish. Open can of cherry pie filling and pour it in pie dish. Bake at 350 degrees for 45 minutes and left cool.

2. The word "grease" is spelled wrong. What command is the best way to fix this one error?

- ○ Search and Replace
- ○ Move (or Cut and Paste)
- ● Insert
- ○ Delete

Put dough in a pie dish. Grease pie dish. Open can of cherry pie filling and pour it in pie dish. Bake at 350 degrees for 45 minutes and left cool.

3. The words "Grease pie dish" should go before "Put dough in a pie dish." What is the best way to fix this problem?

- ○ Search and Replace

Figure C.3
Sample word processing questions
(Martinez, 1988, p. 15)

2. Pat has constructed the following spreadsheet to calculate the c of supplies for a lemonade stand open from May through Augus

	A	B	C	D	E	F
1						
2			COST OF LEMONADE INGREDIENTS			
3						
4			May	June	July	Aug
5						
6	Sugar		$ 9.00			
7	Lemons		$12.00			
8	Bottled Water		$ 8.00			
9						
10	TOTAL BY MONTH		$29.00			

What should Pat do to calculate the total cost of lemons for all four months?

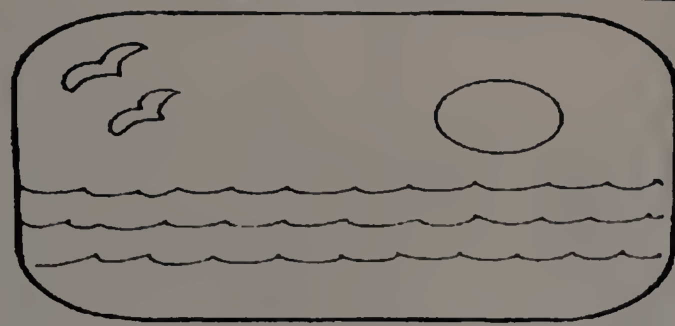
○ Calculate the average of cells C6 through F6.

○ Calculate the average of cells C7 through F7.

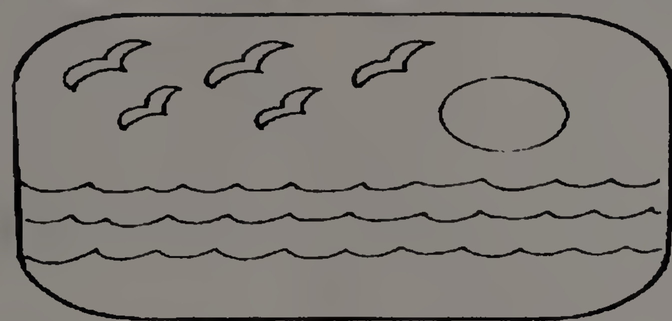
○ Calculate the sum of cells C6 through F6.

● Calculate the sum of cells C7 through F7.

Figure C.4
Sample spread sheet question
(Martinez, 1988, p. 19)



1. Jamie wants to add more birds to the picture, as shown belo



What should Jamie use to add the birds?

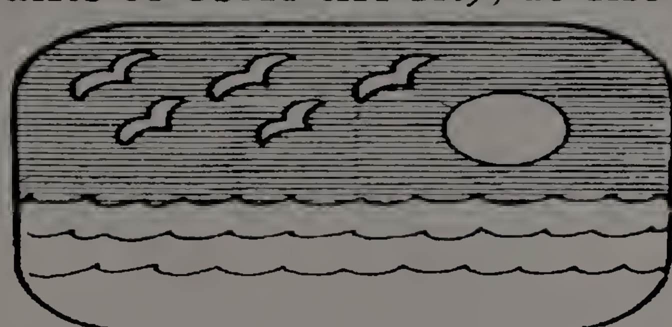
○ SAVE

○ FILL

○ MOVE

● COPY

2. Now Jamie wants to color the sky, as shown below.



What should Jamie use?

○ GRAPH

● FILL

○ MOVE

○ COPY

Figure C.5
Sample graphics questions
(Martinez, 1988, p. 16)

library has a computerized file of its books. A reader of science fiction wants to search the file and print a report like the one below. What would be the best procedure to follow?

SCIENCE FICTION BOOKS PUBLISHED AFTER 1960

AUTHOR	TITLE	DATE
ASIMOV, ISAAC	TRIANGLE	1961
ASIMOV, ISAAC	FANTASTIC VOYAGE	1966
ASIMOV, ISAAC	THE FOUNDATON TRILOGY	1972
ASIMOV, ISAAC	THE GODS THEMSELVES	1974
CLARKE, ARTHUR C.	2001: A SPACE ODYSSEY	1968
CLARKE, ARTHUR C.	REPORT ON PLANET THREE	1972
CLARKE, ARTHUR C.	THE LOST WORLDS OF 2001	1972
CLARKE, ARTHUR C.	IMPERIAL EARTH	1976

○ Sort by title and author, select year greater than 1960, print

○ Sort by author and title, select year less than 1960, print

● Sort by author and date, select year greater than 1960, print

○ Sort by author, select year less than 1960, sort by title, print

Figure C.6
Sample database question
(Martinez, 1988, p. 17)

1. You type these lines:

```
10 PRINT 5 * 7
20 PRINT 5 + 7
RUN
```

What does the computer print after you type RUN?

- ○ Nothing
- ● 35
  12
- ○ 5 * 7
  5 + 7
- ○ 35 12

2. You type these lines:

```
10 PRINT "MONDAY"
LIST
```

What does the computer print after you type LIST?

- ○ Nothing
- ● 10 PRINT "MONDAY"
- ○ MONDAY
- ○ PRINT "MONDAY"

3. Write a program in BASIC to print this:

```
COMPUTER
COMPUTER
COMPUTER
COMPUTER
COMPUTER
```

```
10 FOR X = 1 TO 5
20 PRINT "COMPUTER"
30 NEXT X
```

Figure C.7
Sample BASIC questions
(Martinez, 1988, p. 23)

```
FUNCTION Get Value (VAR A, B: integer): integer;
  BEGIN
    A : = A + 1;
    B : = B + 1;
    Get Value : = A + B
  END;

PROCEDURE Work(First, Second: integer);
  CONST Stop = 10;
  BEGIN
    writeln(First);
      REPEAT
        writeln(Second)
      UNTIL Get Value(First, Second) > Stop
  END;
```

What would happen if the value of Stop were changed to 0 and the procedure call Work(5,7) were made?

○ Get Value would never be called.

● Get Value would only be called once.

○ Get Value would be called 12 times.

Figure C.8
Sample PASCAL question
(Martinez, 1988, p. 24)

APPENDIX D

RESULTS FROM THE NAEP 1986 ASSESSMENT

This appendix contains tables with the results of the 1986 NAEP national computer competency survey. The results were published by Martinez (1988), and collected into tabular format for this study.

Table D.1 contains the national results in total as well as several subgroups. The total score of 46.2 ± 0.6 is the base score utilized for comparison to New Hampshire.

Table D.1
National average computer competency scores

Avg Score	Std Error	NAEP Area	Corresponding NH Area
64.8%	(0.5)	Technology	(Awareness)
		Applications	(Operations)
72.2%	(0.7)	Word Processing	
60.7%	(0.6)	Graphics	
53.4%	(0.6)	Data Base	
31.0%	(0.5)	Spreadsheets	
29.9%	(0.5)	Programming	(Programming)
35.2%	(0.5)	General Pascal	
24.0%	(0.6)	Specific Pascal	
27.2%	(0.5)	Basic	
46.2%	(0.4)	Total Aggregate	

Standard Error of Mean contained in parentheses

Table D.2 lists the scores separated by the principal variables analyzed in this study, sex, type of school and region. The regional score 47.5% ± 0.6 was utilized to illustrate that the New Hampshire score is not only greater than the national score, but is also greater than the Northeast regional score recorded at that time.

Table D.2
NAEP subgroup results

Sex	Males	47.6 (0.6)	44.8 (0.3)	Females
School	Public	45.9 (0.4)	49.3 (1.1)	Private
Region	N.E.	47.5 (0.6)	46.2 (0.4)	Nationwide
Family owned Computer	Yes	52.7 (0.4)	43.5 (0.3)	No

Standard Error of Mean contained in parentheses

Table D.3 contains the results of the NAEP examination segregated by city. The complete definitions of each community size/type is contained in Martinez (1988, p. 80). An abbreviated definition is provided below:

- Medium City are cities with a population between 25,000 and 200,000. Essentially all New Hampshire cities fit this definition, including Keene, Concord, Nashua and Exeter.

- Urban Fringe are urbanized areas, but outside limits of city populations over 200,000 but not classified as cities themselves. Hollis, Nashua, and Exeter would fit this definition.

- Small Place is a community of less than 25,000. Rindge, Hindsdale, Hollis and Hanover would fit this definition.

- Extreme Rural are places that are either less than 10,000 or most workers are farm workers. Rindge and Hinsdale would qualify under these definitions.

- High Metropolitan: City areas where a high proportion of adults was employed in professional or managerial positions and a low proportion employed as factory or farm workers, not regularly employed, or on welfare. School in such communities were in cities, or the urbanized areas of cities with populations greater than 200,000.

Table D.3
NAEP community size analysis
For communities found in New Hampshire

46.3 (0.7)	Medium Cites
46.0 (0.6)	Urban Fringe
45.6 (0.4)	Small Place
45.5 (0.9)	Rural

Standard Error of Mean contained in parentheses

APPENDIX E

CONSENT FORM

This appendix contains a copy of the informed consent statement used in this study. The statement was given to the students with the test packet. The study was explained, and those students who wished to participate signed the statement. The statement was collected during the course of the test so that it could not be associated with any given answer sheet.

[Remainder of page intentionally blank]

INFORMED CONSENT STATEMENT

You have been randomly selected to participate in an assessment of the computer literacy of New Hampshire students.

This study is being done as part of a dissertation for a Doctor of Education Degree. Its purpose is to compare the computer competency level in New Hampshire with that of the Nation as a whole, and other New England states.

Part of this examination is a copy of a nationwide examination used by the National Assessment of Educational Progress in the 1986 National Computer Competency Assessment. The only change is that your answers are being recorded on an answer sheet rather than in the test booklet.

The assessment consists of two parts. The first contains some general questions concerning you, your computer background and usage patterns. The second part consists of questions about computers, their components and their usage. The total time to complete the assessment will be less than 1 hour.

All answers will be made on the answer sheets provided. These sheets will be numbered in such a way that your name and any identifying information will not be recorded on them. There will be no way to identify your paper or your work.

Your unique score will never be reported to any person or agency on an individual basis. It cannot be since there simply is no way to determine which test was yours.

Your signature below indicates that you willing agree to participate in this assessment.

You may withdraw from this examination without penalty.

Thank you. Your time and cooperation is appreciated.

____
Name (Printed)

______________________________ ______________
Signature Date

APPENDIX F

NEW HAMPSHIRE DEMOGRAPHIC QUESTIONNAIRE (NHDQ)

These questions were utilized as the second booklet of the competency examination. They are referred to in the analysis as the NH questions, and referred to as Q45 through Q80. This appendix serves a dual purpose of providing the questionnaire utilized and tabulating the valid responses to the questions.

The answer sheet utilized had responses of 0-9. This caused some confusion in answering this block, where some times, answer 0 was utilized and at other times it was not. It does not appear to have been a problem in the cognitive portion of the examination, where answer 0 was never utilized.

The numbers before the response number is the number of responses. Invalid, skipped or not reached responses are not included. Questions 61-65 and 70-80 contain the responses immediately after the question.

Questions 71-80 were copied from Kay (1990) to permit future research to be done on cognitive vs psychological correlation.

Questions 45-50 were added after an analysis of the first two locations. Responses for this section are lower than other questions.

While most students finished this booklet, two schools with short periods had many students skip a substantial number of questions. Thus, the skipped questions in this section are substantially higher than in the cognitive portions of the examination.

Questions for which a significant difference could not be located have no special symbol after their question number. Questions which contain one or more a statistically significant discriminators (α=0.95) were located are coded with special symbols after their question number as follows:

- √ = significant difference (uncoded).
- ▪ = significant difference (coded).
- ≡ = significant Spearmans Rank probability.
- ? = ambiguous, but not accepted.

A √ or a ▪ indicate a non-parametric difference in the data, usually indicated by a MINITAB Mood Median test.

A coded answer was utilized where there was not a significant difference when all responses were considered. Significant ($\alpha \leq 0.05$) differences were found when answers were grouped. For example, NHDQ question 49 was coded or collapsed into a YES/NO response, with ambiguous results.

A Spearmans rank analysis is used as a non-parametric equivalent of a more conventional Analysis of Variance regression analysis. It shows the strength of a linear relationship among the variables. A ≡ indicates a linear correlation.

Block II -- The New Hampshire demographic questions.

45. Do you or your family have a computer at home?

72 1. My family or I have a computer at home.
46 2. My family or I do NOT have a computer at home.

46. When was your last computer class of any type?

38 0. 12th Grade. (currently enrolled).
22 1. 11th grade.
1 3. 10th Grade.
27 4. 9th Grade.
15 5. 8th Grade.
0 6. 7th Grade.
1 7. Before 7th Grade (Grade School).
1 8. I have never had a computer course.

47. Which statement best describes your overall 4 years of High School computer class experiences or impressions?

14 0. I have not taken any computer classes in high school.
9 1. Terrific. Made me want to become a "computer major".
30 2. Good. It made me want to study more about computers.
57 3. Neutral. Not Good, Not Bad. Just another subject.
9 4. Bad. It made me want to avoid computer studies.
1 5. Awful. Never want to see computer again. Worse than #4.

48.√ Have you had any computer training <u>outside</u> of high school or junior high school?

64 1. No. All my training has been in school.
2 2. Yes, at a summer school or summer camp program.
3 3. Yes, through training provided by my job.
36√ 4. Yes, by myself and/or with help of parents or friends.
5 5. Yes, some combination of #2 - #4 above.
4 6. Yes, some method other than #2 - #4 above.

49.? Have you taken a <u>computer programming course</u> in high school?

36 0. No, and I didn't/don't want to either.
4 1. No, I could not because of a prerequisite of the course.
4 2. No, I wanted to, but could not because it was not offered.
17 3. No, I wanted to, but schedule conflicts prevented it.
5 4. No, but I plan to before I graduate.
3 5. Yes, but I hated it. A total turn off.
5 6. Yes, but I didn't like it. Not as bad as #5 though.
23 7. Yes, and it was ok, not great, but ok.
14 8. Yes, and I actually liked it.
8 9. Yes, and I actually liked it a lot. Better than #8.

50.▪≡ Which statement best describes your use of a <u>word processor</u> throughout your high school career, including all of your subjects.
<u>Do not count specific word processor or keyboarding classes</u>.

9	0. I don't know how to use a word processor.
9	1. I can't find computers available so I don't use them often.
6	2. I can't seem to type well enough to make them faster than writing, so I don't use them very often.
6	3. I know how to use them, but many of my teachers would not accept papers written on them, so I did not use them much.
32	4. I used them for many but less than ½ of my papers.
29	5. I use them for a majority, over ½ of my papers for school.
28	6. I use them for almost all of my written school assignments.

51. Your current school year is

0	1. 11th grade.
154	2. 12th Grade.
0	3. Between High School & College.
0	4. College Freshman.
0	5. College Sophomore.

52.▪√≡ What is your Sex?

95	1. Male
68	2. Female

53. From which state did you graduate or expect to graduate from high school?

161	1. New Hampshire.
2	2. Vermont.
	3. Maine.
	4. Massachusetts.
	5. Other.

54. Have you completed New Hampshire state Computer Competency Requirement?

106	1. Yes.
17	2. No.
39	3. Don't know
0	4. Did not or do not expect to graduate from NH high school.

55. There are several methods to complete your Computer Competency High School graduation requirement. Which method best describes the manner in which you completed this requirement?

(If you completed the requirement several ways, choose the best answer for the FIRST method you achieved).

5	0. Not Applicable. Will/Did not graduate from NH high school
109	1. High School Course.
36	2. Junior High School Course.
6	3. Examination.
1	4. Requirement waived for you individually for some reason.
4	5. Requirement waived for a group of students including you.

56.▪≡ If you took a computer competency or computer literacy course, How long ago was your first course?

22	0. I never took a computer competency or literacy course.
22	1. Within the last year.
35	2. Within the last 2 years.
36	3. Within the last 3 years.
21	4. Within the last 4 years.
13	5. Within the last 5 years.
5	6. Within the last 6 years.
5	7. Within the last 7 years.
4	8. More than 7 years ago.

57.▪≡ How would you best describe that computer competency course?

24	0. I did not take such a course.
27	1. A typing, keyboarding or word processing course.
18	2. A computer science programming Course.
28	3. A course usage course, using software such as spreadsheets, data bases, bulletin boards and paint programs.
6	4. A text book course and not much actual computer usage.
18	5. A combination of 1 & 2.
0	7. A combination of 1 & 3.
7	8. A combination of 2 & 3.
11	9. A combination of 1 & 2 & 3.

58.√≡ How long have you used a computer?

9	1. I have never really used one.
20	2. Less than one year.
12	3. Over one year.
21	4. Over two years.
102	5. Over three years.

59. In your use of computers, as compared to most others you know of your own age and grade level, do you consider yourself to be

1 1. A non-user.
17 2. A novice.
40 3. An intermediate user.
88 4. An expert.
8 5. A past user, but not now.

60.▪≡ How many computer courses have you had in school, including any courses you might have had for computer literacy or computer competency?

2 1. None.
10 2. One Semester (at least 1/2 a semester).
87 3. Two Semesters.
31 4. Three Semesters.
14 5. Four or more semesters.

For Questions 61 through 65, Pick the best answer(s) from the list below that describes YOUR use of the computer in your last year of high school.

Answers 1 through 4 really don't apply at all.
1. I watched the teacher use computer to demonstrate things
2. I used a word processor to write papers.
3. I used the computer for tests, quizzes and practice.
4. I used programs to help me do the work required (example:. spreadsheets, word processors, lab packages, data bases, CD Roms, etc, but not items 2 & 3 above)
5. Both #2 & #1.
6. Both #2 & #3.
7. both #2 & #4.
8. Both #1 & #4.
9. 3 or more answers apply (#1 - #4).
[response totals contained under the question]

61.▪ How was the computer used in your ENGLISH classes?
0=48 1=6 2=75 3=7 4=5 5=4 6=5 7=9 8=0 9=2

62.▪ How was the computer used in your MATH classes?
0=94 1=12 2=35 3=4 4=6 5=3 6=2 7=3 8=0 9=1

63.▪ How was the computer used in your SOCIAL SCIENCE classes?.
0=94 1=12 2=35 3=4 4=6 5=3 6=2 7=3 8=0 9=1

64. How was the computer used in your SCIENCE classes?
0=58 1=18 2=20 3=4 4=32 5=3 6=1 7=10 8=7 9=8

65. How was the computer used in your LANGUAGE classes?
0=108 1=12 2=19 3=5 4=6 5=3 6=4 7=2 8=1 9=0

66. Taken as a whole, how would you best describe how computers were used and/or discussed in your high school years (Do not count actual computer classes to answer this question).

4	1. Almost all of my high school subjects.
25	2. Most of my high school subjects.
33	3. Some of my high school subjects.
56	4. A few of my high school subjects.
38	5. Virtually none of my high school subjects.

67. Not counting my computer teacher, I saw my teachers and school administrators using computers for something other than teaching me

27	1. Almost everyone used computers almost every day.
58	2. Many of them used computers occasionally.
32	3. A few of them used computers almost every day.
30	4. A few of them used computers occasionally.
7	5. Almost none of them used the computer at all.

68.▪ My high school library was 'automated' to allow me to use a computer to find books and periodicals.

68	1. Yes, and I used the computer to help me.
24	2. Yes, but I did not use the computer myself.
38	3. No, but I wish it was computerized.
8	4. No, and I'm glad it was not computerized.
15	5. I don't know if it was or not.

69. If I did not count any computer courses I had taken, I feel that the rest of the high school curriculum covered computers and computer topics

63	1. Not nearly well enough.
55	2. Not well enough.
30	3. About right.
4	4. Had too much coverage and emphasis.
0	5. Had way too much coverage and emphasis.

For questions 70-80, the following answer scale applies.

1. Strongly Disagree.
2. Disagree.
3. Neutral.
4. Agree.
5. Strongly Agree.

[Answer distribution appears below Question]

70. I found my first high school computer course improved my attitude toward computers.
1=10 2=27 3=56 4=43 5=11

71. I could probably do just about anything I need to with computers.
1=23 2=50 3=33 4=33 5=9

72. I feel I need an experienced person nearby when I use computers.
1=14 2=43 3=43 4=29 5=17

73. I can make the computer do what I want it to do.
1=18 2=22 3=64 4=33 5=10

74.▪≡ I need someone to tell me the best way to use the computer.
1=11 2=36 3=44 4=43 5=11

75. I feel confident about using the computer to store important information.
1=16 2=19 3=17 4=62 5=33

76.≡ I will probably never be able to work with computers effectively.
1=50 2=46 3=32 4=11 5=4

77.▪≡ If I had a problem using the computer, I could probably solve it one way or another.
1=10 2=15 3=52 4=57 5=11 8=1

78.▪≡ I would never use computers if someone wasn't pushing me to do so.
1=54 2=55 3=20 4=11 5=6

79.▪≡ I would be able to determine how to use computers in my major area of studies.
1=8 2=12 3=45 4=62 5=20

80. When something goes wrong with the computer, I feel there would be little I could do about it.
1=12 2=32 3=46 4=35 5=18

APPENDIX G

SEX, EXPERIENCE, PROGRAMMING AND SEMESTERS OF STUDY.

There appears to be a complex relationship between sex, self-reported years of computer experience, studying programming, semesters of computer study and the outcome of a computer competence score. Two non-parametric correlation analysis were performed, a Pearson product moment and a Spearmans Rank correlation. The former uses the data itself, and the latter uses the ranks of the data rather than the data itself.

Table G.1 shows a Pearson's correlation matrix between Computer Competency Scores and :

- Q49 - Taken a computer programming course.
- Q52 - Sex.
- Q56 - When computer competency course taken.
- Q58 - How long a computer has been used.
- Q60 - How many semesters computers have been studied.

Several other relationships are also present:

- Sex (Q52) and Programming (Q49).
- Experience (Q58) and Semesters studied (Q60).
- Programming (Q49) and Semesters studied (Q60).

Table G.2 analyzed the same data using a Spearman's Rank correlation, which is another non-parametric analysis.

The only difference in results is that Table G.2 adds a correlation between the timing of the first course and the years experience.

The correlations found in this study is significant beyond the 99% confidence level. This implies that there is a small chance that there is a very small chance that the relationship discovered occurred by accident. However, given that there is a relationship, the next question is how strong the relationship between the various items and the computer competency score is. The Pearson's moment and Spearmans rank give a feel for the strength of the relationship, as distinct from whether it could have occurred by accident. A +1 or -1 would indicate a perfect relationship, and a 0 would indicate no relationship. Both the Pearsons moment and Spearmans rank are presented in table G.1 and G.2 respectively. The relationship of Years Experience (NHDQ-58) and Sex (NHDQ-52) are approximately the same strength (-.29). The absolute meaning of this quantity is beyond the scope of this study. In general it could be said to be rather weak. The portion of the variability in score accounted for is approximately the square of the Pearsons product moment. Thus, sex for approximately 9% of the variation in score.

A second possible interpretation of the product moment is that there is not a single factor that accounts for a large percentage of the variation in score. Rather, that the total score is made up of a large number of small factors. From a policy standpoint, this could be interpreted that emphasis on any single factor would probably not produce dramatic gains in computer scores. This statement has to be taken in the context of the studies general setting. New Hampshire students all took one course in computer competency, and did quite a bit better than the nation at large. This is probably the most significant factor found. Tables G.1 and G.2 could be interpreted as second order effects compared to the major policy of requiring a computer course to start with.

The relationships, while generally weak compared to the effects of a single course in computers, between experience, semesters studied and programming are so seemingly obvious as to be obscure. If computers are studied for some years 'x', then the years experience should be at least 'x'. It is difficult to study computers for long without encountering programming.

The minimum experience is the semesters studied. The maximum experience could be more. Any excess computer usage reported could be attributed to the use of computers in courses other than computer courses. In fact, very few people report experience beyond the number of semesters of computer study. This implies that the competency increase from the integration of computers into other non-computers in the curriculum is very weak, if it exists at all.

Table G.1;
Six factor parametric analysis

Pearson's Product Moment Correlation Analysis
Score vs Sex, First Course, Years Experience, Semesters Studied & Programming

	Score	Q52 Sex	Q56 First Course	Q58 Years Experience	Q60 Semesters Studied	Q49 Programing Course
Score		-0.2978 (164) 0.0001	0.1636 (163) 0.0370	0.2993 (164) 0.0001	0.1783 (163) 0.0228	0.1792 (119) 0.0511
Q52 Sex	-0.2978 (164) 0.0001		-0.0984 (163) 0.2113	-0.1353 (164) 0.0840	-0.0255 (163) 0.7468	-0.2986 (119) 0.0010
Q56 First Course	0.1636 (163) 0.0370	-0.0984 (163) 0.2113		0.1129 (163) 0.1514	0.0468 (162) 0.5545	-0.1572 (118) 0.0891
Q58 Years Experience	0.2993 (164) 0.0001	-0.1353 (164) 0.0840	0.1129 (163) 0.1514		0.2468 (163) 0.0015	-0.0373 (119) 0.6874
Q60 Semesters Studied	0.1783 (163) 0.0228	-0.0255 (163) 0.7468	0.0468 (162) 0.5545	0.2468 (163) 0.0015		0.3756 (118) 0.0000
Q49 Computer Programming	0.1792 (119) 0.0511	-0.2986 (119) 0.0010	-0.1572 (118) 0.0891	-0.0373 (119) 0.6874	0.3756 (118) 0.0000	

The table shows (sample size), and two-tailed P value.

The correlation coefficient measures the strength of the linear relationship between two variables on a scale of -1 to +1. The P value is used to test whether the coefficient is significantly different from zero.

The following pairs of variables are significantly correlated at the 5% level:

	Correlation	P value
Score with Q52 - Sex	-0.2978	0.0001
Score with Q56 - First Course	0.1636	0.0370
Score with Q58 - Years Experience	0.2993	0.0001
Score with Q60 - Semesters Studied	0.1783	0.0228
Sex Q52 with Q49 - Computer Programming	-0.2986	0.0010
Years Experience Q58 with Q60 - Semesters Studied	0.2468	0.0015
Semester Studied Q60 with Q49 - Computer Programming	0.3756	0.0000

Table G.2
Six factor non-parametric analysis

Spearmans Rank Correlation Analysis
(sample size), and two-tailed P value.
Pairwise Elimination

Score vs Sex, First Course, Years Experience, Semesters Studied & Programming

	Score	Q52 Sex	Q56 First Course	Q58 Years Experience	Q60 Semesters Studied	Q49 Programing Course
Score		-0.2815 (164) 0.0003	0.1550 (163) 0.0485	0.3296 (164) 0.0000	0.1771 (163) 0.0242	0.1618 (119) 0.0788
Q52 Sex	-0.2815 (164) 0.0003		-0.0661 (163) 0.4002	-0.1358 (164) 0.0830	-0.0319 (163) 0.6848	0.2959 (119) 0.0013
Q56 First Course	0.1550 (163) 0.0485	-0.0661 (163) 0.4002		0.1743 (163) 0.0265	0.0320 (162) 0.6844	-0.1482 (118) 0.1089
Q58 Years Experience	0.3296 (164) 0.0000	-0.1358 (164) 0.0830	0.1743 (163) 0.0265		0.2244 (163) 0.0043	-0.1043 (119) 0.2571
Q60 Semesters Studied	0.1771 (163) 0.0242	-0.0319 (163) 0.6848	0.0320 (162) 0.6844	0.2244 (163) 0.0043		0.4171 (118) 0.0000
Q49 Computer Programming	0.1618 (119) 0.0788	-0.2959 (119) 0.0013	-0.1482 (118) 0.1089	-0.1043 (119) 0.2571	0.4171 (118) 0.0000	

The correlation coefficient measures the strength of the linear relationship between two variables on a scale of -1 to +1. The P value is used to test whether the coefficient is significantly different from zero.

The following pairs of variables are significantly correlated at the 5% level:

	Correlation	P value
Score with Q52 Sex	-0.2815	0.0003
Score with Q56 First Course	0.1550	0.0485
Score with Q58 Years Experience	0.3296	0.0000
Score with Q60 Semesters Studied	0.1771	0.0242
Sex Q52 with Q49 Programming	-0.2959	0.0013
First Course Q56 with Q58 Years Experience	0.1743	0.0265
Years Experience Q58 with Q60 Semesters Studied	0.2244	0.0043
Semesters Studied Q60 with Q49 Programming Course	0.4171	0.0000

The correlation between sex and programming is negative. This means that girls study programming less than men. As reported in the study, girls do go on to additional courses as often as boys. The tentative, unconfirmed conclusion is that they must locate advanced computer courses that do not involve programming. The second tentative conclusion is that perhaps the lower competency scores of girls are related to their lack of programming courses. But the study concludes that taking a programming course does not significantly raise scores! The ambiguity is not resolved in this study.

The conclusion of this five factor analysis is that a complex relationship is occurring. Each of the five variables is related to at least one of the other predictors, or the score itself. This study can affirm the importance of the variables, but was not designed to directly address the relationships between them. The determination of relationships is an excellent area for further studies.

APPENDIX H

COMPUTER USAGE IN NON-COMPUTER COURSES.

This appendix is a repository for data analysis documenting the degree of computer usage reported on this study.

Tables H.1 through H.6 are histograms and counts of responses New Hampshire Demographic Questions (NHDQ), and have questions starting with 'Q'. Each * represents 2 observations on these figures. The answer keys are:

- 0: Not Used.
- 1: Watched Teacher.
- 2: Word Processing.
- 3: Drill & Practice.
- 4: Used Applications.
- 5: Both 2 & 1.
- 6: Both 2 & 3.
- 7: Both 2 & 4.
- 8: Both 1 & 4.
- 9: three or more answers from 1-4 apply.

Table H.1
Computer usage in English (NHDQ-61)

```
--------------------------------------------------------------------------------
Midpoint   Count   q61   N = 161   N* = 7                 ENGLISH
30%      0     48  ************************
         1      6  ***
47%      2     75  **************************************
         3      7  ****
         4      5  ***
         5      4  **
         6      5  ***
         7      9  *****
         8      0
         9      2  *
--------------------------------------------------------------------------------
Non-Parametric

          Mood median test of score
          Chisquare = 19.93   df = 8    p= 0.011

                                                  Individual 95.0% CI's
                  q61   N<=    N>   Median    Q3-Q1  ---+---------+---------+---------+---
Not Used            0    33    15     45.8     19.2              (-+-)
Watched Teacher     1     4     2     50.0      9.5               (--+--)
Word Processor      2    32    43     54.2     25.0                  (-+---)
Drill & Practice    3     1     6     58.3     17.3                    (-+------)
Used Applications   4     4     1     38.1     18.1            (-+------)
Both 2 & 1          5     1     3     64.0     23.1                     (-----+------)
Both 2 & 3          6     4     1     38.1     35.1   (-----------+-------------)
Both 2 & 4          7     2     7     62.5     26.3                     (----+----------)
Both 1 & 4          8     0     0     ----     ----
Three or more       9     1     1     65.5     26.2                     (------+-----)
                                                     ---+---------+---------+---------+---
                                                       20        40        60        80
          Overall median = 52.4
          * NOTE * Levels with < 6 obs. have confidence < 95.0%

          Mood median test of score

          Chisquare = 12.37   df = 2    p = 0.002

                                                  Individual 95.0% CI's
                  q61   N<=    N>   Median    Q3-Q1  -------+---------+---------+---------
No Use or Watch     0    37    17     46.4     16.3   (---+---)
Drill & Practice    1     1     6     58.3     17.3              (------+----------------)
Word Process        2    44    56     54.2     25.0             (--+-------)
                                                     -------+---------+---------+---------
                                                          48.0      56.0      64.0

          Overall median = 52.4
```

Table H.2
Computer usage in Mathematics (NHDQ-62)

```
--------------------------------------------------------------------------------
 Midpoint   Count   q62   N = 160   N* = 8            MATHEMATICS
53%     0      85  *******************************************
17%     1      26  *************
 4%     2       6  ***
 8%     3      12  ******
 8%     4      12  ******
 1%     5       2  *
 1%     6       1  *
 2%     7       3  **
 4%     8       6  ***
 6%     9       7  ****

70% = No use of computer by students (0 & 1).

--------------------------------------------------------------------------------
            Mood median test of score

            Chisquare = 12.38   df = 3   p = 0.006

                                                      Individual 95.0% CI's
                     q61   N<=    N>   Median    Q3-Q1  ---------+---------+---------+-------
No Use                 0    33    15     45.8     19.2   (---+---)
Drill & Practiced      1     4     2     50.0      9.5       (-----+------)
Word Processing        2    44    56     54.2     25.0               (-+-----)
Other Usage            3     1     6     58.3     17.3                (----+-------------)
                                                        ---------+---------+---------+-------
                                                                50        60        70

            Overall median = 52.4
```

Table H.3
Computer usage in Social Science (NHDQ-63)

```
-----------------------------------------------------------------------------
 Midpoint   Count  q63   N = 160   N* = 8            SOCIAL SCIENCE
59%     0      94  ***********************************************
        1      12  ******
22%     2      35  ******************
        3       4  **
        4       6  ***
        5       3  **
        6       2  *
        7       3  **
        8       0
        9       1  *
-----------------------------------------------------------------------------
            Mood median test of score

            Chisquare = 15.31   df = 7   p = 0.033

                                               Individual 95.0% CI's
                q63   N<=    N>   Median    Q3-Q1  ----+---------+---------+---------+--
                  0    55    39     50.0     20.7         (-+)
                  1     8     4     47.3     23.7    (-----+-----)
                  2    14    21     57.1     21.4          (----+-)
                  3     0     4     79.8     25.2            (-------------+--)
                  4     4     2     42.9     25.2   (---+-----------)
                  5     0     3     70.8     20.8             (-------+--)
                  6     0     2     83.3     33.3                   (--------+-------)
                  7     1     2     57.1     25.6         (-----+------)
                  9     0     1     58.8 Not used
                                                   ----+---------+---------+---------+--
                                                      40        60        80       100

            Overall median = 52.4
            * NOTE * Levels with < 6 obs. have confidence < 95.0%

            Recoding 'Observed' to 'No Use',
              All else to 'Word Processing'

               Mood median test of score

            Chisquare = 8.42   df = 1   p = 0.004

                                               Individual 95.0% CI's
                q63   N<=    N>   Median    Q3-Q1  ---------+---------+---------+-------
                  0    63    43     50.0     21.5   (-------+----)
                  2    19    35     57.1     20.8                 (------+----------)
                                                   ---------+---------+---------+-------
                                                          50.0      55.0      60.0

            Overall median = 52.4

            A 95.0% C.I. for median(0) - median(2): (-15.0,-1.7)
```

Table H.4
Computer Usage in Science (NHDQ-64)

```
-----------------------------------------------------------------------------------------------
Midpoint    Count  q64   N = 161   N* = 7                      SCIENCE
36%     0     58  *****************************
11%     1     18  *********
12%     2     20  **********                  Used Word Processing
 2%     3      4  **                          Responses 2+5+6+7+9 = 26%
20%     4     32  ****************
 2%     5      3  **                          Used applications
 1%     6      1  *                           Responses   4+7+8+9 = 35%
 6%     7     10  *****
 4%     8      7  ****
 5%     9      8  ****
-----------------------------------------------------------------------------------------------
```

```
           Mood median test of score
           Chisquare = 16.42   df = 8   p = 0.038
                                                     Individual 95.0% CI's
                q64   N<=    N>   Median    Q3-Q1   --------+---------+---------+--------
                  0    37    21     46.7     20.9             (-+--)
                  1    11     7     50.0     22.9          (------+--)
                  2     9    11     55.5     24.4               (----+--)
                  3     3     1     43.8     46.6    (--------+--------------------)
                  4    16    16     52.7     23.1                (-+----)
                  5     1     2     70.8     24.4                (----------+)
                  6     0     1     57.1   Not used
                  7     3     7     59.5     14.0                 (----+--)
                  8     1     6     61.9     18.5                 (-----+-------)
                  9     1     7     71.4     19.3                    (-------+---)
                                                    --------+---------+---------+--------
                                                           40        60        80
           Overall median = 52.4
           * NOTE * Levels with < 6 obs. have confidence < 95.0%
-----------------------------------------------------------------------------------------------
```

```
           Recoding 'observation' to 'non-user'
           Recoding all else to 'computer use'

           Mood median test of score
           Chisquare = 8.61   df = 1   p = 0.003
                                                    Individual 95.0% CI's
                q64   N<=    N>   Median    Q3-Q1   ---------+---------+---------+-------
                  0    48    28     47.6     21.0   (-------+-------)
                  2    34    51     57.1     20.8                (-------+-------)
                                                    ---------+---------+---------+-------
                                                           48.0      54.0      60.0
           Overall median = 52.4
              A 95.0% C.I. for median(0) - median(2): (-19.0,-0.6)
```

Table H.5
Computer usage in various subjects

Have you used computers in following classes (NAEP demographic question)

(Results of 1986 NAEP survey shown in Parentheses) (p = Mood Analysis)

```
Mathematics   Histogram of C1   N = 25   N* = 143    (p = 0.734)

              Midpoint   Count
 60%          Yes    1      15  ***************
(29% NAEP)           2      10  **********

English       Histogram of C2   N = 25   N* = 143    (p = 0.405)

              Midpoint   Count
 68%          Yes    1      17  *****************
(16% NAEP)           2       8  ********

Science       Histogram of C3   N = 25   N* = 143    (p = 0.610)

              Midpoint   Count
 60%          Yes    1      15  ***************
(15% NAEP)           2      10  **********

Social Science Histogram of C4   N = 25   N* = 143    (p = 0.915)

              Midpoint   Count
 32%          Yes    1       8  ********
( 5% NAEP)           2      17  *****************

Art           Histogram of C5   N = 25   N* = 143    (p = 0.317)

              Midpoint   Count
 20%          Yes    1       5  *****
( 3% NAEP)           2      20  ********************

Music         Histogram of C6   N = 25   N* = 143    (p = 0.238)

              Midpoint   Count
 12%          Yes    1       3  ***
( 4% NAEP)           2      22  **********************
```

Table H.6
Frequency of computer use

How often do you use computer to do each of the following?

(NAEP demographic questions)

N* = N/A (p = Mood) Study% 1986%

Midpoint	Count	C10	N = 25 N* = 143 (p=0.842)	Math	NAEP
Daily	1	0		0%	6%
< Daily	2	1	*	4%	5%
Weekly	3	1	*	4%	10%
< Weekly	4	8	********	32%	18%
Never	5	15	***************	60%	62%

Midpoint	Count	C14	N = 50 N* = 118 (p=0.649)	Writing	NAEP
Daily	1	1	*	2%	4%
< Daily	2	0		0%	6%
Weekly	3	3	***	6%	8%
< Weekly	4	18	******************	30%	26%
Never	5	28	****************************	56%	55%

Midpoint	Count	C15	N = 50 N* = 118 (p=0.308)	Science	NAEP
Daily	1	1	*	2%	1%
< Daily	2	0		0%	2%
Weekly	3	7	*******	14%	2%
< Weekly	4	18	******************	36%	9%
Never	5	24	************************	48%	87%

Midpoint	Count	C17	N = 49 N* = 118 (p=0.997)	Music	NAEP
Daily	1	1	*		
< Daily	2	1	*		
Weekly	3	2	**		
< weekly	4	13	*************		
Never	5	32	********************************		

APPENDIX I

STUDENTS PERCEPTIONS OF COMPUTERS IN SCHOOL

This appendix is a repository for data analysis documenting the degree of student satisfaction on the computer training that they have received at school. Table I.1 contains the responses to the relevant questions in the NAEP portions of the examination. Table I.2 contains the responses to relevant questions as contained in the New Hampshire Demographic (NHDQ) portions of the examination. The probability associated with an appropriate null hypothesis, that the response made no difference in score was not a result of chance, is indicated by (P=x.xxx). As shown, none of the responses were statistically valid as a determinant on computer competency outcome assessment scores. Table I.3 contains the responses as to whether the students thought computers were covered enough in computer classes.

Table I.1
Student perceptions of computer interest

Do you find the class work on computers in your school interesting ?

	Midpoint	Count	C73 N = 25 N* = 143 (p=0.100)		NAEP
Yes	1	16	****************	64%	32%
No	2	7	*******	28%	11%
N/A	3	2	**	8%	55%

Table I.2
Student perceptions of computer utility

NAEP demographic Item

Is your school teaching you the computer skills you would like to have?

Midpoint	Count	C74 N = 25 N* = 143 (p=0.686)		NAEP	
Yes	1	17	*****************	68%	29%
No	2	8	********	32%	17%
N/A	3	0		0%	53%

Table I.3
Student perception of computer coverage (NHDQ-69)

69. If I did not count any computer courses I had taken, I feel that the rest of the high school curriculum covered computer and computer topics:

Mood median test of score

Chisquare = 1.85 df = 3 N = 152 (p = 0.605)

		q69		N<=	N>	Median	Q3-Q1	Individual 95.0% CI's
Not Near Enough	41%	63	1	36	27	50.0	23.0	(------+---)
Not Enough	36%	55	2	25	30	54.2	29.7	(---+-------)
About Right	20%	30	3	14	16	54.0	21.3	(-------+-------)
Too Much	3%	4	4	2	2	52.7	24.2	(---------+--------------------)
Way Too Much	0%	0	5	0	0			
								50 60 70

Overall median = 52.4
* NOTE * Levels with < 6 obs. have confidence < 95.0%

The observations of students watching their teachers and administrators working on computer about the school is shown in Table I.4. Role models of both sexes are available, in addition to computer being available for classroom usage.

Table I.4
Student perception of role models (NHDQ-67)

67. Not counting my computer teacher, I saw my teachers and school administrators using computers for something besides teaching me:

Response	Count	Histogram
Skipped	1	*
Almost all the time	24	************
Many of them occasionally	54	***************************
A few every day	30	***************
A few occasionally	27	**************
Almost none used computer	7	****

APPENDIX J

CONTENTS OF COMPUTER COMPETENCY CURRICULUM

This appendix contains several tables that analyze the New Hampshire Demographic Questionnaire (NHDQ), Question 57. Since the subject is of more than passing importance, the question is repeated in Table J.1. A histogram type analysis is contained in Table J.2.

Table J.1
Computer competency course content (NHDQ-57)

57. How would you best describe [your] computer competency course?

24	0. I did not take such a course.
27	1. A typing, keyboarding or word processing course.
18	2. A computer science programming Course.
28	3. A course usage course, using software such as spreadsheets, data bases, bulletin boards and paint programs.
6	4. A text book course and not much actual computer usage.
18	5. A combination of 1 & 2.
0	7. A combination of 1 & 3.
7	8. A combination of 2 & 3.
11	9. A combination of 1 & 2 & 3.

Table J.2
Histogram of course content (NHDQ-57)

```
MTB > histogram c17

Histogram of q57   N = 162   N* = 6

Midpoint   Count
       0      24  ************************
       1      27  ***************************
       2      18  ******************
       3      28  ****************************
       4       6  ******
       5      18  ******************
Recoded to 0   6       0
       7      23  ***********************
       8       7  *******
       9      11  ***********
```

The analysis of the data begins with Table J.3 which contains a MINITAB Mood Median test, along with the recoding of the data into nothing, typing, programming and combinations with applications.

In order to have ascending data, the "no course" option was recoded from the original '5' to '0'. This has the effect of making no course less useful than a typing course, and provides an ascending ordering of responses.

Table J.3
Computer competency course content analysis (NHDQ-57)

```
------------------------------------------------------------------------------------------
Non-Parametric

 Mood median test of score

             Chisquare = 22.72   df = 8   p = 0.004

Note: Response 0 = Response 5 on original Exam        Individual 95.0% CI's

                  q57   N<=    N>   Median    Q3-Q1  -------+---------+---------+---------
No course            0   18     6     44.3     30.8   (-----------+------)
Typing               1   19     8     45.8     13.0              (--+-----)
Programming          2   12     6     45.8     16.0              (--+-------)
Applications         3    9    19     60.4     18.9                      (------+---)
Textbook only        4    2     4     56.3     26.0  (-----------------------+--)
Type & Programming   5    5    13     61.9     37.5                (--------------+----)
Type & Applications  7    9    14     57.1     14.3                       (---+---)
Prog. & Applications 8    2     5     57.1     19.6                  (--------+----------)
Type, Program & Appl. 9   6     5     52.4     26.8          (------------+---------)
                                                     -------+---------+---------+---------
                                                           36        48        60

             Overall median = 52.4
------------------------------------------------------------------------------------------

            Recoding
                        Text Book to None.
                        Combinations 5, 6, 7, 8 & 9 to 5, a single combination

 Mood median test of score

             Chisquare = 17.18   df = 4   p = 0.002

                                                     Individual 95.0% CI's
                  q57   N<=    N>   Median    Q3-Q1  -------+---------+---------+---------
                    0    20    10     45.8     29.7   (-----------+-------)
                    1    19     8     45.8     13.0         (---+-----)
                    2    12     6     45.8     16.0         (---+---------)
                    3     9    19     60.4     18.9                  (-------+---)
                    5    22    37     57.1     20.8                   (---+----)
                                                     -------+---------+---------+---------
                                                           40        50        60

             Overall median = 52.4
```

Table J.4 further collapses the data into just two groups, combination courses and other. It then contains three different significance tests.

Table J.4
Recoding computer course content (NHDQ-57)

Recoding Question 57 into Keyboarding & Programming into no course.

Note: It was decided to leave application as a combination course since applications normally teach several subjects.

Non-Parametric

Mood Median Test of score

Chisquare = 16.88 df = 1 p = 0.000

```
                                                Individual 95.0% CI's
                q57  N<=   N>  Median   Q3-Q1  -+---------+---------+---------+-----
None or Single Subj  0   51   24    45.8    19.0   (------+------)
Combinations         1   31   56    58.3    19.6                      (------+-----)
                                                 -+---------+---------+---------+-----
                                                42.0      48.0      54.0      60.0
```

Overall median = 52.4

A 95.0% C.I. for median(0) - median(1): (-19.0,-9.5)

Kruskal-Wallis Test of same data

162 CASES WERE USED
6 CASES CONTAINED MISSING VALUES

LEVEL	NOBS	MEDIAN	AVE. RANK	Z VALUE
0	75	45.83	66.0	-3.90
1	87	58.33	94.8	3.90
OVERALL	162		81.5	

H = 15.20 d.f. = 1 p = 0.000
H = 15.22 d.f. = 1 p = 0.000 (adj. for ties)

Mann-Whitney Confidence Interval and Test

score N = 168 Median = 52.380
q57 N = 162 Median = 1.000
Point estimate for ETA1-ETA2 is 51.940
95.0 pct c.i. for ETA1-ETA2 is (49.000,54.169)
W = 41412.0
Test of ETA1 = ETA2 vs. ETA1 n.e. ETA2 is significant at 0.0000

The test is significant at 0.0000 (adjusted for ties)

Table J.5 contains a linear regression fit. It also is significant at the 95% confidence level.

Table J.5
Regression of type of course

Parametric Regression Analysis

The regression equation is
score = 48.7 + 1.11 q57

162 cases used 6 cases contain missing values

Predictor	Coef	Stdev	t-ratio	p
Constant	48.665	2.118	22.97	0.000
q57	1.1058	0.4649	2.38	0.019

s = 16.81 R-sq = 3.4% R-sq(adj) = 2.8%

Analysis of Variance

SOURCE	DF	SS	MS	F	p
Regression	1	1599.3	1599.3	5.66	0.019
Error	160	45227.7	282.7		
Total	161	46826.9			

APPENDIX K

SAMPLE ANNOTATED BOX AND WHISKER PLOT

Figure K.1 is to illustrate an annotated <u>Box and Whisker</u> plot for those who may not be familiar with this particular type of drawing.

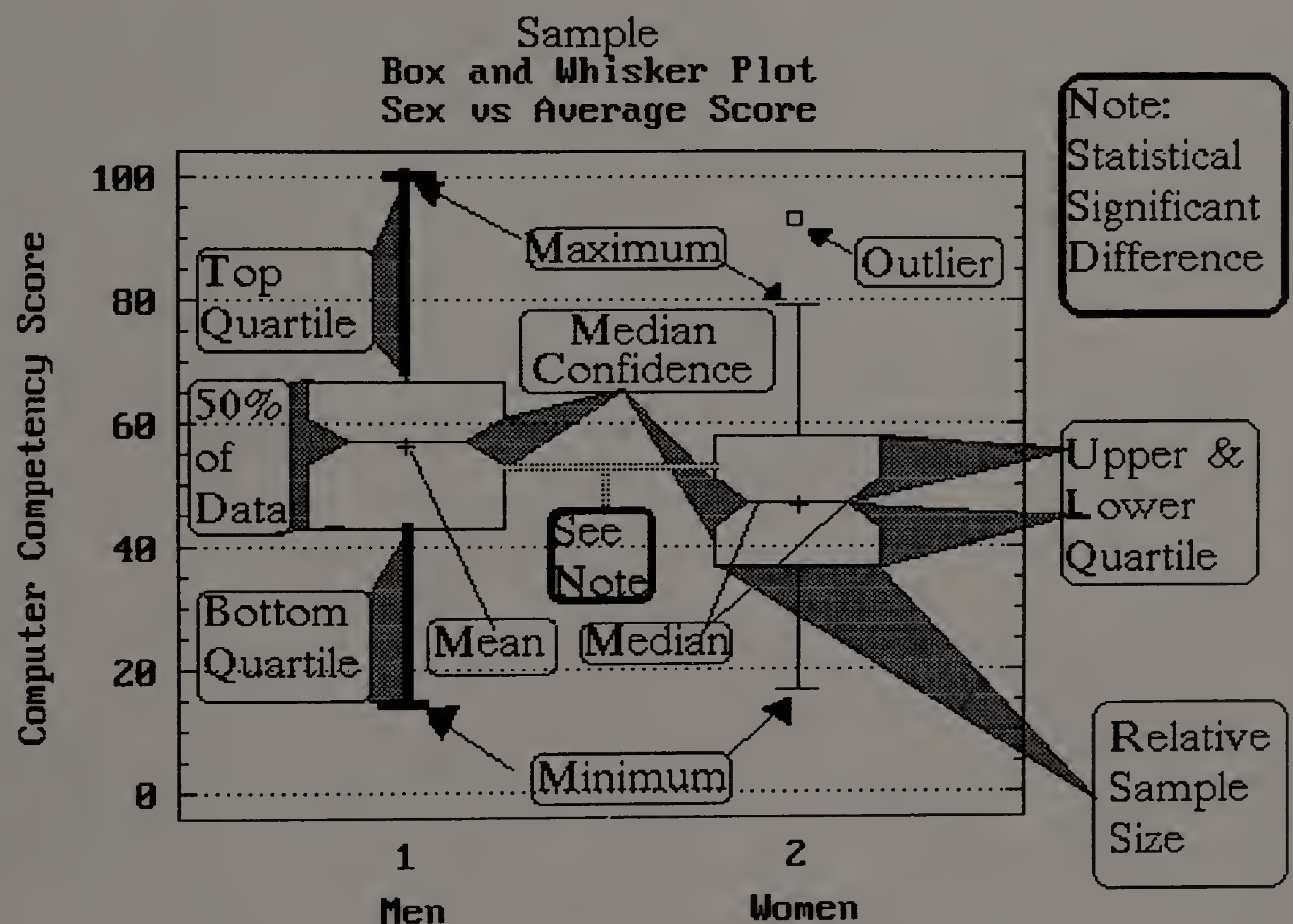


Figure K.1
Annotated Box and Whisker Plot:
As used in dissertation

The median notches have the property that if the lower edge of one notch is above the upper edge of the median notch of another box, the likelihood is very high that a statistically significant difference will exist.

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