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A Study of the Effect of Computer-Based Mastery Quizzes on Student Learning

by
Darren Provine

A Thesis

Submitted in partial fulfillment of the requirements of the
Master of Arts Degree
of
The Graduate School
at
Rowan University
Monday, 1 May 2000

Approved by _____
Professor

Date approved 4/24/00

ABSTRACT

Darren Provine, A Study of the Effect of Computer-Based Mastery Quizzes on Student Learning, 2000, Eric Milou, Higher Education - Computer Science

This study was designed to measure the effect of mastery quiz techniques on the test scores of undergraduate students enrolled in computer science classes.

The experimental group took on-line mastery quizzes, administered over the Internet via web browser; the control group followed a relatively standard pop quiz methodology. Test scores of these groups were compared at the end of the study.

A two-sample t-test showed no statistically significant difference in the scores of the two groups.

MINI-ABSTRACT

Darren Provine, A Study of the Effect of Computer-Based Mastery Quizzes on Student Learning, 2000, Eric Milou, Higher Education - Computer Science

This study compared the test results of two groups of students, one class of students given random pop quizzes, and one using mastery quizzes administered over the Internet. Results indicated that the mastery quizzes had no significant effect on test scores.

Acknowledgements

Thanks to my advisors, Eric Milou, Jennifer Kay, and Don Stone.

Thanks also to my students, who let me experiment on them and never once complained.

A word of appreciation to my parents, who gave me a love of learning, and who let me grow up despite the many reasons I gave them not to.

Thanks to the developers of FreeBSD, KDE, and L^AT_EX, for providing software systems that make it possible to get work done.

Thanks to Steve Carr, who developed the initial prototype of the web quizzing software used in this study.

And finally, to my wife Nancy and our daughters Carolyn and Emily, for giving me the time and support to undertake the project, and for dragging me away from it when I needed a break.

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Chapter 1

Introduction

Background

“Mastery learning” is a term applied to a group of teaching techniques which have been used increasingly over the last several decades (Slavin, 1987; Bloom, 1987). The term derives its name from the main feature of most mastery learning systems: the idea that students should master certain material before advancing to other material. This is usually contrasted with course scheduling that attempts to keep student progress constant across an entire class, regardless of individual student needs and abilities.

The idea of establishing a criterion level of performance which must be attained before proceeding to new material has roots at least as far back as the 1920s (Washburne, 1922; Morrison, 1926). The early programs were not sufficiently developed to sustain a successful strategy, and eventually atrophied (Block, 1971). The idea was revived in the 1950s (Glaser, 1968; Atkinson, 1968; Suppes, 1966), with programmed instruction, which attempted to break subjects down into component parts and teach each component separately. The basic idea was that after students learned the parts, they would easily be able to master the whole. Programmed instruction worked well for students who required repeated drilling, but it was ineffective for most other students, and faded in importance (Block, 1971).

John Carroll’s “Model of School Learning” (1963), based on his own earlier teaching, provided a theoretical model outlining factors in school success. Carroll’s model

was later formalized by Benjamin Bloom (1968) and Keller (1968) into working models for the mastery learning techniques as they are known today (Lee, 1998; Anderson, 1994).

Bloom's (1968) system, called "Learning for Mastery" (LFM) proposed modifying traditional instruction by using two assessments at the end of a unit instead of one. For those not achieving mastery on the first, it would serve as a diagnostic tool for further teaching efforts. The main elements of LFM are: (1) explicit objectives, (2) previously-set standards for mastery, (3) formative tests (as distinct from summative tests), (4) additional learning experiences, and (5) unlimited time.

Keller (1968) devised an alternate program called "Personalized System of Instruction" which divided learning into short units, through which students moved at their own pace. Students not meeting the specified criterion on the end-of-unit assessment would be expected to study the material repeatedly until they could reach the level intended.

As experiments have been conducted and results collected, refinements to the originally proposed techniques have been developed (Bloom, 1971, 1976; Block, 1971, 1973; Block & Anderson, 1975; Clark, Guskey, & Benninga, 1983; Reiser, Driscoll, & Vergara, 1987). Studies have been conducted at a wide variety of educational levels in many different subjects (Anderson, 1994). Results from these studies have been mixed: some report no statistically significant improvement on standardized tests (Kulik, Kulik, & Bangert-Drowns, 1990; Slavin, 1990). Others indicate notably higher scores among students in mastery learning classes (Willett, Yamashita, & Anderson, 1983; Guskey & Gates, 1985).

Many classes, and Computer Science classes are no exception, involve a great deal of information which must be assimilated and understood before the student is ready

to move on to other classes (Rowan University, 1998). One class taught in Rowan University's Computer Science department, known as *Computer Lab Techniques*, includes sections on many of the specialized programming tools needed to develop software systems on modern computers, primarily those running a UNIX¹ operating system. These tools are used by students taking higher-level classes, as well as professionals working in the field.

While easy-to-use interfaces and programs have been developed for UNIX and UNIX-like systems, they are intended to simplify the tasks done by general users (*e.g.*, word processing, reading and sending electronic mail, and browsing the World Wide Web). Many of the tasks which have to be done by system administrators and software developers (*e.g.*, adding and removing users, configuring electronic mail systems, managing web servers, compiling and debugging software, and configuring new hardware peripherals) require a more sophisticated and intricate understanding of both the operating system and its tools.

These more advanced UNIX tools were developed by different teams at different times, often in response to new situations for which no good solution existed at the time. Because there was little coordination behind the development of these tools, they are not always consistent in how they should be used. Many UNIX programs, even widely-used ones, have strange limitations and exhibit quirky behavior (Lamport, 1994). Further, because of economic pressures, new versions of many tools must remain compatible with the earlier ones (Sobell, 1994). Because this somewhat anarchic development resulted in many oddities, the tools simply have to be learned as they are to be used effectively. This lack of consistency presents a significant obstacle to some users who are new to UNIX (Kernighan & Pike, 1984).

¹UNIX® is a registered trademark of The Open Group.

Despite the difficulties beginners encounter learning to use UNIX (and UNIX-like) systems, these systems continue to grow in popularity as a result of their technical advantages and their use of nonproprietary protocols and architectures (Wang, 1996).

Failure to understand the standard UNIX tools can cost a student many hours of lost productivity in later classes, and even after graduation when they begin work and are expected to use the programming tools in high-pressure work environments (Wang, 1996).

Improving students' mastery of this material would therefore help students in their later classes and when they are employed. Such improvement would also reduce the need for reviewing the tools in the advanced computer science classes, freeing up class time professors can use for more in-depth coverage of their own subjects.

Statement of the Problem

This study attempts to determine whether mastery learning techniques can be used to improve students' understanding and command of the tools available in a UNIX (or UNIX-like) programming environment.

Research Question

Stated as a hypothesis:

H_0 : For college students learning to use UNIX systems, there is no significant difference in test performance between students who have been given mastery quizzes and students who take standard pop quizzes.

In addition to objective measures of test performance, the researcher was interested in student preferences about mastery learning, both whether to use such a system and how it should operate. To explore this topic, difficult to measure objec-

tively, a survey was developed.

Need for the Study

Some studies (Garver, 1998; Clark et al., 1983; Reiser et al., 1987) report that a change to mastery learning in a college course, even the limited adoption of mastery techniques to be integrated into a traditionally-taught class, can involve unexpectedly large amounts of effort. Additional time is needed on the part of the instructor, who may have to develop many hundreds of questions for each quiz, instead of only five or ten, but who may also have to keep the question bank updated over time as textbooks change and material is grouped in ways incompatible with earlier quizzes. Students taking pop quizzes are usually given 15 minutes and then they are done; whatever studying was involved is completed. With mastery quizzes, students may find themselves re-taking the quizzes a dozen times, while not actually deriving concrete benefits from the time invested.

For students, this is time that could be spent studying, and working on assignments, for other courses. For the instructor, this necessarily cuts into time which could be spent on research, other university obligations (such as committee work, advising, and sponsoring student organizations), and even other courses.

It would obviously be pointless to spend time and effort on a classroom technique which (whatever its benefits in other contexts) may not be of use to the students involved, or may even decrease their performance for some reason. To see whether the students studying UNIX (and UNIX-like) systems would benefit from the use of mastery learning techniques, it was decided to teach one section with mastery quizzes (the treatment group) and one without (the control group), and do a comparison of their achievement.

Limitations

1. The study was conducted on two sections of “Computer Lab Techniques” taught at Rowan University’s Glassboro campus. This class has a limit of 25 students, because that is the size of the computer labs on campus.
2. The two sections of the class met at different time periods. This meant that it was not possible to arrange random assignment of the students to the treatment and control groups.
3. The study was conducted over a relatively short period. While long-term retention of material is an interesting topic, relevant information could not be collected for this paper.
4. The survey of attitude relies on self-reporting, which gives some concern for accuracy of the data.

Definitions

Computer Lab Techniques A course at Rowan University that focuses on the effective use of computers as tools, showing how concepts discussed in other classes are actually implemented by modern computer systems, as well as covering some of the many tools needed by system developers.

Formative test A test designed to measure student progress and allow for remediation while the educational process is continuing. Because the tests are given during the course of instruction, the results can be used to modify the instruction and improve learning. (Compare with *summative test*, below.)

LFM “Learning for Mastery,” a Mastery Learning technique developed by Bloom, which focuses on group-based lessons led by an instructor.

Mastery Quiz An assessment instrument on which students must achieve a specific performance criterion before moving on to more advanced material.

PSI “Personalized System of Instruction,” a Mastery Learning technique developed by Keller, which focuses on self-paced lessons used by individual students.

Summative test A test intended to certify or grade students, compare curricula, or judge the effectiveness of the teacher. Mastery Learning proponents argue that summative tests, especially those given at the end of a term, do not help the students. Bloom, Hastings, and Madaus (1971) write that:

Too often in the past, evaluation has been entirely summative in nature, taking place only at the end of the unit, chapter, course, or semester, when it is too late, at least for that particular group of students, to modify either [the process of teaching or learning] (p. 20).

UNIX A computer operating system originally developed by AT&T which has since branched into a wide variety of different versions and which runs on many different computers made by many different manufacturers. Since the original development of UNIX, similar systems have been developed independently. Since “UNIX” is a trademark, these alternate systems (which include Linux² and FreeBSD³) are often referred to as “UNIX-like.”

²Linux® is a registered trademark of Linus Torvalds.

³FreeBSD® is a registered trademark of FreeBSD Inc.

Chapter 2

Review of Related Research and Literature

Introduction

In the three decades since mastery learning took on the form we know today, many studies have been conducted. Hymel and Dyck (1993) reported finding over 2000 references to “Mastery Learning” while working on their retrospective.

This chapter will review some published reports on mastery learning. These include primary literature written by those who have conducted studies, meta-analyses which summarize other reported results, and one significant paper which calls into question the usual interpretation which cast mastery learning in such a positive light.

As the subject of this study is undergraduate students enrolled in a college course, reviews of experiments will be restricted to those conducted with similar groups. Most of the studies discussed here were conducted at other colleges, and one was conducted with college-age Naval recruits.

Review of Research

Bloom’s and Keller’s programs both anticipate flexibility in the scheduling of a course, thus allowing time for features such as retaking tests several times and self-pacing. In practice, however, many studies are conducted at institutions which have specified schedules, and researchers have to limit opportunities for remediation.

One such study of the effect of a mastery learning technique was conducted at the Naval Recruit Training Command in Illinois in 1997-98 (Lee, 1998). In this

study, students in both the treatment (82 subjects) and control (83 subjects) groups attended both lab exercises and lecture periods. The treatment group was also given a workbook which provided feedback to them on their progress. They worked through this book at their own pace outside class before they were tested. This gave them them an opportunity to discover areas in which their knowledge was weak, and review the material prior to testing.

This study found that students in the mastery group were able to complete the assigned task in fewer attempts than students in the control group. However, it found that students in the control group had a more positive disposition toward the subject matter, which was contrary to the expectation, given other studies on mastery learning. Some mitigating factors were considered; it was later discovered that the mastery group was rushed through a section of laboratory work as a result of a fire drill. Some students expressed dissatisfaction that they were not able to repeat the lab work, and this may have affected their general disposition.

There are several caveats about this study. First, the population was composed entirely of people in the military, which raises some concerns for extrapolations to the population at large. Second, due to the way the Naval administration scheduled the training divisions, all the subjects were male, again calling into question the generality of the results. Thirdly, the workbook provided only a single opportunity for remediation; in an ideal mastery environment, students have more than one opportunity for review and retesting.

A similar study, on mastery learning in undergraduate education courses, was conducted at the University of Kentucky (Clark et al., 1983). In this study, 197 students in were separated into 55 students for the mastery learning group (2 sections) and 142 for the control group (4 sections). The sections using mastery learning

techniques were given formative tests, but were not able to retest. Instead, corrective work was assigned to students who did not attain 90% mastery on the formative tests.

At the end of the semester, all six sections were given a common final exam. Results were largely positive: students in the treatment group performed better on tests, and demonstrated higher motivation, than students in the control group. Students in the mastery-oriented classes also had higher average attendance than the other groups.

One potential difficulty with extrapolating these results is that the class sections using mastery learning were taught by different instructors than the sections which constituted the control group. Additionally, those teaching the treatment group had volunteered to use the mastery techniques in their classes. The volunteers may have put more effort into their sections than did the instructors teaching the control sections. They may also have been better instructors generally, regardless of style. Additionally they may have volunteered because of an enthusiasm for mastery learning, or for the subject matter generally, which enthusiasm might have led to their better results.

Where the two previously-described programs either did not allow retesting, or allowed only one opportunity for retesting, other research has allowed more room for multiple testing opportunities.

A computer-based mastery learning quiz is being used in a new program at Victor Valley College (Garver, 1998). In this program, students learning anatomy take practice quizzes, which do not count toward student grades, whereby a computer selects questions from a large test bank. Students are encouraged to retake the practice quizzes until they score at least 85%. Tests which do count toward student grades cover the same topics as the practice quizzes.

This program has been in place for several years, and the reported results have been largely positive. Student test scores show improvement, and attitudinal surveys indicate that over 90% of the students would like to take other classes which use the computerized mastery-learning system.

Unfortunately, it is not clear that this study attempts to compare the use of computers generally with the use of computers in a mastery learning context. That is, perhaps students were simply attracted to the colorful graphics and interesting visuals. Perhaps they spent more time on the practice quizzes than they would have otherwise, reviewing material because it was presented in an interesting and engaging fashion. Additionally, this program was adopted in all sections of the anatomy class where it has been implemented, meaning that there is no control group for comparison.

The courses described above, while using some elements of mastery learning, were all instructor-paced. Lectures or lab exercises constituted an integral part of the learning experience, and the students were unable to proceed entirely at their own pace.

In a study at Florida State University (Reiser et al., 1987), students enrolled in educational psychology proceeded without regard to a set classroom schedule. This study analyzed the effect of different criteria in a mastery-oriented course. Students who agreed to participate in a study of mastery learning were randomly assigned to one of three groups. One group (27 students) was required to demonstrate a steady 80% mastery throughout the course. The second group (26 students) was required to attain 70% at the beginning the course, with the requirement increasing to 90% as the course progressed. The the third group (21 students) was required to attain 90% at the beginning of the course, and that requirement was relaxed to 70% as the course went on.

The results indicated that, overall, a moderate and steady mastery requirement (80%) gave better results in terms of student performance and attitude. Criteria that were too high dampened enthusiasm and reduced effort, causing some students to feel defeated. Standards that were too low did not require serious effort from the students, and so they did not perform. And in both cases, making the mastery criterion into a “moving target” (*i.e.*, changing the required level of performance during the course) prevented students from getting comfortable with the process and establishing a routine.

This study, while a useful guideline, doesn't constitute support for mastery learning in general, because there was no non-mastery control group. A more serious problem is that, even within the realm of mastery learning, there was no control group across performance standards. That is, there was no group that was required to achieve 90% for the entire semester, and none that was held only to a steady 70%. Further, the instructors were all volunteers, and knew they were being studied, which may have affected their performance. Each of the three sections was taught by a different instructor; as with previously-mentioned studies, that leaves “instructor” as an independent variable that is difficult to control for when evaluating the results.

A study conducted by Bergin (1995) at the University of Toledo (Ohio) compared two groups of college students assigned to either a mastery (26 students) or a non-mastery (25 students) educational group. The students, who were enrolled in one of several undergraduate education classes, studied a text on children's writing. They were later given a free-recall test. The results indicated that the mastery group had both higher achievement and greater interest.

This study avoided some of the pitfalls mentioned above. The students, while they volunteered for the study, were assigned randomly to their groups. Additionally, the

subjects represented the reasonably broad demographics of the college's student body as a whole. However, one obvious problem seen above recurred here: the two groups were taught by separate instructors. The paper included a brief explanation of how the free-recall test was graded: each sentence written by the students was rated on a scale of 1-3 for relevance, and the sum of these numbers was that student's score. This method leaves quite a lot of room for subjectivity, and the paper does not describe any methods used to correct for that. It may be that the papers were randomly mixed among the instructors with the names removed, but no such tactics are mentioned by the researchers. Another objection, which may be considered more serious, is that the entire study was conducted in only three days: one for the instruction and studying, and then the test two days later.

While most of the studies mentioned so far have focused on Benjamin Bloom's LFM (see page 7), a study of Physical Education students at Virginia Polytechnic Institute (Cregger & Metzler, 1992) was based on Keller's PSI (see page 7). In this study, students taking an introductory volleyball course were given written instructional materials about the game, describing various aspects of the game and providing instructions about how to perform different roles required of players (serving, rotation, and so forth). The students worked through these materials at their own pace, advancing to later sections when they had mastered earlier ones. The instructors acted as motivators, and helped to diagnose problems students encountered when practicing. The students were not told that a study was being conducted.

The researchers reported high attendance, that the students achieved good performances in the volleyball-related tasks, and that the students subjectively reported good attitudes about the course.

As with some other studies, this one lacked a control group. An additional concern

for the general applicability of this study has to do with the course in question. The volleyball course was an elective course, and as such probably attracted primarily those who either already liked the sport (and may have known quite a bit about the game and the rules in advance) or who were generally athletic and enjoyed team sports. Such people may have performed well, attended regularly, and enjoyed the course anyway. Also, the paper indicates that the class did not involve intensive written examinations or significant amounts of “book learning,” which casts doubt on the applicability of this study to more academically-oriented classes.

In a continually-evolving program at the State University of New York College at Cortland (Luyben, 1998), computer-assisted instruction is used to implement some aspects of mastery learning. Students taking a course offered in the Department of Psychology are required to take a review/practice quiz every other week. The quizzes are administered in a proctored computer lab. Feedback is given after each question, and students may retake the quizzes as often as they like. The highest score achieved is the one which is counted toward the student’s grade. The course also makes use of mastery quizzes, in which students must achieve 90% mastery to have the quiz counted as completed.

The number of quizzes taken varies widely from student to student: some appear to be actively overlearning the material, while others take the minimum number of quizzes needed to achieve a high score. The researcher reports that students come to lectures better prepared, participate more and engage in a higher level of discussion, score higher, and enjoy the class more. The majority of the students report that the computer assisted quizzing helps them to learn, and express a desire to have other classes structured in a similar way. Some, however, prefer a more traditional lecture-and-notes format, with tests restricted to material presented in class.

Unfortunately, because this program continues to evolve, and is not the same from any semester to any other, the positive results cannot be quantified or assigned to any one variable. The mastery learning aspect of the class was implemented at the same time as the computer-aided instruction, making it impossible to isolate one or the other as the cause of reported improvements. The paper closes with a report that an empirical experiment is scheduled; the results of that experiment have not (as of this writing) been published.

Senemoglu and Fogelman (1995) conducted a study at the Hacettepe University (Ankara, Turkey), in which 90 students were separated into three groups. One group (30 students) was a control group. The second (27 students) were given a pretest at the beginning of the course to test prerequisite learning. Those scoring less than 70% were given supplementary teaching on those prerequisite subjects. A third group (33 students) was given the same pretest and supplemental teaching treatment, but were also provided with feedback and correction through formative tests.

At the end of the semester, a common summative test was given to all three groups. The mastery learning group had scores that were significantly better than the second group's, which in turn were higher than the control group's. The researchers concluded that enhancing initial prerequisites has a positive effect on learning, and that the regular feedback and correctives of mastery learning techniques also improve student achievement.

This study attempted to correct for lecturer effects by rearranging the order of the subjects covered in each class. That is, each group was taught a given subject by the same instructor, but they learned the subjects in different orders. This raises the question of whether the topics are easier to learn in one order than another, but the researchers indicate that the material in the course is not sequence-sensitive, and

that the topics do not build on each other.

A study at Valencia Community College (Kysilka & Zapico, 1992) focused on students enrolled in General Chemistry with Qualitative Analysis I. Those in the treatment group (116 students) were taught with what the researchers called a “Quasi-Mastery Learning System” (QMLS), which includes four of Bloom’s five major elements mentioned in section (page 2). They were (1) learning objectives; (2) previously-set standards for mastery; (3) formative tests; and (4) additional learning experiences. As with many of the studies on mastery learning, Bloom’s fifth element, unlimited time, was omitted so that the course could be completed in the 15 weeks of a semester. At the end of the course, in addition to a standard exam, students in the experimental group were surveyed about their opinions on the class; 88 of the responses were considered usable (no explanation is given about why the others were unusable).

This study indicated that the mastery learning elements used by the researchers were effective in increasing student achievement and retention. Students in the experimental group also had increased participation in class, and were generally more positive about the course as a whole. Retention was higher, with only 14% of students in the treatment group withdrawing from the course, compared with 21% of the control group. Of those responding to the survey, 77% felt that they performed better because of the QMLS features of their class.

It is not clear from the paper the extent to which the researchers controlled for instructor effects, nor is it clear whether the students were given some form of pretest to account for differing degrees of knowledge coming into the classes.

Another study was conducted on 377 freshman students enrolled in mathematics basic skills at a 2-year community college (Abadir, Anglin, & Gooden, 1993). In

this study, the mastery learning group used self-paced instruction with no lectures. Students in the mastery learning section did better than those in the traditional section, but had higher attrition than the control group.

One problem with this study is that students chose which section they wanted to be in, and many chose the mastery learning section because it was flexible and could be incorporated into their work schedules.

In addition to studies such as those discussed above, many studies on mastery learning have been done with younger students in primary or secondary education. In this section, one typical summary analysis will be discussed, followed by a more critical examination which points up some problems with the studies which paint such a rosy picture.

Anderson (1994) published a synthesis of research, in which he cites studies which were in turn reviews of *other* studies. The studies are broken down into different areas: achievement, retention, student attitude, and other related variables.

To take a typical example, he cites seven studies which were reviews of a total of 279 other studies. Of those 279 primary studies reporting sample sizes, they included over 22,000 students. Experimental subjects included students ranging from kindergarten to college, using both Bloom's group-based Learning For Mastery program and Keller's individualized Personalized System of Instruction. Of these 7 review studies, 6 report statistically significant positive results for the primary research reviewed.

In the face of so much positive press, it is important to note that Mastery Learning studies have come in for criticism. Slavin (1987) cites a number of problems that have plagued many studies in Mastery Learning. Firstly, he notes that many of them are less than four weeks in duration, and thus do not serve to demonstrate real mastery—which requires long-term retention—of the material (compare the duration of Bergin's

study, on page 13).

Additionally, he notes the problem of unequal time: in Mastery Learning, students who do not demonstrate command of the material are given additional instruction. But here the idea of a control group breaks down: perhaps the increased performance is merely due to the extra time spent covering a subject, and students would show equal improvement if an extra few days were allotted for the topic to begin with. If so, then all the trappings of mastery learning are really of no effect except to indicate that, for some students, sufficient lecture time was not allotted in the first place. Slavin states (page 179) “It is virtually unheard-of in educational research outside of the mastery learning tradition to systematically allocate an experimental group more instructional time than a control group, except in studies of the effects of time itself.”

Even beyond the failure to control for this effect on the studies, there is the dilemma that it raises. Slavin cites Cooley and Leinhardt (1980) to support the contention that even for low achievers, spending extra time to master a given subject, instead of using the time to cover more subjects, is not always beneficial. And if the extra time is spent in regular class periods, this produces a “Robin Hood” effect: robbing time from the better students (which might be used on other subjects) to give it to the poorer ones (who need further teaching on those subjects where they have not yet achieved mastery).

When the time is controlled for, the benefits of mastery learning seem to evaporate: Slavin cites a study by Arlin and Webster (1983) in which mastery students achieved at twice the level of nonmastery students - but the mastery students had spent four times as long on the material. Taking this into account, nonmastery students retained far more *per hour of instruction* than mastery students.

Another issue raised by Slavin is that in many studies, students in mastery sections

are not given the same achievement tests as those in the control group. He notes that when standardized tests are given to the students, much of the benefit demonstrated by the mastery students disappears.

Summary

There are many published studies on mastery learning. Some cover complete implementations of either Bloom's Learning For Mastery or Keller's Personalized System of Instruction, while others considered courses which included only some ideas from mastery learning worked into a more traditional instructional framework.

Many of these studies report positive effects on achievement and accomplishment for students being taught with mastery learning techniques; however, many of those same studies suffer from difficulties of atypical sample populations, lack of control groups, failure to account for teacher effects, or failure to account for use of computers.

While meta-analyses often collect and present the positive results of these studies, some fail to consider sources of bias or inaccuracy in the experimental results. While critical studies are not in great supply, those such as Slavin's "Mastery Learning Reconsidered" (1987) do raise objections that must be addressed.

This present study, as described in the following chapter, will attempt to avoid some of the problems which appear in those mentioned above.

Chapter 3

Methodology

Experimental Subjects

This study involves students enrolled in Rowan University's *Computer Lab Techniques* class. The students were undergraduate Computer Science majors. Each section of the course is limited to 25 students. Students were not told in advance which section of the course would involve Mastery Quizzes, enrolling based on which section fit best with their own schedules. The two class sections were taught by the same instructor, the researcher.

The classes followed different schedules; one met twice a week (on Tuesdays and Thursdays) during the afternoon, while the other only met once a week (on Tuesdays) in the late evening. By random selection, the evening class was chosen as the treatment group, and the daytime section was the control group.

The control group had 18 people, of whom 6 were female and 12 male. The treatment group had 23 people, of whom 6 were female and 17 male.

Experimental Design and Methods

The mastery quizzes were given in the form of multiple-choice tests by computer, over the Internet. Students took the quizzes on their own time via a web browser. For each instructional unit of the class, a test bank of approximately 100 entries was created. Each entry included a question, up to 16 answers (any number of which could be listed as correct or incorrect), and up to four topics (indicating what areas of knowledge this question was designed to test). Students chose one answer to each

question (if more than one answer was correct, choosing any single correct answer was acceptable). Topics were used to provide feedback to students after they had completed the exam,

When a student connected to take a quiz, 20 questions were chosen at random from the test bank. The answers were also randomized. The student's browser then displayed a multiple-choice quiz consisting of the questions and possible answers. The time allotted for completing the quiz was 10 minutes. (A typical example can be found in Appendix C.) After the student selected answers and submitted the quiz for grading, another program checked the student's answers.

The grading program reported the number of questions correct, the time needed to complete the quiz, and whether the student passed. For each question the student got wrong, the grading program printed out the topic or topics that had been included with the entries, and how many questions on that topic were incorrectly answered. Because some questions covered more than one topic, the numbers could sum to greater than 20. Students were not told which questions they got wrong or which answers were correct, only the subject areas in which their answers were not correct. (An example of the grading output can be found in Appendix D.)

The quizzes were made available to the students on the Wednesday morning after the Tuesday class on the material being tested. To have the quiz count as completed, students were required to pass with at least 80% correct by noon on the following Tuesday. (After the first week, the students requested that the deadline be extended to 4 p.m., arguing that they had signed up for a night class because they were not "morning people." This modification was made.)

To encourage students to review material not understood, instead of just randomly clicking on answers over and over, the quiz generating program would refuse

to generate a quiz for a given student more than once every thirty minutes.

Several potential security problems were addressed. Students, after failing to achieve 80% on a quiz, might have clicked their browser's "Back" button, changed a few answers, and resubmitted the same quiz. To eliminate this possibility, each quiz generated, and each student's attempted answers, were archived. Submitting a second set of answers to a quiz produced a message reminding the student that they had already attempted this quiz, and would have to have a new one randomly generated. Students, on seeing a quiz with questions they could not answer, might have clicked their browser's "Reload" button to get a new quiz generated. Because previously-generated quizzes were archived, an attempt to get a new quiz within the 10 minute allotted time would result in the same quiz being redisplayed. (The allotted completion time was not extended by the reloading: if it were, a student could effectively get 19 minutes and 59 seconds to work on the quiz, by waiting until 9 minutes had passed, and reloading the quiz to reset the timer.) After the 10 minute allotted time had passed, an error message would be presented reminding the student of the 30 minute delay between generating quizzes. (Samples of the various reminder messages are presented in Appendix E.)

Data to be Collected

The data to be collected included the scores from the pretest, the scores from the first mid-term, and student opinions in response to an affective instrument (which appears in Appendix F).

Statistical Analysis

To answer the research question, whether mastery learning techniques can be used to improve students' understanding and command of the tools available in a UNIX

(or UNIX-like) programming environment, a two-sample t-test paired differences was employed.

Due to external matters of class scheduling, random assignment of students to the control and treatment group was not possible. For this situation, the nonrandomized control group, pretest-posttest design was appropriate for this study (Ary, Jacobs, & Razavieh, 1990). (The pretest appears in Appendix A; the posttest appears in Appendix B.)

The need for a pretest results from the lack of random assignment. Though the subjects were not assigned to classes for the purposes of the experiment, and the selection of sections for control or treatment was random, other issues may have interfered with the study's internal validity. Historically, Rowan's late evening computer science classes attract many older students who have daytime jobs, and some of whom already have computer experience and training. As a result, a posttest-only design could incorrectly show significantly higher results for one group.

Time Schedule

The pretest was given at the beginning of the semester, on the first day of class. The first mid-term exam was given during the fifth week of class, after four weeks (12 classroom hours) of instruction.

This time schedule was chosen due to the time constraints imposed on the study from outside, and also to address a potentially troublesome ethical issue which confronts all research on human subjects: adverse effects of the treatment. In this case, it was judged that, in the event the mastery learning group learned *less effectively* than the control group, there would be sufficient time during the semester to make up any lost ground.

Chapter 4

Results

This chapter presents the data collected for this study. It includes an overview, tables of the results, and the statistical analysis of those results.

Overview

The purpose of this study was to determine whether computer-based mastery quizzes improved student learning. The study's hypothesis was that the treatment group would not perform significantly better than the control group on an exam. An additional research question concerned student preference for the mastery learning environment. Each group was given a pretest at the beginning of the study, and a posttest in the form of a semester midterm exam. The treatment group was also given an attitudinal survey to assess their opinions about the mastery learning environment and suggestions for improving it.

Test Performance

At the beginning of the semester, the control and treatment groups were given a pretest (which is reproduced in Appendix A). After five weeks of instruction, each group was given the posttest (reproduced in Appendix B) on the same day.

It was not possible to schedule both groups to take the exam at the same time, raising the possibility that students in the afternoon section might advise students in the evening section about specific questions on the test. To reduce the likelihood of such activity, and its potentially-corrupting events on the study, some misdirection was employed. Students in each section were advised to ensure that they had not

inadvertently been giving the exam for the other section. The justification given was that the two sections had covered different material, and the exams were not the same. Both the control and treatment groups had covered the same material, and the same exam was given to each section. This deception, and its experimental purpose, was explained when the exams were returned.

The pretest and posttest results for both the groups are in Table 4.1.

Table 4.1: Student Scores on Pretest and Posttest

Control Group		Treatment Group	
Pretest	Posttest	Pretest	Posttest
8	46	10	56
5	41	13	66
10	95	15	81
91	87	46	90
25	79	46	93
17	71	5	58
9	69	10	59
9	70	15	78
32	65	10	45
13	87	53	78
24	48	27	92
11	49	20	75
32	82	10	82
9	55	55	76
25	71	22	67
10	84	27	68
66	82	18	51
5	32	10	69
		8	75
		28	74
		9	59
		0	52
		10	74

As described in Chapter 3 (page 23), a two-sample t-test of the paired differences was employed. The results of that t-test appear in Table 4.2.

Table 4.2: Summary of t-test Results

Group	Number of Students	Mean (post-pre)	Standard Deviation (post-pre)
Control	18	45	22
Treatment	23	50	13

The t-value of these results is 26.4, which was not significant at the $p < .05$ level.

Student Preferences

In addition to the test scores, students in the treatment group were given a survey (reproduced in Appendix F). This survey was designed to discover the students' overall opinions about the mastery quizzes, as well as to determine the students' preferences about some of the changes which had been suggested during the course of the semester.

One potential problem with student evaluations is fear of retribution (Arreola, 1987). The students in the treatment group were aware during the course of the study that the mastery quiz system was under development, and that the software for the system had been written by a friend of the instructor, and later modified by the instructor directly. In such an environment, students might be reticent to express negative opinions, lest they offend an instructor who will be assigning them grades. To reduce any concerns the students had about fairness in grading and honest opinions, the surveys were anonymous. Additionally, most of the items called only for a number from one to five, meaning that there would not be any significant handwriting samples for comparison. Nevertheless, one survey was returned completely blank. The numerical responses from the non-blank surveys can be found in Table 4.3.

Some survey responses were unconventional and did not precisely follow the direc-

Table 4.3: Student Responses to Attitudinal Survey

Student Number	Responses to Survey Items										
	1	2	3	4	5	6	7	8	9	10	11
1	5	5	4	3	5	5	5	5	5	2	2
2	5	5	4	4	5	1	3	5	5	3	3
3	5	5	4	5	5	3	5	4	2	2	3
4	5	4	5	5	5	5	5	5	5	1	2
5	3	3	4	2	5	5	4	3	4	2	3
6	5	5	4	4	5	5	3	3	3	2	5
7	5	3	4	4	4	4	4	5	3	2	2
8	5	5	5	5	5	5	5	5	3	1	5
9	4	4	2	2	5	5	5	4	5	3	3
10	5	5	5	5	3	1	5	3	5	1	1
11	5	5	5	5	5	5	5	3	3	3	3
12	4	5	4	4	2	1	3	5	3	1	3
13	4	3	4	4	2	1	5	5	3	2	5
14	5	5	5	4	4	2	2	2	3	1	1
15	5	4	4	4	2	2	4	4	4	3	3
16	5	5	4	4	5	3	5	5	4	1	4
17	5	5	5	5	4	2	4	5	4	1	2
18	4	1	4	1	5	5	5	3	1	2	5
19	5	5	5	4	3	5	5	1	5	1	5
20	5	3	4	4	5	4	3	4	4	1	3
21	5	5	5	5	5	5	5	3	4	2	3
22	4	4	4	4	4	5	1	1	5	2	1
mean	4.7	4.3	4.3	3.6	4.2	3.6	4.1	3.8	3.8	1.8	3.0

tions, but the intended interpretation was considered obvious. Because it was possible to interpret the answers in a way consistent with the purpose of the survey, the unconventional responses were included in the analysis. One student responded to item seven with “5, 5, 5,” and another responded to item five with “5, 5, 5, 5, 5, 5, 5.” Both of these answers were recorded as being “5” for the purposes of the study, with the additional “5” symbols being considered extraneous. One student responded to item five by supplementing his numerical answer with the notation “That would be

cool.” The numerical answer was recorded, and the additional notation considered a misplaced remark intended for the section “Other Comments.”

The results of the survey are summarized in Table 4.4.

Table 4.4: Summary of Attitudinal Survey Responses

Survey item		Mean	Std. Dev.	t value	Significance
No.	Topic				
1	Continue mastery quizzes	4.7	0.6	13.9	$p < .001$
2	Use in other classes	4.3	1.1	5.5	$p < .001$
3	Quizzes helped	4.3	0.7	8.5	$p < .001$
4	Quizzes are efficient	3.6	1.1	4.1	$p < .01$
5	List missed questions	4.2	1.1	5.2	$p < .001$
6	Give correct answer	3.6	1.6	1.7	$p > .100$
7	Allow more time	4.1	1.1	4.5	$p < .001$
8	Reduce required wait	3.8	1.3	2.7	$p > .270$
9	Add review system	3.8	1.1	3.3	$p < .01$
10	Raise passing criterion	1.8	0.8	-7.7	$p < .001$
11	Lower passing criterion	3.0	1.3	0.2	$p > .870$

Items 1-4 of the survey asked students to express their agreement or disagreement with statements about the mastery quizzes. Items 5-11 asked them to specify their approval or disapproval of changes to the quizzes which had been proposed by students during the semester.

The survey used a five-point scale, with “1” indicating strong disagreement or disapproval, “5” indicating strong agreement or approval, and “3” indicating neither.

A discussion and analysis of the test and survey results appears in chapter 5.

Chapter 5

Conclusions

Sun Tzu, in *The Art Of War* (ca. 475 B.C.) wrote “*Fei Li Bu Dong*” – “No money no move.” Less literally, “Take no action unless there is advantage to it.”

That advice, as applicable generally as it is to military action, was the original motivation for this study: time and effort should not be spent developing and maintaining computer-based mastery learning systems, and taking and retaking mastery learning quizzes, unless there is something to be gained.

Interpretation of Student Test Results

The test results, as summarized in Table 4.2 (page 26), did not demonstrate any significant difference between the test performance of the treatment and control groups. These results support the null hypothesis.

Interpretation of Student Survey Results

The first two survey items focused on whether students preferred taking on-line mastery quizzes to having paper and pencil quizzes. The responses to both questions indicate that the students have a clear and strong preference for the on-line mastery quizzes.

The third and fourth items focused on how well the quizzes helped them learn. The responses, while not as overwhelmingly positive, indicate that the students believed the quizzes were beneficial and generally efficient.

The fifth through eleventh items summarized suggestions which had been made during the semester, allowing the students to express opinions on how the quizzes could be improved. Here, there was strong support for having the grading program present the actual questions missed, instead of just the relevant topics (item five); but there was no significant support for having the computer also tell the students what the correct answer was (item six).

Most students supported allowing more time to complete the quizzes (item seven), but there was no clear preference about removing the 20-minute waiting period between attempts (item eight).

Item nine focused on allowing students to review their previous attempts in some automated way; as expected, students support for the suggestion was present, but tepid. Most students were printing paper copies of the quizzes and their answers anyway; as a result, this feature would only add convenience, not functionality.

The last two items offered students the chance to express opinions about raising or lowering the quizzes' passing criterion. They strongly rejected making the criterion harder; there was no consensus about making it easier.

Discussion

This present study did not demonstrate any noteworthy academic benefits of computer-based mastery learning techniques. However, student responses did indicate a strong preference for the computer-based mastery quizzes. This suggests some possible alternate benefits, which are exemplified by some of the responses given in the "Other Comments" section of the survey. Several students wrote that they felt less pressure when taking the on-line quizzes, even with the 80% passing standard and the ten-minute limit. One student wrote that, with pencil and paper quizzes, there is always the possibility of studying the wrong material, or failing to anticipate

a question, and the anxiety that goes with not knowing what to expect. With the on-line quizzes, no such anxiety exists: even if one does badly on the first attempt, that attempt gives the student a general sense of what will be covered and what is expected. Another student wrote of having an “all or nothing” feeling with paper and pencil quizzes: “you get one try, and you sink or swim.” Here again is a source of anxiety that the mastery quizzes avoid: students can try as often as they like.

As discussed in Chapter 2, many previous studies (Abadir et al., 1993; Anderson, 1994; Clark et al., 1983; Cregger & Metzler, 1992; Garver, 1998; Kysilka & Zapico, 1992; Lee, 1998; Luyben, 1998; Senemoglu & Fogelman, 1995) have shown a positive academic benefit to mastery learning techniques. One possible explanation for this study’s different outcome may have to do with the mechanics of the mastery learning system which was used. The results of the student survey, both responses to item five and free-form comments, expressed a clear dissatisfaction with having the computer list only the topics for questions answered incorrectly. The student comments on this point expressed frustration: “Quizzes would be more helpful if I knew what I got wrong,” “I am never sure of what is wrong or right from one attempt to the next,” and “Listing the questions themselves that are wrong would be helpful.”

It may be that previous studies which reported positive benefits involved mastery learning systems which had more detailed, or otherwise superior, reporting mechanisms to the one used in this present study. Unfortunately, most of the studies lack such details, despite their potentially-significant effect on the outcome. An appendix to the study by Lee (1998) includes the workbook used in the study, in which students took a sample quiz printed in the book and then checked their own answers on a following page. The answers were accompanied by instructions on how the students were to proceed depending on their performance. In this situation, the students ob-

viously had access to which questions they had wrong. The system used by Garver (1998) includes a feature which gives immediate feedback on each question. While the form of feedback is not described, the students would know which questions had been answered incorrectly.

Another possible difference between this study and previous ones which reported success is in the reporting made to the instructor. Some of the studies (Abadir et al., 1993; Clark et al., 1983; Kysilka & Zapico, 1992; Senemoglu & Fogelman, 1995) mention supplementary learning experiences arranged for students in response to their performance on formative tests. While few details are included, efficiently planning supplementary learning requires knowing what subjects need additional coverage.

This present study was, unfortunately, lacking in an effective instructor reporting system. Such a feature, to provide a summary for the instructor of which topics gave students the most difficulty, was not implemented in the original prototype by its developer, and there was not time to properly write and debug such a mechanism during the time the study was proceeding. The intent was to have the system report troublesome topics, so that the instructor could revisit those topics at the beginning of the following class, thus increasing efficiency of remediation.

The lack of such a feature proved frustrating. It was the feature most desired by the instructor (who is also the researcher), in the hopes of making better use of the archived quizzes and answers. At the time of the mid-term exam, the students had taken a total of 285 quizzes which included an aggregate of 5700 questions – over 1400 pages of raw data. Having a lot of information about student performance is something an instructor should be able to benefit from, but looking for meaningful patterns in so much raw information, even with general-purpose sorting tools, proved essentially hopeless. It was frustrating to have the data and not be able to glean

useful information from it. It is the researcher's opinion that had such a summary feature been present, an instructor using the mastery learning system would know better what the students had learned and what they had not.

Another possible explanation for the differing outcomes can be found in the exam preparation. The instructor has for several years provided students with very complete exam review materials, usually consisting of 20 to 30 questions, modeled on those of previous exams, and similar to those which will appear on the actual exam. Industrious students have been known to work out detailed answers to each of the sample questions, creating entire computer directory structures on which to experiment and memorizing manual pages of any commands needed to solve the questions. It may be that the effectiveness of such diligent preparation, made possible by the nature of the review material, was equal to or greater than any benefit conferred by the quizzes. It is too late to collect the information at this point, but it would be interesting to have the students keep track of how much time they spent studying for the exam, to see if there was any difference in study time between the two groups.

Suggestions for Futher Research

Several areas for further research on computer-based mastery quizzes were suggested by the results of this study.

The modification most overwhelmingly supported by the students was to have the grading system give a list of the questions which were answered incorrectly. One obvious application of this preference would be to repeat the study with a computer grading system which does list the questions.

Another potentially useful and interesting avenue of research would be to repeat the study by adding the feature most desired by the instructor: a method of sifting the data archive to give concise summaries of which areas gave students trouble.

This would allow for efficient in-class remediation, taking five to ten minutes at the beginning of each class to review the topics from the previous week which had proved most confusing.

Summary

While the data from the experiment did not show any significant positive effect of the mastery quizzes on the students' test scores, it is the researcher's opinion that the quizzes were nevertheless beneficial. The students expressed a strong preference for mastery quizzes, and indicated that the mastery quizzes greatly reduced anxiety. The control group, after the experimental period was over, was shown the mastery quizzing system and voted unanimously to switch to mastery quizzes. Their preference for a system they had not used can obviously not be cited as unqualified support for mastery learning, but it does indicate dissatisfaction with more traditional quizzing techniques.

In class, the treatment group was more animated and participatory; of course, this may not be a result of the mastery quizzes. It could result from the class meeting time, the individual students, or the environment (the evening section met for the entire time in a computer lab, while the daytime section was only in a lab on Thursdays, meeting in a classroom on Tuesdays).

One concern of the researcher was that the experimental teaching technique could reduce student learning. Thankfully, although the results showed no significant positive effect, they also showed no *negative* effect. Because the quizzes apparently did not reduce student learning, the researcher is satisfied that this ethical issue need not be a bar to further testing of computer-based mastery quizzes. Future testing should be done with careful tracking of progress to ensure that any adverse effects on learning are quickly discovered, allowing a more traditional teaching technique to be

substituted before students have fallen seriously behind.

Provided careful attention is given to student achievement, the suggestions for further research mentioned above could prove fruitful and beneficial.

Appendix A

Pretest

This appendix includes the pretest given to the students in both sections at the beginning of the course.

Questions 1, 4, 5, 6, 8, and 11 are basic UNIX literacy questions; topics which would probably be familiar to any regular user of a UNIX or UNIX-like system. Questions 7, 9, and 10 are also general, but ask about more advanced subjects.

Questions 2, 3, and 13 ask about specific UNIX tools likely to be known primarily to software developers or system administrators.

Question 12 is not UNIX-specific, but rather touches on level of knowledge about the Internet. Computer Science students can usually be expected to have a familiarity with the Internet, but often at a superficial level.

Question 14 is also not UNIX-specific, but is instead just a question intended to discover whether students understand basic programming structures and how to use them.

1. Describe in a few words what the following programs do. If you don't know, write 'don't know'.

(a) sed

(b) grep

(c) ls

(d) mv

(e) rm

2. I wrote a buggy program, ran it with the Gnu Debugger (gdb), and collected the output. What should be checked to correct the problem?

```
Program received signal SIGSEGV, Segmentation fault.  
0x8048845 in IntStack::pop (this=0xefbfd730) at stack.C:41  
41         int data = top->data;
```

3. You may have used one of these systems: RCS, SCCS, CVS (any is equally good; they are all similar). Write one sentence that explains what such a system does.

4. There is a program called 'ls'. What does it mean if I say 'see ls(1)'?

5. The 'ls' program usually gives its output in alphabetical order. There is an option, 'r', which causes ls to give its output in reverse order. But if I just write 'ls r', the ls will try to work on the 'r' file. How do I tell 'ls' that r is an option flag, and not a file to work on?

6. The standard Unix command interfaces (there are several different ones) share a syntax for specifying many files. Assuming all the C++ programs in a directory end with '.C' in their filenames, or '.h' for header files, how would I specify all the C++ programs *and* header files in one step?

7. Homer's personal directory is '/usr/people/homer'. Draw the directory tree that results if Homer starts in his personal directory and runs these commands:

```
elvis 1% mkdir homework
elvis 2% mkdir homework/labtech
elvis 3% cd !1$
elvis 4% mkdir testing
elvis 5% pwd
```

What would be the output of command #5?

8. Directory listings, by default, do not show all the files in a directory; some files are hidden. Which files are not listed?

How can you get a listing which includes the usually-hidden files?

9. I have a program whose mode is 644. Who is allowed to look at the program?

Who is allowed to change the program?

Who is allowed to run the program?

10. What does 'chmod go-rwx *directoryname*' do?

11. What is the only character that can never appear in a filename?

12. What does 'http' stand for?

13. What is a 'Makefile' for?

14. Write a short loop in any language that prints out the numbers 1 through 10.

Appendix B

Posttest

This appendix contains the semester mid-term exam, used as the posttest for this study.

The point values for each question appear in **bold**. On questions marked with an asterisk (*), you can earn a bonus points for giving a minimal answer.

1. **[12]** Describe in a few words what the following programs do.

(a) sed

(b) grep

(c) ls

(d) mv

(e) rm

(f) cp

2. **[12*]** Given this output from `ls -a`, give shell filename matches which correspond to the lists below. You may not use curly braces in your answers.

.	ANAGRAM	News	contest	foo
..	Ada	Ziptest	core	foo2
.cshrc	Books	aaa	crashmessage	foobar
.login	GRAD	aaa.c	crypt.csh	stevephone
.mailrc	Java	bubblesort	deletem.csh	zorchedfiles
.netscape	Mail	condrift.html	emacs-help.html	

(a) The files **Anagram, Ada, aaa, and aaa.c**.

(b) The files **aaa.c, condrift.html, crypt.csh, deletem.csh and emacs-help.html**.

(c) The files **Anagram, Ada, Books, GRAD, Java, Mail, News, and Ziptest**.

(d) The lower four files in the first column.

(e) The files **crypt.csh and deletem.csh**.

(f) The files **GRAD, Java, Mail, News, core, and foo2**.

3. [12] Assuming you are still in the same directory as for the previous question, list the files, if any, which would be matched by the following shell wildcards. If none match, write '(none)'.

A. ?a

D. c*h*

B. ?o****

E. [b-d]*e

C. *t*

F. *e

4. [10] Consider this output from the jobs command:

```
[1] - Suspended      robots
[2]   Suspended      vi foo.main
[3] + Suspended      man gethostbyname
[4]   Running        netscape &
[5]   Suspended      rot13
```

- Which job was the last one you suspended?
 - Give any way of referring to the editor session.
 - Give any way of restarting the robots game.
 - Give any way of restarting the manual command.
 - Give any way of killing the netscape session.
5. [5] There is a program on Elvis called 'fuser'. What does it mean if I refer to 'fuser(1)'?
6. [10*] I have a directory on Elvis where I have answered all of the problems on this test, checking my shell scripts and so forth. For obvious reasons, I want to keep people from reading these files. What permissions should I set on the directory so I can get in but nobody else can? What command can do this? How can I check the permissions after I set them?

7. [10*] The command 'file' opens the files named on the command line and opens the files up in an effort to discover what their contents are. I set up a sample directory, ran 'file *', and got this output:

```
baz:      directory
foo.jpg:  JPEG/JFIF compressed image file
foo.desc:  ascii text
house.gif: GIF image(version 89a) (0x226 x 0x092)
zorch.c:  c program text
```

Suppose I have a mixture of files in a directory, including images in GIF and JPEG format. I want to know what files are *not* images, and I want *only the names* of those files. For the sample data given above, correct output would look like this:

```
baz
foo.desc
zorch.c
```

Write a **single-line** shell pipeline which will allow me to go into any directory that includes GIF and JPEG files, and will give a list of *names only* of those files in that directory which are not images. (You may assume that there are no files with 'image' as part of the name.)

8. [10] Homer's personal directory is '/usr/people/homer'. Draw the directory tree that results if Homer starts in his personal directory and runs these commands:

```
elvis 1% mkdir homework
elvis 2% mkdir homework/labtech
elvis 3% cd !1$
elvis 4% mkdir compiler
elvis 5% cd labtech
elvis 6% touch Makefile
elvis 7% cp Makefile ../compiler
elvis 8% mkdir RCS
elvis 9% touch Makefile
elvis 10% cd ../compiler
elvis 11% touch lexfile.l
elvis 12% touch yaccfile.y
elvis 13% pwd
```

What would be the output of command #13?

9. [5*] The command 'du' reports on disk usage. By default, it will descend a full set of subdirectories and report on all of them. With the '-s' flag, it will only report summaries of those files listed. If you go into a directory and type 'du -s *', you can get a list of what items under that directory use up the most disk space. But the list will not be sorted. Here are a few lines of the output generated by running 'du -s *' in my home directory on the machine Palestrina:

```

701    ACM
5      Aterms
1      BOOKLIST
1487   CLASS
227    CVSSTORE
10017  DOWNLOAD
44     GNOME
282    GNUstep
14889  GRAD

```

Suppose I am close on my disk quota. I need to find out where in my directory tree I should clean up first. Write a single-line shell pipeline which starts with 'du -s *', and will list (in ascending order by size) the 10 biggest disk hogs in the current directory.

10. [14] Given the lines on the left, list (by number) which line(s), if any, would be matched by grep using the regular expressions on the right. If none match, write '(none)'. (Note that the numbers and colons are not part of the lines.)

1: I could not, would not, on a boat.	A. ar
2: I will not, will not, with a goat.	B. ^...i
3: I will not eat them in the rain.	C. [Ee].\$
4: I will not eat them on a train.	D. ^[IN].*.*\$
5: Not in the dark! Not in a tree!	E. [^er]a
6: Not in a car! You let me be!	F. !
7: I do not like them in a box.	G. o[xr]
8: I do not like them with a fox.	
9: I will not eat them in a house.	
10: I do not like them with a mouse.	
11: I do not like them here or there.	
12: I do not like them ANYWHERE!	
13: I do not like green eggs and ham!	
14: I do not like them, Sam-I-am.	

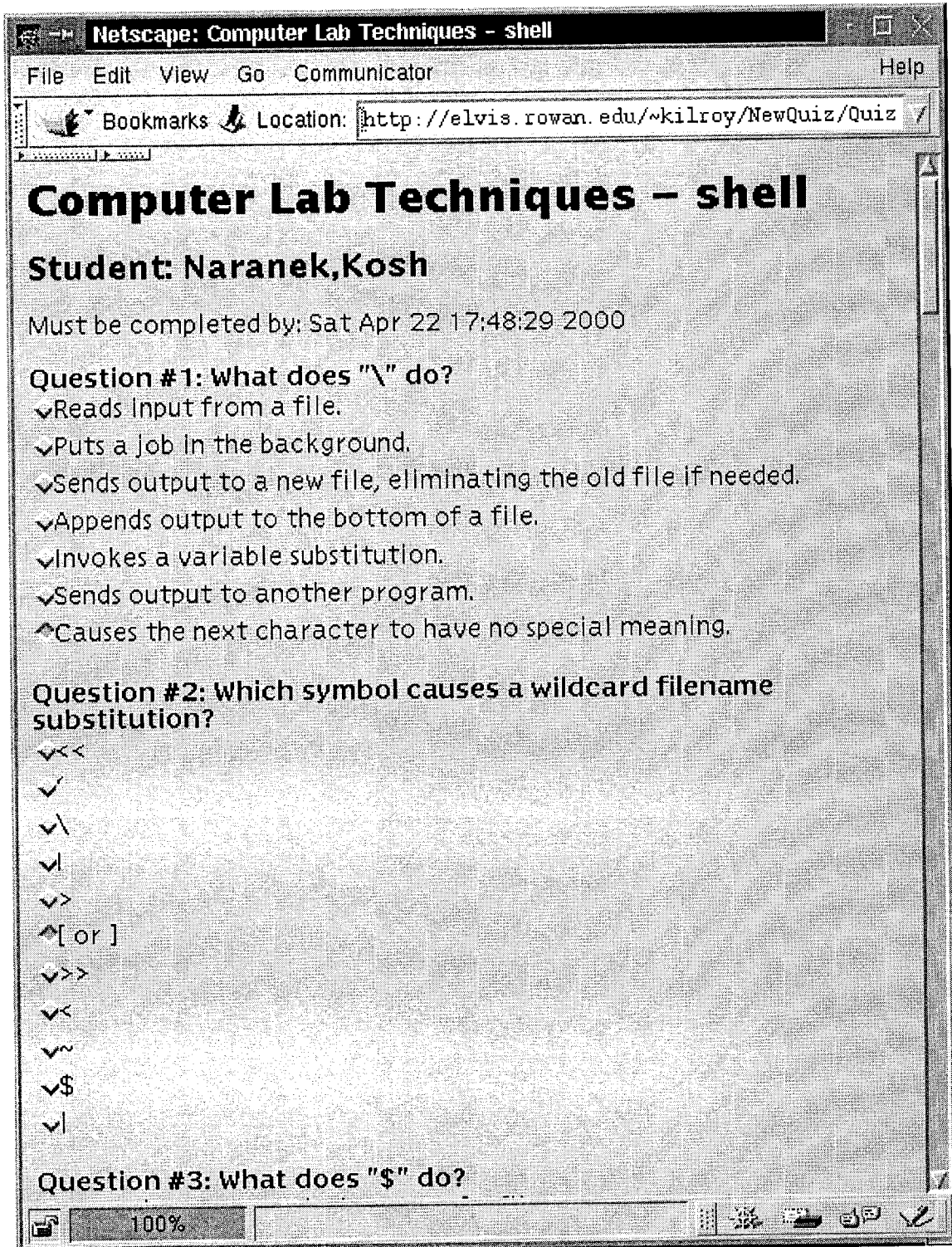
Appendix C

Sample Quiz

This appendix contains an example on-line quiz. The quiz is too long to be displayed easily in a single web browser window without scrolling. To present the data in a format suitable for printing, a single image of a typical browser window (Netscape Navigator¹), is included first. The name on the sample quiz is fictitious.

The pages following include a text presentation of the questions and answers, without attempting to preserve the formatting which would be seen by students taking the quiz.

¹Netscape Navigator® is a registered trademark of Netscape Communications Corporation.



Question #1: Which of the following happens last?

- ◇ Variable substitution.
- ◇ File name expansion.
- ◇ History substitution.
- ◇ Alias substitution.
- ◇ Command substitution.

Question #2: Which symbol appends to a file?

- ◇ >>
- ◇ \$
- ◇ <
- ◇ ‘
- ◇ <<
- ◇ !
- ◇ ~
- ◇ >
- ◇ \
- ◇ |
- ◇ *

Question #3: In a directory with files ‘Ada’, ‘Books’, ‘ZipDrive’, ‘anagram’, ‘awfulhak’, and ‘core’, you want to match only ‘Ada’, ‘Books’, and ‘ZipDrive’. Which shell match will work?

- ◇ *[ase]
- ◇ A?B?Z?*
- ◇ [a-z]*
- ◇ [ABZ]*
- ◇ None of the other answers will work.
- ◇ A*B*Z*

Question #4: In a directory with files ‘Ada’, ‘Books’, ‘ZipDrive’, ‘anagram’, ‘awfulhak’, and ‘core’, you want to match only ‘Ada’ and ‘anagram’. Which shell match will work?

- ◇ [Aa]*
- ◇ None of the other answers will work.
- ◇ [Aa]*a*
- ◇ *a*
- ◇ [Aa]?a*
- ◇ a*

Question #5: Which is a shell wildcard which will match strings that include the substring 'doh' ?

- ◇ [doh]*
- ◇ Cannot be done.
- ◇ *doh*
- ◇ doh

Question #6: Which command will show me the current settings of my environment variables?

- ◇ set
- ◇ None of the other answers is correct.
- ◇ show environment
- ◇ print
- ◇ showenv

Question #7: Which of the following happens fourth?

- ◇ File name expansion.
- ◇ Command substitution.
- ◇ Variable substitution.
- ◇ Alias substitution.
- ◇ History substitution.

Question #8: Shell variables and History references share modifiers. What does ':h' do?

- ◇ Returns everything before the final "/".
- ◇ Returns everything after the first ".".
- ◇ Returns everything before the first ".".
- ◇ Returns everything after the final ".".
- ◇ Returns everything after the first "/".
- ◇ Returns everything before the final ".".
- ◇ Returns everything after the final "/".
- ◇ Returns everything before the first "/".

Question #9: You have some directories with names like 'test001', 'test002', and so on up to 'test045'. They are filled with large files you don't need anymore. How can you clean them all up easily?

- ◇ "rm test*"
- ◇ You have to cd into each directory, type "rm *", and then cd back out.
- ◇ None of the other answers is correct.
- ◇ "rmdir test???"
- ◇ "rm test??*/*", followed by "rmdir test???".

Question #10: Which is a shell wildcard that will match strings starting with 'a' or 'A'?

- ◇ [Aa]*
- ◇ Aa.*
- ◇ ^[Aa]
- ◇ [Aa].*
- ◇ Cannot be done.

Question #11: Shell variables and History references share modifiers. What does ':e' do?

- ◇ Returns everything after the final ".".
- ◇ Returns everything before the final "/".
- ◇ Returns everything before the first "/".
- ◇ Returns everything after the first "/".
- ◇ Returns everything after the first ".".
- ◇ Returns everything before the first ".".
- ◇ Returns everything after the final "/".
- ◇ Returns everything before the final ".".

Question #12: Which symbol causes a wildcard filename substitution?

- ◇ ?
- ◇ <<
- ◇ |
- ◇ '
- ◇ >>
- ◇ \
- ◇ <
- ◇ !
- ◇ \$
- ◇ >
- ◇ ~

Question #13: What does '<' do?

- ◇ Causes the next character to have no special meaning.
- ◇ Invokes a variable substitution.
- ◇ Sends output to a new file, eliminating the old file if needed.
- ◇ Appends output to the bottom of a file.
- ◇ Sends output to another program.
- ◇ Reads input from a file.
- ◇ Puts a job in the background.
- ◇ Causes a filename match.

Question #14: Which symbol causes a history substitution?

- ◇ \
- ◇ >
- ◇ *
- ◇ ,
- ◇ <
- ◇ ~
- ◇ \$
- ◇ !
- ◇ <<
- ◇ ‘
- ◇ "

Question #15: Which filename below would NOT be matched by ‘[Aa]*’ ?

- ◇ Argon.gif
- ◇ They would all match.
- ◇ Algorithms
- ◇ a
- ◇ answers.txt

Question #16: Which is a shell wildcard which will match strings that include the character ‘/’ ?

- ◇ Cannot be done.
- ◇ */*
- ◇ /

Question #17: What does ‘!’ do?

- ◇ Sends output to another program.
- ◇ Puts a job in the background.
- ◇ Invokes a variable substitution.
- ◇ Sends output to a new file, eliminating the old file if needed.
- ◇ Appends output to the bottom of a file.
- ◇ Invokes a command substitution.
- ◇ Invokes a history substitution.
- ◇ Causes a filename match.

Question #18: Which command stops a program running in the background?

- ◇ stop
- ◇ bg
- ◇ fg
- ◇ kill
- ◇ ^Z (control-Z)
- ◇ None of the other answers is correct.

Question #19: What does the shell variable 'path' store?

- ◇ The set of directories which the user has visited with 'cd'.
- ◇ None of the other answers is correct.
- ◇ The full pathname of the current directory.
- ◇ The list of directories where commands are stored.

Question #20: Which is a shell wildcard which will match strings that start with clt-96s?

- ◇ clt-96s*
- ◇ Cannot be done.
- ◇ ^clt-96s*
- ◇ ^clt-96s

Appendix D

Sample Grading Output

This appendix contains several examples of grading output. Due to difficulties rendering screen images, only one image has been rendered directly from a browser window (this image is from Konqueror). As with the sample quiz, the name on the sample grade report is fictitious.

The format of all grade reports was the same:

The name of the student and the quiz being taken.

The number of correct answers.

The time taken.

Whether the student achieved an 80% score.

Whether the student took too long.

Whether the student passed or will have to try again.

A list of topics and the number of questions on that topic the student got wrong.

Computer Lab Techniques - Quiz Results

File Edit View Go Bookmarks Cache Options Help

Location: <http://elvis.rowan.edu/~kilroy/NewQuiz/Grade.cgi>

RESULTS for Naranek,Kosh on Quiz 'shell':

You got 4 questions right.
You took 1 minutes and 30 seconds.

You missed by 12.
You will have to try again.

Here is a list of what gave you trouble and how many questions were involved:

Topic	Number
Shell Variable Substitution	1
Shell Special Characters	9
Shell Job Control	3
Shell Input Processing (5 Substitutions)	1
Shell Filename Matching	4
Input/Output Redirection	4
Shell Quoting	1
Shell Special Variables	1
Shell Command Execution	1
Shell History Substitution	1

Document Done

Appendix E

Sample Reminder Messages

This appendix contains several examples of reminder messages printed by the grading program. Due to difficulties rendering screen images, only one image has been rendered directly from a web browser window (Mosaic¹).

The possible error messages, and their causes, were:

You already submitted answers for this quiz. You'll have to start over with a new one.

The student submitted the answers, went back to the quiz, and then re-submitted the answers (possibly having changed one or more).

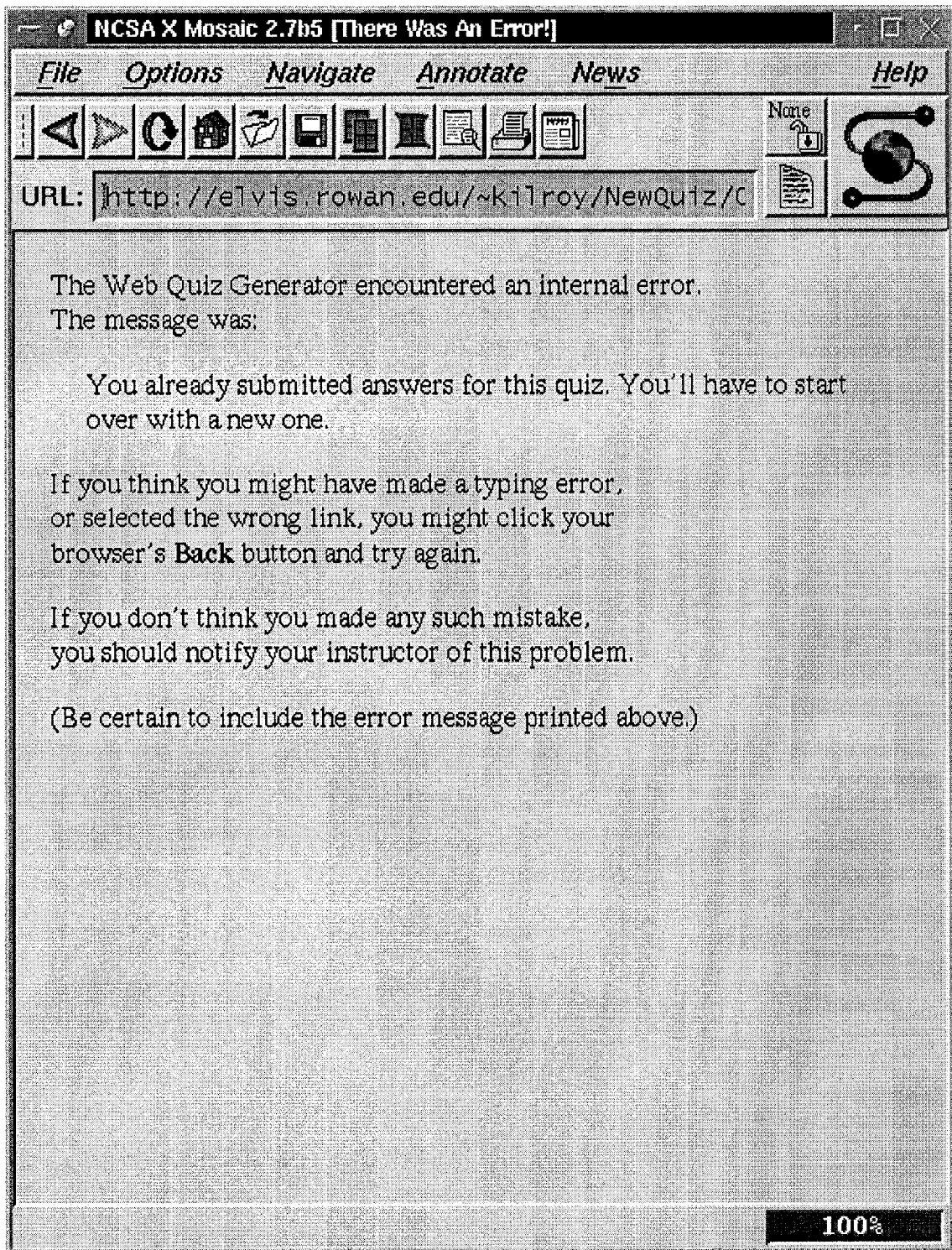
You must wait 30 minutes between quizzes. I suggest you use this time to review.

The student completed a quiz and tried to take another one before the waiting period had expired.

The SSN given was invalid: *number*

The student entered an unrecognised ID number.

¹Mosaic® is a registered trademark of the University of Illinois



The Web Quiz Generator encountered an internal error.
The message was:

You already submitted answers for this quiz. You'll have to start over with a new one.

If you think you might have made a typing error, or selected the wrong link, you might click your browser's **Back** button and try again.

If you don't think you made any such mistake, you should notify your instructor of this problem.

(Be certain to include the error message printed above.)

100%

Appendix F

Survey

This appendix includes the survey given to the students in the treatment group after they had taken the posttest.

The first four items were to get the students' overall impressions about the mastery learning quizzes. The first two survey items focused on whether students preferred taking on-line mastery quizzes to having paper & pencil quizzes. The third and fourth items focused on how well the quizzes helped them learn.

The fifth through eleventh items summarized suggestions which had been made during the semester, allowing the students to express opinions on how the quizzes could be improved. Items five and six concerned what kind of feedback the grading program should present. Items seven and eight focused on the time restrictions, both how much time was allotted per quiz, and whether the enforced review period should be removed. Item nine focused on summary reports visible to the students. The last two items offered students the chance to express opinions about raising or lowering the quizzes' passing criterion.

Computer Lab Techniques - Web Quiz Survey

Overall Impressions

As we have discussed, the on-line web quiz program we have used this semester was an experiment. Now we have to decide if we want to keep using it, or stop, or change how we use it. And whether I'll show it to other professors who might decide to try it themselves. Your answers will determine what happens next. Rank the truth of each statement on a scale of 1-5, where '5' is 'strongly agree', '4' is 'agree', '3' is 'neither agree nor disagree', '2' is 'disagree', and '1' is 'strongly disagree':

_____ I would like to continue with on-line quizzes instead of having paper & pencil quizzes.

_____ I would like to have on-line quizzes in other classes.

_____ The on-line quizzes have helped me to learn the material for this class.

_____ The on-line quizzes have been an efficient use of my time.

Voting on Improvements

Several students have made suggestions during the semester about ways to change the on-line quiz program. Some of these suggestions are listed below. As before, indicate whether you agree with the suggestions by ranking each one on a scale of 1-5, where '5' is 'strongly agree', and '1' is 'strongly disagree'.

_____ Instead of listing topics involved in wrong questions, list the questions themselves.

_____ As above, but include the correct answers.

_____ Allow more than ten minutes to complete the quiz.

_____ Allow quizzes to be taken without a waiting period in between.

_____ Allow students to review their previous attempts.

_____ Make the passing grade harder (85% or 90%).

_____ Make the passing grade easier (70% or 75%).

Other Comments

Do you have any other comments? (Use the back of the sheet if necessary.)

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