Improving the Introductory Computer Science Education at the University of Virginia: Restructuring the Closed Laboratories

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On my honor as a student of the University of Virginia, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Papers in TCC Courses.

Signed_____________________________________

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Glossary of Terms

**Closed laboratory** – A closed laboratory is a laboratory that students are required to attend. It is held during a fixed time in a fixed place and is staffed with an instructor with one or more assistants. During a closed laboratory students are given exercises that are to be completed during the laboratory’s duration.

**CS 101** – The course entitled “Introduction to Computer Science” which is taken by all engineers at the University of Virginia as well as various other students. It introduces the basic principles and concepts of object-oriented programming through a lecture (two days a week) and a closed laboratory (one day a week).

**Instant messaging (IM)** – A form of communication that takes place over the Internet using an instant messaging client such as AOL, MSN Messenger, etc. The messages are sent back and forth as the form of text between two people at two separate computers. Each user logs into the system with a user name and password; the user name is the unique identifier by which a person is sent a message.

**Jabber** – “An open XML protocol for the real-time exchange of messages and presence between any two points on the Internet”; a protocol that can be used as a basis for many applications (“What is Jabber?”). The first application of Jabber technology was to an “asynchronous, instant messaging platform” which is how the client Psi was developed. Jabber lists many advantages over other traditional instant messaging clients: it is open source, extensible, decentralized, and secure (“What is Jabber?”).

**Jabber client** – An application that uses Jabber. The Virtual Office Hours part of this project used the Jabber client called Psi (http://psi.affinix.com), which is an instant messaging application.

**Open laboratory** – An open laboratory is a laboratory that is offered to students as an option. The students are informed that the laboratory and staff are available for their use, but they are not required to attend. Assignments and exercises given out are completed at the student’s leisure, as long as they are complete by the specified due date.

**Teaching assistant (TA)** – An undergraduate or graduate student that makes up the staff responsible for running the closed laboratories associated with CS 101. The duties performed by one include running the laboratory, helping students during the laboratory, grading homework and exams, and holding office hours.
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The introductory computer science course at the University of Virginia, CS 101, is taught with a combination of two elements: bi-weekly lectures and a weekly closed laboratory. The closed laboratory has not been significantly altered since its addition to the curriculum in 1992.

This project sought to improve the laboratories through a three step process. The first step was to evaluate the usefulness of the current laboratory for the students through a survey published online. For the second step, the laboratory manual was scrutinized, and those exercises deemed useless, outdated, or confusing were replaced by other exercises or online quizzes, which were meant to replace simple drilling. The final step involved developing new methods of instruction and interaction (Virtual Office Hours) that took advantage of the Internet to make help more widely accessible by students.

It was determined that the vast majority of students found the laboratories to be the most helpful part of the curriculum. The aspects they usually benefited from included interaction with teaching assistants, drilling/practice/reinforcement (repetition), collaborating on work with a partner, and writing programs as a series of small intermediate steps. The replacement of the laboratory exercises resulted in a mixed reaction. Many students liked the more dynamic exercise used to supplement the drilling, but many did not feel as though the online quizzes were very helpful. The Virtual Office Hours, however, was met with an early encouraging amount of success.

I was able to concretely determine which elements of the laboratory students found most helpful and improve upon them as well as determine which parts need to be overhauled. The Computer Science Department will hopefully be able to apply the information gathered to the other courses that use closed laboratories.
CHAPTER ONE: INTRODUCTION

1.1 PROJECT SUMMARY

The primary goal of this project was to assess and improve the effectiveness of the closed laboratories used for CS 101, the introductory level computer science course offered at the University of Virginia. The Computer Science Department realized that the current laboratories are resource intensive and wished to find ways to improve them while simultaneously reducing the cost.

The first step of this project was determining what elements of the laboratory are helpful to students as well as instructors. This included determining which teaching and instruction style best conveys important concepts and which exercise and drilling style results in the highest level of student comprehension and retention of knowledge. Next, outdated or confusing exercises found in the laboratory manual were removed or replaced by online quizzes or other exercises that better illustrated computer science concepts. The final part of this project included the development of Virtual Office Hours, a new method of instruction and interaction that took advantage of the Internet to make information and help more widely accessible by students.

1.2 PROBLEM DESCRIPTION

CS 101 is a mandatory course for all engineers as well as computer science minors and pre-commerce school students. The majority of students taking the class do not intend to be computer science majors. This makes it extremely difficult to teach, since the various learning curves for this wide range of students must be taken into account.

The laboratories that supplement CS 101 have traditionally been the backbone of the course. The labs are structured around the closed laboratory concept: students are
required to attend the lab at a fixed time and place to complete a series of different exercises that are meant to supplement the material taught in lecture.

As a teaching assistant for this course for the past three years, I noticed that all students do not obtain the same level of value from the labs. Some consider it a waste of their time; it is too simple for them since they have been previously exposed to a programming language. Others struggle with each laboratory exercise, staying in the lab past the designated time, being frustrated and not effectively learning the material.

The laboratories have not been significantly altered since they were added to the curriculum in 1992. Since then, the cost of maintaining these laboratories has increased because the resources in terms of manpower and equipment (both hardware and software) required have increased. It was time to restructure and remodel the laboratories so they are modern, useful for the majority of students, and cost-effective.

1.3 Scope and Rationale of the Project

Restructuring and remodeling the CS 101 closed laboratories is important because it improves the core set of computer science labs, which in turn provides a strong foundation for the computer science major and others (commerce, other engineering disciplines) at the University of Virginia. It is in the best interest of a large group of people to ensure that the course is well designed because it is a core class for such a wide variety of students. Three main groups stand to benefit from this research: the administration, the professors, and the students.

The administration of the University of Virginia gains the knowledge that it offers a strong introductory computer science course, which adds stability to many of the popular majors. Since cost is a major concern addressed by this project, it also benefits the University by getting the “most bang for its buck.” This is especially important
during this time in which statewide budget cuts have forced the University to discontinue services, hire fewer faculty and staff, and postpone equipment upgrades.

The professors that teach computer science acquire a tool that facilitates and complements their teaching. The current closed laboratories are implemented in a way that makes them seem like a separate entity from the course being taught. In the past, I have encountered many students who felt that the material learned in lecture did not relate at all to anything done in the labs. Clearly, overhauling the labs to more closely complement the class is advantageous and ideal. Professors become more effective as teachers when they know that the concepts covered in class are accompanied in the laboratories.

Finally, the students benefit from a well-designed laboratory. They attain a greater understanding of the material, exposure to the tools and software used, and experience in manipulating and writing their own programs. They experience less frustration or ennui because the laboratories takes into account those students with programming experience and those without.

1.4 Overview of the Thesis Report

Past literature was analyzed to determine the best way to begin reforming the closed laboratories. As mentioned before, the project discussed in this report took three different approaches to achieving the goal of improving closed laboratory effectiveness. These steps included:

1. Evaluating and determining the useful elements of the current laboratory through the distribution of a survey to students who had previously taken the course.
2. Revising and updating the laboratory manual by replacing the traditionally drilling exercises with online quizzes.
3. Developing supplementary laboratory materials (Virtual Office Hours).

Much insight was gained into student perception of the laboratories through the survey distributed to previous students. My sponsors and I were able to determine the
parts of the lab that were most helpful to the students as well as those parts that were useless or confusing. The results from the first step of the project helped us determine which exercises in the laboratory manual needed to be replaced by quizzes or removed completely for the second step. Finally, the development of supplementary laboratory materials resulted in the concept of Virtual Office Hours, which took advantage of the Internet and easy accessibility to make help and teaching assistant (TA) help more reachable by students.

Although each of these steps was met with varying degrees of success, the overall goal was achieved. No long term changes have been integrated into the computer science curriculum, however the results of this project are invaluable to the Computer Science Department of the University of Virginia, for CS 101 is not the only course with a closed laboratory. CS 201, CS 216, and CS 340 all have closed laboratories used in conjunction with lecture, all which could use an overhaul. It is my recommendation the data and findings of this project be applied to improving other courses in the computer science curriculum.
Chapter Two: Review of Literature

2.1 Overview of Modern Computer Science Education

Successful computer science education at the introductory level has been a growing concern for many major colleges and universities since the 1990s. In 1989 Denning, et al. stated that computer science was based on three paradigms taken from science, mathematics, and engineering (9). This idea gave rise to the notion that computer science students should be taught using the tradition established by other sciences: students carrying out experiments under supervision (Fekete and Greening, 295). In the early 1990s, structured laboratories were being added to beginning level computer science classes in hopes that they would improve class retention and reduce student frustration with learning fundamental concepts. These laboratories were either considered closed (students were required to attend the laboratory at a fixed time) or open (students utilized a laboratory at almost any time to complete the assignment) (Chavey, 288).

2.2 Introduction of Laboratories to the Computer Science Curriculum

In 1991 Beloit College, a small college in Wisconsin, developed a structured closed lab to supplement their introduction to computer science course. The makeup of the students who took the course was similar to the students that take the course here at the University of Virginia: engineering/science majors and others who take the class as a requirement. The results of the addition of the mandatory lab were mixed. The students taking the course who were science majors felt the lab was helpful, but those taking it only as a requirement felt resentful of the extra work (Chavey, 293). Overall, however, the effect of the closed laboratory on the curriculum was a positive one because despite
the complaints, scores on homework assignments and exams had increased. Other universities began to adopt this trend.

During this early adoption period, some institutions felt as though the “success” of closed labs was only based on opinions and perceptions, not facts. Professors at Middle Tennessee State University decided to compare closed and open laboratories by analyzing quantitative results (exam scores, programming assignment scores) produced by the two techniques. They divided the students into different labs and found that those in closed labs always had higher comprehensive exam scores than those who took the open labs (Thweatt, 81-82).

2.3 Evolution of Closed Laboratories

As closed labs became a norm in computer science curriculum, many people began to realize that the original labs developed were not always the most effective. The problem moved from the integration of labs into the coursework to the upgrading, maintenance, and improvement of lab equipment, exercises and teaching techniques.

Professors at Northeastern University, the State University of New York, and Western Kentucky University proposed a graphical presentation approach to labs. The backbone of this curriculum was based on three things: the use of “interactive animations and experimentation programs to introduce and illustrate dynamic processes,” the use of “graphics in student presentations for motivation, visual feedback, and debugging”, and using “model programs, shell drivers, toolkits, and procedures that encapsulate abstractions” (Proulx, et al., 366). The basic computer science concepts were hidden and abstracted into graphics, pictures, and demonstrations; the laboratory experience was visually based.

In 1995 Doran and Langan of the University of South Alabama projected structuring exercises using a cognitive based approach: each lab is geared towards
helping students reach specific “levels of knowledge” (220). The idea of incorporating an end result or goal into the development of labs was also employed by Parker and McGregor at their respective institutions. Before implementing laboratories into their curriculums, they developed a list of goals to which each laboratory course should strive. This list included some aspects not discussed by others in the field. For instance, along with giving students “an additional mode of learning to supplement the standard lecture format,” they wanted to “reinforce...oral and written communication skills” and “establish a sense of community among students and faculty” (Parker and McGregor, 93). Up to this point, the goals of most universities concerning the implementation and maintenance of closed laboratories were centered on retaining students and improving exam scores.

Closed labs were also seen as an ideal place to use special software (or “courseware”), because students having difficulty using the software or learning the concepts could get help from the lab instructor (Lin, 16). It was proposed that this software could be used as an effective computer based instruction tool because it would present an interactive and visual picture of abstract concepts or ideas. Several guidelines for producing and incorporating courseware into laboratories include the selection of suitable topics, extraction of relevant information, and good user interface design (Lin, 18).

Finally, it was proposed that the only section necessary for an introductory course was a closed laboratory (as opposed to a lecture-lab combination). The first information science course at the University of Arkansas, Little Rock is composed of a core of 25 laboratory sessions, with no accompanying lecture, only a textbook (Karlson, 325). It is felt that students learn to be “pro-active learners from the beginning” and “lab courses facilitate learning among students with differing levels of expertise and accommodate different learning styles” (Karlson, 326).
In 1992 the University of Virginia received a three-year curriculum development grant from the National Science Foundation (NSF). This grant was used to re-structure the core curriculum for the computer science major. The results of that project included the following: the adoption of C++ as the programming language, the decision to have “an early introduction to relevant mathematics,” and most importantly, “a focus on the practice of computing...by providing a closed laboratory” (Knight, 156).
Chapter Three: The Current Closed Laboratory

3.1 Overview of Goals

To improve the effectiveness of the CS 101 laboratories, I first had to determine which parts of the laboratories facilitated student learning and were considered helpful. Although the laboratory itself had not been overhauled in a number of years, it was believed that it possessed some aspects that have helped the majority of students who have taken the course. In the past, student evaluation of CS 101 as a whole (both lecture and laboratory) has revealed that students derive unique benefit from the labs. Before proposing and introducing changes, I had to make sure that I did not eliminate the useful features simply to save resources. This would not have proven beneficial to anyone.

3.2 Materials and Methods

It was decided that the best way to find out what parts of the laboratories students liked or disliked was by conducting a survey. The majority of the people surveyed included those who had taken CS 101 between Spring 2001 and Fall 2002. This group was chosen because everyone in it has completed the entire semester-long laboratory with the same basic set of laboratory exercises (this is why current students, for Spring 2003, were not surveyed). Both fall and spring semester students were surveyed because class composition (in terms of diversity of majors and interests) tends to change radically between the two. Traditionally, the spring semester is the "engineering" semester when most engineers take the course, while the fall usually has a wider variety of engineering, commerce, and liberal arts majors.
The survey was geared towards determining which lab activities were helpful (or not) and gathering general opinions about the structure, function, and environment provided by the laboratory (for the complete text of the survey distributed, please see Appendix A.1 – Text of Survey). The initial draft of the survey was the result of the collaboration of Professor Ruth Anderson, Michele Co (a graduate student), and myself. It was created and posted online using SurveySuite, a survey generation tool developed by Intercom, a group dedicated to Internet commerce, which is based here at the University of Virginia. Students were notified by email about the survey, which was posted online for six days.

### 3.3 Results

The survey was distributed to a total of about 1,150 students (for a complete listing of survey results, please see Appendix A.1 – Results of Survey). The majority of responses came from those who had taken the course during Spring 2001, Spring 2002, and Fall 2002. However, a few people had taken CS 101 before Spring 2001. The majority of those who responded to the survey were in the School of Engineering and Applied Science (69.05%), 27.89% were in the College of Arts and Sciences, and 1.19% was in the McIntire School of Commerce (see Figure 1, next page). The other 1.79% was comprised of students from other areas of the University, which surprisingly consisted of those from the Architecture School and Curry School of Education. These results were interesting to note because prior to the start of this project, students in these areas were not considered in the group that took CS 101. Another fact worth mentioning was roughly half (49%) of those surveyed had been previously exposed to programming language, which was a percentage higher than expected. This is most likely a result of the current trend for many high schools to offer or require a programming course since personal computing has become mainstream.
The first section of the survey attempted to discover what parts of a closed laboratory students found the most helpful. A closed lab is structured around a core of five major ideas. These include drilling/practice/reinforcement, teaching assistant interaction, enforcement of exercises being completed in a certain amount of time, collaboration with peers, and working in a standard environment that meets regularly. Of these, the students found the following the most useful (the highest number of students ranked the activities to be fairly to very useful): teaching assistant help during the lab and working in a standard lab environment. The aspect the students found the least useful (81 ranked it to be not very useful or slightly useful) was the time constraint that came along with the lab environment. Many students were dismayed by the fact that the exercises had to be completed and demonstrated in a certain amount of time, probably because they felt rushed. Of course, this aspect can’t be helped, for an inherent part of the closed laboratory environment is the time constraint.

The next section of the survey attempted to discover what students preferred more: those features offered in the lab or comparable ones offered outside the lab. The data overwhelmingly indicates that an in laboratory experience is preferred, in particular (once again) teaching assistant help, drilling/practice/reinforcement, and the distinctly in-lab activity of solving many small, iterative tasks to figure out a programming assignment rather than just being given the problem and developing the solution in one large step (this is how many students complete homework assignments). The only major
aspect of an in laboratory experience that was found to be inferior to an out of laboratory one was the software and hardware provided. 90 people (53.57%) strongly to somewhat disagreed that computers and software found in lab was better than those they had access to outside the lab while only 17.25% somewhat to strongly agreed. This is interesting because traditionally the labs have offered better software and hardware. This is probably not the case for the University of Virginia in particular because the University’s ITC (Information, Technology, and Communication) computer labs have all the same software that can be found in the computer science labs and oftentimes it is running on faster and newer hardware.

The third section focused specifically on laboratory activities; I wanted to gain insight as to which the students preferred. A detailed list was given for students to give their opinion on. Consistent with previous results, teaching assistant interaction in general ranked with the majority students as being fairly to very useful. However, the majority found only one TA related activity useful (77.98% of people surveyed): receiving help to complete a programming activity. Other TA related ones (including watching a demonstration by the TA, listening to a brief lecture by the TA, and participating with the TA in a question/answer session) did not score as highly with the students. The reaction was almost evenly split, with a little less than half of the students finding these activities fairly to very useful for each activity.

Students found completing an activity composed of several steps helpful, which is in line with previous survey results. This result is also consistent with another activity found useful: writing parts of a program to be completed in lab (as apposed to a whole program to be completed in lab). 55.95% also believed learning to use the software and hardware in lab was useful. Collaboration with other students to write or modify a program was found fairly to very useful by 62.5%. The least popular activities included taking a quiz or exam (76.19% found this to be not very to moderately/slightly useful)
and listening to a short lecture by the instructor or teaching assistant (60.12% found this to be not very to moderately/slightly useful).

The final section of the survey was comprised of two free response questions geared towards gathering student opinion on their overall lab experience and finding out what they would do to improve the CS 101 laboratory experience. This section had the most diverse range of responses. This disparity can be traced back to the prior programming experience of the students. Memorable lab experiences included boredom and apathy by some students (“I was drunk and got an A+ in lab”), to frustration (“I thought all of the labs were extremely hard and confusing”). This was expected. However, contradictory to the statistical results mentioned above, many students listed frustration with the TAs as their memorable lab experience. A number of comments stated that TA help was beneficial, yet rarely obtained because TAs on the whole were scarce, monopolized by other students, on “power trips” (less experienced students felt belittled), or did not really know the material.

Finally, students had three main suggestions on how to improve the labs. One was to hire more teaching assistants and have a more stringent hiring process for those hired. The second suggestion was to completely get rid of one portion of the course: either the lab or lecture and concentrate on making the remaining part more effective. Finally, many recommended breaking up the introductory course into two different sections: one section for those with previous programming experience and one for those without prior experience.

### 3.4 Analysis of Results

It was clear that the majority of students found the laboratory environment helpful in learning computer science. Not surprisingly, the teaching assistants made the greatest contribution to a successful laboratory experience. 40.48% stated that TA help
during the lab was very useful and 43.45% rated it as moderately to fairly useful. Despite several students’ disgruntled reaction at individual interactions with teaching assistants, they remain on the whole the most demanded resource. Unfortunately, they are also one of the most expensive. Hiring more TAs is not feasible at this moment, however making the current ones more helpful and effective is. Right now the TAs are rather loosely organized and the hiring process is not particularly rigorous. There should be an enforced meeting between both the graduate and undergraduate TAs (currently, only the graduate students have a weekly mandatory meeting) to ensure that everyone knows the material being covered and the exercises being done in lab that week.

A short training session for the hired teaching assistant that takes place at the beginning of the semester would also be beneficial. This will not prove to be an extra expense because the hired staff already has a meeting during which they are assigned to a particular lab section or grading duty. This meeting simply needs to be extended by about 30 minutes and the TAs be given certain guidelines of conduct during laboratory sections. The important thing to stress is that one cannot spend all of one’s time with a single student. Rather, one should give hints or clues, then remind the student that others may require help.

Teaching assistants are also able to better serve students if the lab section size is smaller. Those that took the course in the fall usually had a more favorable lab experience because fewer students were in the lab. This meant the space was not crowded and students could form stronger bonds with the other people and the TAs. The obvious solution would be to offer more laboratory sections so that the size would be smaller. However this is not feasible because the number of lab sections has already been increased in the past two years (and subsequently shortened to one hour and 15 minutes to fit more in one day) to accommodate the rising number of students entering the engineering school. Further shortening of the sections would prove stressful to
students because the majority was already resentful of the time constraint. Requiring
the current number of people to staff more sections would also be unreasonable, and the
suggestion of hiring more would go against the goal of this project.

A solution to this may be to recommend a slight change in the curriculum to the
Computer Science Department or the School of Engineering. Both administrations state
in the curriculum guidelines that all engineers should CS 101 during spring semester.
Rarely do advisors push the option for students to take it in the fall. Both should
recommend to students to take it either fall or spring of their first year. In this way,
there may be a more even distribution of people across the board and in turn, the lab
sizes will be moderated. This does not require any monetary expenses, just discussion
with the administration.

An interesting solution to the problem of disparity between students suggested by
the survey results was breaking up the course into two separate ones: one for those with
programming experience and one for those without programming experience. Although
this idea has been proposed in the past by students and has even been discussed by the
Computer Science Department, it is not feasible. The cost is simply too high, and
restructuring the curriculum would require time and effort that cannot be obtained at
this moment. No other major university breaks up their computer science curriculum in
this way, and they have successful students. Granted, computer science is unlike
anything faced by most students prior to their first year, however they must remember
that a certain level of achievement is expected out of them. The current curriculum does
not bend over for those with little experience, but upholds all students to the same
standards. This is how it should remain.

The other main results gleaned from this survey were used as inspiration for the
subsequent two steps of this project. Students preferred the drilling/practice/
reinforcement, so I attempted to capture this in my online quizzes (see Chapter Four).
The introduction of the quizzes freed up lab time for other exercises, which were assigned instead of the ones found in the manual. These exercises involved solving a problem in steps with a defined end goal, which the survey determined to be the preferred method of instruction. They were also meant to challenge those students who felt bored with the activities traditionally used.

Students also benefited greatly from discussions with the TA (obvious from the above analysis); therefore I decided to open up a new forum for interaction with Virtual Office Hours (see Chapter Five). The survey results show that students rarely take advantage of office hours although they are present. Mitigating the disadvantages of the current office hours was the main objective of Virtual Office Hours.
Chapter Four: The Laboratory Exercises

4.1 Initial Concept and Idea

At the onset of this project, it was decided that CS 101 laboratories would be rather difficult to reform because of the background of a variety of students had to be taken into account. However, the survey showed that although the majority of students who took the course were not computer science majors, half of them had been previously exposed to a programming language. The reactions documented tended to split along this line, rather than that of major/discipline. Those who had experience often felt that the lab was too slow for them or that the exercises were too easy. At the same time, however, the concept of drilling/practice/reinforcement (repetition) also ranked as being useful to most students. Figure 2 shows that it is almost a bell curve, however, it is centered towards the more useful side.

This would seem like a contradiction, because one would expect that half or less than half of the students would find this type of exercise helpful because they are usually geared towards those with little or no experience.

To simultaneously appease those who felt bored with the exercises and to keep the concept of drilling, online quizzes were introduced. It was believed that most of the simple drilling exercises could be moved to a quiz (not graded), which students would
take during the laboratory. The process of going through the quiz and answering questions using knowledge and deduction was thought to provide the same benefit as the drilling exercises offered by the laboratory manual. Removing the drilling exercises would also free laboratory time for students to do other, more useful, fun, and dynamic exercises that expanded upon the simple concepts seen in the quiz.

4.2 Materials and Methods

It was decided that the online quizzes would be published via the ITC Toolkit provided by the University of Virginia. Although there are a number of other commercial solutions available (Blackboard and WebCT among others), Toolkit was chosen because the CS 101 teaching staff was already using it, it had University support, did not require new software/hardware setup, and was free. This was in line with the project’s goal of improving the laboratories while making them less resource intensive. Toolkit has a Quiz Maker feature that allows instructors to post quizzes with specific start and end dates, different types of questions, and pictures/images. It also incorporates a grade book feature and tabulates student results both graphically and as a worksheet file that can be opened by most database programs.

For the purpose of this project I borrowed a teaching assistant account name and password and created two quizzes, one to replace parts of Laboratory Four and one to replace Laboratory Six of the current lab manual (for the complete text of both quizzes, see Appendix A.2). These labs were chosen for replacement because many of the exercises found within them were of the following drilling variety:

1. Look at a code sample.
2. Determine computer output (by hand).
3. Run program and verify output.

Clearly this layout suggests an elementary exercise, one that can easily be adapted to a quiz format. Each quiz had a total of nine questions, which were multiple choice,
true/false, or free response. All questions were modeled off of the examples found in the laboratory manual, but code was not copied. Throughout the quizzes I attempted to model the drilling and repetition found in laboratory exercise, but also tried to stress learning semantics, not just syntax.

The quiz to replace Laboratory Four was given out as a “test run” to ensure that all students could log into the Toolkit system and take a quiz. The students were told that the quizzes were not going to be graded so that extra anxiety would not be present. No technical problems were encountered, so a two week experiment was devised for giving out the replacement quiz for Laboratory Six. The laboratory in the manual, composed of ten problems in the “drilling” format mentioned above, was broken up into two halves. The first week, the students were given the first half of the “traditional” drilling exercises from the manual to complete along with an extra exercise (known as “Funny Faces”) that expanded upon the simple concepts. In contrast to the format of the drilling exercises, it involved students iterative developing a small program whose end result was an interactive program to display funny faces. The second week the online quiz was distributed to replace the other half of the drilling exercises. A short survey was given to the students after they took the online quiz the second week to gauge their reaction to traditional vs. quiz drilling as well as the extra exercise.

4.3 Student Response

A total of 387 people responded to the survey, which is close to the total enrollment of the course (for a complete text and listing of survey results, see Appendix A.3). The majority of students taking CS 101 this semester (91%) are part of or applying to be in the School of Engineering and Applied Science. 49% of students had previously learned about the programming concept being taught (in this case, value parameters and parameter passing) before taking the laboratory, which interestingly corresponds exactly
with the survey given out to previous students (49% of students surveyed had previous programming experience before taking CS 101).

Two thirds of the students, 66%, felt as though the traditional drilling exercises given the first week were a good use of lab time, while only 7% felt as though it was not. The reaction was similar for the “non-traditional” exercise given out, which 67% found useful. When asked to agree/disagree how useful certain activities were in helping them learn value parameters and parameter passing, “doing the lab last week” ranked the highest, with 74.68% agree to strongly agreeing that they learned using this method. “TA help in lab” ranked next highest, then “listening to/go to lecture.” Finally, when asked to specifically compare the traditional drilling for the quiz style drilling, over half the class preferred doing the lab exercises in the manual (55%) rather than the online quizzes (18%); 27% of the class had no opinion either way.

4.4 Analysis of Results

It was disappointing to discover that the majority of the students did not prefer the online quizzes. Perhaps there is too much stigma attached to the word “quiz,” so students took the exercise too seriously instead of objectively viewing it as an alternative to the traditional exercises. I envisioned the online quizzes to be the start of a solution to solving the problem of the knowledge disparity in CS 101. The drilling was kept as a way to appease students who had little to no experience programming while the extra time gained by moving the drilling to the quizzes would allow for the more advanced students to test their knowledge and skill with dynamic and more thought-provoking exercises. However, student reaction indicates a preference for the lab manual style of drilling.

Since repetition and reinforcement are clearly the preferred methods of learning, the online quizzes probably will not be added to the CS 101 laboratory curriculum. The online quizzes may prove to be useful in other ways, however. The incorporation of a
quizzing system that is added to the course for a grade may motivate students. The online quizzes could also be given as an optional “warm-up” for students before they start on the laboratory exercises for the week, or as an optional review for students after they complete the lab or before a major exam. Students prefer study aids, and quizzing is often an effective way of reviewing concepts. It is my belief that online quizzes still have value in the CS 101 curriculum; unfortunately they will probably not be particularly helpful in the laboratory environment.

Although students did not favor reducing the amount of drilling time by replacing the traditional drilling activities with online quizzes, they did enjoy the non-traditional “Funny Faces” lab exercise that was introduced (it is not found in the laboratory manual). The success of this exercise shows that students of various backgrounds were sufficiently challenged by it and many learned from it. Many felt it was a good use of the laboratory time, which shows that it provided some benefit to them and was not boring or exceedingly difficult. Perhaps it can be integrated into the curriculum at a later date, or introduced as a revision to the laboratory manual.
CHAPTER FIVE: A NEW RESOURCE — VIRTUAL OFFICE HOURS

5.1 INITIAL CONCEPT AND IDEA

Today’s classroom and instruction style takes advantage of the great benefit offered by the Internet. Many professors have a class web page in which important class information, homework assignments, and links to resources are posted. It provides an efficient way for professors to distribute information for students and gives students an easy way to access information 24 hours a day, seven days a week. Many courses at the University of Virginia take advantage of the ITC Instructional Toolkit, which allow instructors to easily maintain class web pages but also offer a host of other features such as online quizzes (discussed in Chapter Four) and discussion forums.

The main idea behind the discussion forum is that a student can post questions online about various assignments and get an answer from a teaching assistant monitoring the board or by other students (who are also able to post responses). This method encourages interaction, but is limited by the response time. Teaching assistants and professors are not required to monitor the discussion board, therefore a timely response is not guaranteed. This is why other courses, and CS 101 in particular, have maintained “traditional” office hours. For CS 101, this involves two to four TAs making themselves available in a computer lab during a certain time to help students with general questions as well as those that arise because of recently assigned programming homework.

The results of the survey distributed to students who had already taken CS 101 (see Chapter Two) shows that a significant amount derived benefit from interaction with a TA when it came to learning about and understanding computer science concepts. However, past evaluations of the course have shown that students often don’t take
advantage of office hours, which basically put a TA at any student’s disposal for three hours every night, four nights of the week (Monday through Thursday). Upon analysis, it was determined that there are several disadvantages to traditional office hours that may hinder students from taking advantage of them. They are usually held late at night (from 7 PM to 10 PM) in a fixed location (Stacks Computer Lab, Engineering School), which may prevent some students from attending. It is often hard to find the TAs in the lab, for the Stacks Computer Lab is a public lab, and often has many other people working in it during all hours of the day. Finally, there is sometimes a long line for the attention of the TA, and the significant wait does not make it worth it for the one seeking help.

Traditional office hours also pose inconvenience to the teaching assistant. If students do not seek their help during the pre-allotted time, they are often bored and forced to sit for long hours in the computer lab with nothing or a limited amount of other work to do. Also, since many TAs are upperclassmen, commuting to the Stacks Computer Lab from locations farther off-Grounds can be a hassle. The proposed solution to the problems experienced by students and teaching assistants alike was Virtual Office Hours.

5.2 Virtual Office Hours Overview

Virtual Office Hours was a concept structured around providing students with easy to access help. The “easy access” part is accomplished by using the Internet, particular instant messaging (IM), to create a forum for questions and answers that is dynamic, in real time (there is no response delay, as can be found in the above mentioned discussion boards), and convenient. The general idea was that a student could contact a teaching assistant whenever he or she is online for answers to simple questions or perhaps to have a discussion of concepts. The two “chat” as if they would if they were both in the same room, but each is at his/her personal computer. Each person
does not have to travel to a particular place to have this conversation (as with traditional office hours) nor do they have to meet between the same pre-established times. Virtual Office Hours can be held at all hours of the day, not just the static 7:00 – 10:00 PM time slot.

For this part of the project, three teaching assistants staffed Virtual Office Hours over a period of two weeks. They were Michele Co (graduate teaching assistant and head teaching assistant for two lab sections this semester), Jeff Segal (undergraduate teaching assistant who currently holds traditional office hours) and myself (also an undergraduate teaching assistant). Over the course of the experiment, we held office hours for several hours a week during various times for to maintain flexibility for the students and ourselves (see Figure 3). This experiment took place of the course of a two week period, during which one homework assignment was due (3/27-28) and one exam (3/26) took place.

<table>
<thead>
<tr>
<th>Teaching Assistant</th>
<th>Office Hours Held [day, date, and times]</th>
<th>Number of People Helped</th>
</tr>
</thead>
<tbody>
<tr>
<td>Michele Co</td>
<td>Wed (3/19), 11 AM</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Wed (3/19), 9 – 11 PM</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Mon (3/24), 11 AM</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Tues (3/25), Noon</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Wednesday (3/26), 9-11 PM</td>
<td>11</td>
</tr>
<tr>
<td>Jeff Segal</td>
<td>Thurs (3/20), 9 – 11 PM</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Wed (3/26), 12 – 1 AM</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Wed (3/26), 8 – 9 PM</td>
<td>5</td>
</tr>
<tr>
<td>Kathy Lin</td>
<td>Tues (3/25), 7 – 8:30 PM</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Wed (3/26), 10:15 – 12:15 PM</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Thurs (3/27), 3 – 3:30 PM</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Thurs (3/27), 10 – 10:30 PM</td>
<td>0</td>
</tr>
</tbody>
</table>

*Figure 3. Virtual Office Hour TAs and Hours Held.* This table shows the TAs who administered Virtual Office Hours, when they held them, and how many people were helped during each session.

### 5.3 Virtual Office Hours Implementation

The first major problem that was foreseen about using instant messaging as a forum for discussion is the wide variety of clients that are currently in use: AOL Instant Messenger (AIM), MSN Messenger, ICQ (“I Seek You”), and Yahoo! Messenger. It is inefficient for the TA to have multiple clients open under multiple names. To solve this
problem, a Jabber client, Psi, was used to handle the messages incoming on the TA’s end. In effect, the TA appears to have multiple clients open, but really only has one. In this way, students are not forced to use a specific program, they can continue to use whatever instant messaging software they have already set up on their computer. Also, the TA does not need multiple clients to handle the message; he/she only uses one.

It was decided that the majority of users have either an AIM screen name or a MSN Messenger screen name. Each teaching assistant was assigned a pair of screen names that allowed him or her to accept messages from these two types of users. For example, I had the names “UVACS101TA1” (AIM) and “UVACS101TA1@hotmail.com” (MSN), which allowed me to communicate with students using either AIM or MSN Messenger through Psi.

The second major problem anticipated was that of maintaining fairness. Students should be able to have their questions answered first come, first serve, as in traditional office hours. The major messaging clients do not allow one to distinguish which order messages come in. Once a new message is received, it is either placed on top of whatever message one was in before, or stays behind the window one was using but simply “blinks” to get one’s attention. If a TA is suddenly swamped by a number of messages, it becomes impossible to tell which one was received first, last, etc. Psi solves this problem by queuing the messages (called “events”) automatically. By default, incoming messages are listed in the buddy window and do not open up a new window (Figure 4,).

To receive the next message, one
can select the appropriate option from the dock menu, which displays the message sent. Order is ensured so that fairness to students can be maintained (see Figure 5, previous page).

5.4 Results

Teaching Assistant Reaction

Each teaching assistant (excluding myself) filled out a brief questionnaire detailing his or her experience and reaction to staffing Virtual Office Hours (for a complete text of the questionnaire, see Appendix A.4). None of the TAs had any technical problems although Jeff spent a little time orienting himself with Psi. Each TA was online for approximately 1.5 hours per session. Approximately 13 hours of office hours were held total over a two week period, and 31 students messaged the TAs. Although the number of students that messaged the TA was low per session (three), the overall results were very positive.

During Michele’s first hours on Wednesday, the two people who communicated with her asked questions related to the homework. She was able to resolve both of the questions using chat, even though one was a technical question and one was not. She related, “both students seemed to be happy they figured it out.” When asked what she personally thought Virtual Office Hours, she stated, “I haven’t really helped enough students to have an idea of what problems can occur yet, but so far I think that I like it.” She did state a limitation with Psi: the inability to share files. When helping one student she had to get him to email her the file since she could not understand the description of the problem he was having. During her busiest office hours, she stated that although it was hectic she liked the Virtual Office Hours because they allowed her to help students concurrently instead of one at a time.
During Jeff’s first session of Virtual Office Hours (see Figure 3), he received messages from a few more students, and they ranged from those related to the homework to those related to the exam. Overall, he felt that he could answer the students questions using the forum provided by the Virtual Office Hours, but stated that there were a few matters he could not help students with. He did not have any major problems using the system, but suggested for busy nights that TAs be allowed to limit their responses to reduce the strain that comes with typing. He also stated that he preferred Virtual Office hours over the traditional office hours he also offers each week.

The Virtual Office Hours I held were relatively sparse, but I felt as thought all of the questions asked were sufficiently answered. The questions I received were mainly concept questions related to the homework assignment. Each student seemed pleased that they reached a solution quickly. I was surprised that none of the questions I received Tuesday (3/25) were exam related. I was also surprised that I did not receive many students on Wednesday night when I co-hosted with Michele and Jeff since Michele received so many. I did not encounter any technical problems although Psi does have the odd habit of trying to repeatedly store names in the buddy list.

**Student Reaction**

Although attempts were made to gauge student reaction and opinion on this part of the project, only five out of the 31 students who utilized the office hours responded to the survey posted online (for complete results, please see Appendix A.4). This survey was not geared towards the class as a whole, only those who had used the office hours. 100% of the students felt as though Virtual Office Hours were helpful, 100% felt their questions were sufficiently answered, and 100% would use them again if they were offered in the future. Four out of five students preferred having night office hours. They
also felt as though the office hours were sufficient, but file sharing should be present and they should be held more hours a week.

5.5 Analysis of Results

Although all three teaching assistants thought Virtual Office Hours was a “neat and fun” idea, it was not clear that it proved more helpful to students than traditional office hours. Although it was only run temporarily as part of this project, it did meet some limited success with the few students who used it and the teaching assistants who held the hours.

Another encouraging preliminary result was the stability of Psi, the Jabber client used for messaging. All teaching assistants felt overall, chatting was a sufficient means of answering a student’s question. They did not encounter any major technical problems with Psi running on their own personal computer, which included operating systems of several different types (Windows for Michele and Jeff, Mac OS X and Linux for Kathy) and overall, everything ran smoothly. The queuing of messages did work as expected, although since large numbers of people never messaged either of the teaching assistants at once, it cannot be known at this moment whether or not the self-queuing provided by Psi will prove useful when the TAs are really busy.

Since Virtual Office Hours are such a new concept, I believe that it will take a longer amount of time for them to become integrated and accepted into the curriculum. If they were offered over the course of a longer period of time, more students would come to use and accept them. However, preliminary results were very encouraging, and the overall feeling associated with this part of the project was positive.
Chapter Six: Conclusion

6.1 Summary

Survey For Previous CS 101 Students

The survey distributed to students who had previously taken CS 101 resulted in a large amount of student feedback. Of the approximately 1,150 people who were notified of the survey, 168 responded (14.6%). Approximately half of those had previously been exposed to a programming language. Students believed that the two most useful aspects of a closed laboratory were the drilling/practice/reinforcement (repetition) style of activity and the teaching assistant help. They preferred the solving a large problem through iterative steps instead of with one large step.

The majority of students did not enjoy the time constraint that was inherent with the closed laboratory. Also, many felt the hardware and software provided in the laboratory was not better or superior to that found outside the laboratory. They also listed frustration with the teaching assistants as a norm in the lab environment because they felt as though the TA’s time was unfairly monopolized.

When asked for suggestions on how to improve the course, students offered radically different views. Some students suggested getting rid of the laboratory part of the course while others recommended keeping the labs and dropping the lecture. Many students felt as though CS 101 should be split into two courses, one geared towards those with previous programming and one for beginners to the field.

Online Quizzes

The online quizzes were not a success with over half of the students. The online quizzes, meant to replace the traditional drilling/practice/reinforcement (repetition)
activity were not preferred by 55% of the students. Only 18% of those surveyed favored the quizzes, and 27% did not care. When asked how they best learned the laboratory concepts of that week (parameter passing), the students ranked the traditional lab exercise above other methods of instruction available (including listing to-going to lecture, reading lecture slides/notes, TA help during the lab, and TA help during office hours). However, the online quiz given as an experiment did free up lab time for the nontraditional “Funny Faces” exercise, which was helpful for 67% of the students.

Virtual Office Hours

The three teaching assistants who held Virtual Office Hours (Kathy Lin, Jeff Segal, and Michele Co) all felt as though it was a good idea albeit young and not significantly tested. Each session hosted by the TA lasted for approximately 1.5 hours, although both Michelle and Kathy tried to be online during random times of the day (11 AM, 3:30 PM, noon). The average number of students who used the hours was three, and the “vibe” received from most students by the TAs was a positive one. Each teaching assistant felt as though the majority of the questions were sufficiently answered using the instant messaging format. A survey was posted to gauge the opinion of those students who used the hours; five students responded. All five liked the office hours, felt their questions were answered, and would use them again if offered in the future.

6.2 Interpretation

The main goal of this project was to introduce reforms to the CS 101 closed laboratories that would make the labs effective and useful to the students and instructors, as well as make them less resource intensive. I was able to determine what parts of the laboratory students enjoyed and benefited from, and attempted to offer alternatives that would be just as useful. Disappointingly, the online quizzes were not a
success. Although it seemed like a dynamic solution to the multifaceted problem of appeasing beginners who wanted easier and more drill-like activities and appeasing experienced students who wanted more creative and substantial lab activities, it did not turn out to be one. It appeared to me that students just wanted to “take the easy way out.” Those with little experience wanted to keep the easy exercises because they seemed less thought intensive than quizzes and those with more experience just wanted to get lab over with as quickly as possible and opted to keep the simple exercises they knew they could complete in a short amount of time.

However, the Virtual Office Hours looks like a success in the making. Students messaged the TA just to say it was a good idea and I believe that it will catch on given more time and publicity. It was not an extra hassle for the TAs, and in fact, mitigated many of the disadvantages of traditional office hours. Consistent with our goal, it improved the effectiveness of the laboratory environment by providing students with another forum in which to discuss computer science with the TAs. It was also extremely cost effective because it used the resources already present (the current TAs already hired) and cost nothing in terms of setup and maintenance. Although the positive feeling surrounding the Virtual Office Hours is more qualitative than quantitative (it is based on TA responses to questionnaires and limited student response), I still believe this part of the project was a success.

The surveys that were distributed during the various parts of the project were all fair and unbiased. The first (distributed to those who had previously taken CS 101) were given to a wide variety of students to ensure a response that was the best representative of the whole. Unfortunately, I could not ensure who took the survey so a greater of number people from one semester responded than those from another. Also, one has to keep in mind that those who respond to surveys usually feel strongly about the matter; therefore, the “middle ground” is lost. Also, due to the limitations of the survey
generation program, I had to change the scale for “ranked” responses for different questions, which may have confused students or slightly altered the results. However, the survey distributed for online quiz assessment did not have these limitations because everyone in the labs was required to take it and only one “scaled” response question was present. This ensured a more accurate, complete set of results.

The culmination of all of the results gained by this project give the administration (the Computer Science Department and the School of Engineering and Applied Science) insight and information as to what aspects of the labs are beneficial and what teaching styles and methods of instructions will most likely be accepted or rejected by future classes. CS 101 is not the only class taught at the University of Virginia with a closed laboratory. CS 201, the second level introductory course taken by many engineers (computer science majors, systems engineers, and electrical engineers) has a very similar structure and probably has the same student and instructor complaints. In fact, the two courses are so closely tied together that the very initial scope of this project involved looking at the both CS 101 and CS 201 laboratories. Other courses with labs include CS 216 and CS 340. All of these can be improved by the applying the results found here.

6.3 Recommendations

Professor Tom Horton, my technical advisor, told me once that it was “really, really hard to change CS 101.” At the time, I wasn’t sure what he meant. I believed that I could at least do something to improve the class I had helped with and been a part of for so long (I have been a teaching assistant for the past five semesters). Now I am at the conclusion of this project, I see what he means. The class is very large, very established, and tightly ingrained in routine. It is hard to experiment with new changes much less implement them. Testing and tinkering has to go on over the course of several semesters before there is a noticeable effect.
Clearly the results have a reach far outside the scope of this project. The foundation has been laid down here with the preliminary work performed. My first recommendation is to continue with the work, even if it means going back to the beginning and brainstorming more. Online quizzing turned out to have less than stellar success, however another concept may prove to be better solution to the problem it was trying to solve. I would continue to plug away at this problem in an iterative fashion, addition improvements as they present themselves. In this way, although the laboratories and the course will not change overnight, at least it will be making a move towards the better.

The students and professors that have helped with this project should expand on the generalized data gathered here. Perhaps data that is geared more specifically to a certain topic can be gathered and the results applied towards other, more scope-limited projects (unlike, for instance, the far reaching one pursued here). The point to realize is that this project provides a very wide and solid foundation for future work that can branch off in many different directions to help improve the various closed labs at the University of Virginia.
B I B L I O G R A P H Y


APPENDICES

A.1 Determining Current Lab Effectiveness Survey

Text of Survey

The purpose of this survey is to get student opinion on the closed laboratories that supplement CS 101. A closed laboratory is one in which student participation is mandatory, and usually some sort of exercise or activity takes place that must be completed during lab time. In contrast, an open laboratory is one in which students are given an assignment and utilize a laboratory at any time to complete the assignment.

Right now, the labs are resource intensive, so the Computer Science department is looking for ways to make the laboratories better yet more cost effective.

What school are you part of (pick one)?
- School of Engineering and Applied Science
- College of Arts and Sciences
- McIntire School of Commerce
- Architecture School
- Curry School of Education

When did you take CS 101?
- Fall 2002
- Spring 2002
- Fall 2001
- Spring 2001
- Fall 2000

Prior to taking CS 101, did you have any programming experience?
- Yes
- No

Give a usefulness rating for each of the following specific aspects or activities.

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Not Very Useful</th>
<th>Slightly Useful</th>
<th>Moderately Useful</th>
<th>Fairly Useful</th>
<th>Very Useful</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drilling, Practicing, and Reinforcement (Repetition)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teaching Assistant help during the lab</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enforcing lab exercises completed &amp; demonstrated in a certain amount of time</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collaboration (partners) allowed for lab work</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Work in a standard lab environment that meets regularly

Please rate the following experiences.

<table>
<thead>
<tr>
<th>Experience</th>
<th>Strongly Agree</th>
<th>Somewhat Agree</th>
<th>Neutral</th>
<th>Somewhat Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall, my laboratory experience was useful.</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>I felt as though I would gain the same amount of benefit doing the same work on my own outside the lab, rather than in the lab.</td>
<td></td>
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</tr>
<tr>
<td>I benefited more from outside office hours rather than in-lab TA help.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I believe that drilling/practice and repetition in lab helps me remember more concepts than trying to figure things out on my own outside the lab.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Given that I had to work in a team/pair, I felt as though working in lab was more helpful than working as a team/pair outside of the lab.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I felt as though the computers, software, and hardware provided to me in the lab was better than the ones I have access to outside the lab.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I felt as though solving many small tasks that reinforce concepts was better than solving one large problem with lots of code.</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

*The following questions pertain to the closed lab section of CS 101 that you participated in, and do NOT pertain to activities that you did outside of the laboratory meeting (i.e. Pre-labs, post-labs, or homework assignments).*
For each of the following activities, please rate its usefulness.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Strongly Agree</th>
<th>Somewhat Agree</th>
<th>Neutral</th>
<th>Somewhat Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete an activity composed of several intermediate steps.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Learn how to use a software or hardware system.</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Write an entire program from scratch that is to be COMPLETED during lab.</td>
<td></td>
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</tr>
<tr>
<td>Write parts of a program that is to be COMPLETED during lab.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collaborate with other students to write or modify a program</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Take a quiz or exam.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Listen to a short lecture by the instructor or TA.</td>
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</tr>
<tr>
<td>Observe a demonstration by the instructor or TA.</td>
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<td></td>
</tr>
<tr>
<td>Participate in a question and answer session led by the instructor or TA.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Receive help from the instructor or a TA to complete a programming activity.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The following are free response questions.

Please describe a memorable lab experience from CS 101, whether it was fun, boring, pointless, extremely easy, extremely confusing, helpful, useless, etc.

What would you like to change about the closed laboratory courses at UVA?

Results of Survey

What school are you part of (pick one)?

- Architecture School
- College of Arts and Sciences
- Curry School of Education
- McIntire School of Commerce
- School of Engineering and Applied Science
When did you take CS 101?

Prior to taking CS 101, did you have any programming experience?

Give a usefulness rating for each of the following specific aspects or activities.

- Drilling, Practicing, and Reinforcement (Repetition)

- Teaching Assistant help during the lab
• Enforcing lab exercises completed and demonstrated in a certain amount of time

![Bar chart showing student opinions on lab exercises completed in a certain amount of time.]

• Some collaboration (partners) allowed for lab work

![Bar chart showing student opinions on collaborative lab work.]

• Work in a standard lab environment that meets regularly

![Bar chart showing student opinions on working in a standard lab environment.]

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Please rate the following experiences.

- Overall, my laboratory experience was useful.

- I felt as though I would gain the same amount of benefit doing the same work on my own outside the lab, rather than in the lab.

- I benefited more from outside office hours rather than in-lab TA help.
• I believe that drilling/practice and repetition in lab helps me remember more concepts than trying to figure things out on my own outside the lab.

• Given that I had to work in a team/pair, I felt as though working in lab was more helpful than working as a team/pair outside of the lab.

• I felt as though the computers, software, and hardware provided to me in the lab was better than the ones I have access to outside the lab.
• I felt as though solving many small tasks that reinforce concepts was better than solving one large problem with lots of code.

For each of the following activities, please rate its usefulness.

• Complete an activity composed of several intermediate steps.

• Learn how to use a software or hardware system.
• Write an entire program from scratch that is to be COMPLETED during lab.

![Bar Chart: Student Opinion on Writing a Program from Scratch]

• Write parts of a program that is to be COMPLETED during lab.

![Bar Chart: Student Opinion on Writing a Complete Program During Lab]

• Collaborate with other students to write or modify a program

![Bar Chart: Student Opinion on Collaborating with Other Students]
• Take a quiz or exam.

• Listen to a short lecture by the instructor or TA.

• Observe a demonstration by the instructor or TA.
• Participate in a question and answer session led by the instructor or TA.

- Receive help from the instructor or a TA to complete a programming activity.

A.2 Online Quizzes

Online Quiz for Laboratory Four

Consider the following loop for the next two questions:

```java
while ( expression ) {
    Action
}
```

1. True or false. The "expression" has to evaluate to true for the Action to take place.

Answer: True

2. Consider the following code. It is meant to display the sum of the integers in the range (1...n) where n is a user-supplied positive value. For example, if n were 4, then the sum calculated is: \( \text{Sum} = 1 + 2 + 3 + 4 = 10 \). There is one mistake with the code with the updating of \( \text{Sum} \).
```cpp
#include <iostream>
#include <string>
using namespace std;

int main() {
    cout << "Enter a positive integer: ";
    int n;
    cin >> n;
    int i = 1;
    int Sum = 0;
    while (i <= n) {
        Sum = Sum + n;
        ++i;
    }
    cout << "The sum from 1 to " << n << " is " << Sum << endl;
    return 0;
}
```

Which of the following variables changes while the loop is running?

a. Sum  
b. n  
c. Sum and n  
d. Sum and i (answer)

3. If the user entered in 4 for n, how many times should the loop execute?

a. 3  
b. 4 (answer)  
c. 5  
d. 6

4. What change should be made to the code in the while loop so that Sum is updated properly?

```cpp
while (i <= n) {
    Sum = Sum + n;  // What should this line be?
    i++;
}
```

a. Sum = Sum + n;  
b. Sum = Sum + 2*n;  
c. Sum = Sum + i; (answer)  
d. Sum = Sum + 1

5. True or False. There are some for loops that cannot be written as a while loop.

Answer: False.

6. Consider the following loop:
for (int a = 0; a < 5; ++a) {
    cout << "Hello world!" << endl;
}

How many times will "Hello world!" be printed on the screen?

a. 5 (answer)
b. 6
c. 10
d. 12

7. Consider the following code.

#include <iostream>
#include <string>
using namespace std;

int main() {
    int Counter1 = 0;
    int Counter2 = 0;
    for (int i = 1; i <= 10; ++i) {
        ++Counter1;
    }
    for (int j = 0; j < 15; ++j) {
        ++Counter2;
    }
    cout << "Counter1: " << Counter1 << endl;
    cout << "Counter2: " << Counter2 << endl;
    return 0;
}

What are the values of Counter1 and Counter2?

a. Counter1: 9, Counter2: 14
b. Counter1: 10, Counter2: 15 (answer)
c. Counter1: 11, Counter2: 16
d. Counter1: 10, Counter2: 14

8. Consider the following code:

int main() {
    int Counter1 = 0;
    int Counter2 = 0;
    for (int i = 1; i <= 10; ++i) {
        ++Counter1;
        for (int j = 15; j >= 1; --j) {
            ++Counter2;
        }
    }
}
cout << "Counter1: " << Counter1 << endl;
cout << "Counter2: " << Counter2 << endl;
return 0;
}

What are the values of Counter1 and Counter2?
a. Counter1: 10, Counter2: 15
b. Counter1: 11, Counter2: 16
c. Counter1: 11, Counter2: 160
d. Counter1: 10, Counter2: 150 (answer)

9. Free Response. What is it called when a loop is found inside the body of another loop?

Answer: nested

Online Quiz for Laboratory Six

#include <iostream>
#include <string>
using namespace std;

void MyFunc(int a, int b)
{
    cout << "MyFunc: a = " << a << " ,";
    cout << "MyFunc: b = " << b << " ,";
}

int main()
{
    int i = 10;
    int j = 20;
    MyFunc(i, j);
    cout << "main: i = " << i << " ,";
    cout << "main: j = " << j << endl;
    return 0;
}

1. Consider the code above for the first 4 questions. What are the formal parameters of MyFunc()?

a. int a and int i
b. int a and int b (answer)
c. int i and int j
d. int b and int j

2. What are the actual parameters passed to MyFunc()?

a. int a and int b
b. int i and int j (answer)
c. int a and int I
d. int b and int j
3. What is the output produced?

**MyFunc: a = 10, MyFunc: b = 20, main: i = 10, main: j = 20** (answer)
MyFunc: a = 20, MyFunc: b = 10, main: i = 20, main: j = 10
MyFunc: a = 10, MyFunc: b = 10, main: i = 10, main: j = 20
MyFunc: a = 20, MyFunc: b = 20, main: i = 10, main: j = 20

```c
int main()
{
    int i = 10;
    int j = 20;

    MyFunc(10, j);  // Used to be MyFunc(i, j)

    cout << "main: i = " << i << ",";
    cout << "main: j = " << j << endl;
    return 0;
}
```

4. TRUE or FALSE. If the call to MyFunc() in main was replaced with “MyFunc(10, j)” then the output produced would change. (See the above code for clarification).

Answer: False

```c
void GoWahoos(string player_name, int &bball_score)
{
    cout << "GO " << player_name << "!!" << endl;
    ++bball_score;
}
```

5. Consider the parameters of GoWahoos() in the above code. What type of parameter is string player_name (value or reference)?

Answer: value

6. What type of parameter is the second parameter to function GoWahoos() (value or reference)?

Answer: reference

```c
void MyFunc(int &a, int b)
{
    a = a + 30;
    b = b + 20;
    cout << "MyFunc: a = " << a << ",";
    cout << "MyFunc: b = " << b << ",";
}
```

```c
int main()
{
    int i = 10;
    int j = 20;
    MyFunc(i, j);
```
cout << "main: i = " << i << " ,";  
cout << "main: j = " << j << endl;  
return 0;  
}

7. Consider the above code. What output is produced?

MyFunc: a = 40, MyFunc: b = 40, main: i = 40, main: j = 20 (answer)
MyFunc: a = 40, MyFunc: b = 40, main: i = 10, main: j = 20
MyFunc: a = 30, MyFunc: b = 20, main: i = 10, main: j = 20

void AnotherFunction(const int k, int &a)
{
    a = a * 1900;
    k = a * 2;
}

8. TRUE or FALSE. The above code is illegal.

Answer: True

#include <iostream>
#include <string>
using namespace std;

void YetAnotherFunction(int a, int b = 50)
{
    cout << "MyFunc: a = " << a << " ,";  
cout << "MyFunc: b = " << b << " ,";  
}

int main()
{
    int i = 10;
    int j = 20;
    YetAnotherFunction(i, j);
    YetAnotherFunction(20);
    cout << "main: i = " << i << " ,";  
cout << "main: j = " << j << endl;
    return 0;  
}

9. Consider the above code. What output is produced?

A.3 Determining Online Quiz Success Survey

Text of Survey

The purpose of this survey is to gauge student reaction to drilling techniques (as demonstrated in last week’s lab on parameter passing) and determine whether or not online quizzes are helpful in learning the week’s material.

What school are you a student of (or applying to become a student of)?
- School of Engineering and Applied Science
- College of Arts and Sciences
- McIntire School of Commerce
- Architecture School
- Curry School of Education
- School of Nursing

What is your major (or intended major)?
- Computer Science
- Computer Engineering
- Electrical Engineering
- Mechanical Engineering
- Chemical Engineering
- Civil Engineering
- Systems Engineering
- Cognitive Science
- Pre-Commerce, Commerce
- Other

Have you seen or learned about parameter passing previously?
- Yes
- No

Did you think last week’s exercise on parameter passing was a good use of lab time (did it help you effectively learn lab concepts)? This question refers to exercises 6.1-6.6 in the lab manual which required that you read code and figured out what the output would be. (See pages 43-48 in the lab manual).
- Yes
- No
- Neutral

Did you think last week’s exercise on functions (Funny Faces) was a good use of lab time (did it help you effectively learn lab concepts)?
- Yes
- No
- Neutral

Which do you prefer?
- I prefer drilling in lab by doing the lab exercises found in the manual.
- I prefer drilling in lab by taking online quizzes.
- I don’t really care.
I learned about value parameters through:
- Reading the book
- Listing to/going to lecture
- Reviewing the lecture slides
- The lab exercises last week
- Help from the TA in lab
- Help from the TA during office hours

If there were more online quizzes, I would prefer doing the quizzes:

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>During the laboratory</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Sometime before the laboratory</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Sometime after the laboratory</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Don’t care</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

Results of Survey

What school are you a student of (or applying to become a student of)?

<table>
<thead>
<tr>
<th>School</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architecture School</td>
<td>1%</td>
</tr>
<tr>
<td>College of Arts and Sciences</td>
<td>7%</td>
</tr>
<tr>
<td>McIntire School of Commerce</td>
<td>1%</td>
</tr>
<tr>
<td>School of Engineering and Applied Science</td>
<td>91%</td>
</tr>
</tbody>
</table>

What is your major (or intended major)?

<table>
<thead>
<tr>
<th>Major</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical Engineering</td>
<td>2%</td>
</tr>
<tr>
<td>Civil Engineering</td>
<td>7%</td>
</tr>
<tr>
<td>Cognitive Science</td>
<td>15%</td>
</tr>
<tr>
<td>Computer Engineering</td>
<td>6%</td>
</tr>
<tr>
<td>Computer Science</td>
<td>19%</td>
</tr>
<tr>
<td>Electrical Engineering</td>
<td>10%</td>
</tr>
<tr>
<td>Mechanical Engineering</td>
<td>8%</td>
</tr>
<tr>
<td>Mechanical Engineering</td>
<td>2%</td>
</tr>
<tr>
<td>Pre-Commerce, Commerce</td>
<td>9%</td>
</tr>
<tr>
<td>Electronics Engineering</td>
<td>6%</td>
</tr>
<tr>
<td>Systems Engineering</td>
<td>1%</td>
</tr>
<tr>
<td>Other</td>
<td>22%</td>
</tr>
<tr>
<td>Other</td>
<td>7%</td>
</tr>
</tbody>
</table>

Have you seen or learned about parameter passing previously?

<table>
<thead>
<tr>
<th></th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>49%</td>
</tr>
<tr>
<td>Yes</td>
<td>51%</td>
</tr>
</tbody>
</table>
Did you think last week’s exercise on parameter passing was a good use of lab time (did it help you effectively learn lab concepts)? This question refers to exercises 6.1-6.6 in the lab manual, which required that you read code and figured out what the output would be. (See pages 43-48 in the lab manual).

![Pie Chart]

- 27% Neutral
- 66% No
- 7% Yes

Did you think last week’s exercise on functions (Funny Faces) was a good use of lab time (did it help you effectively learn lab concepts)?

![Pie Chart]

- 67% Neutral
- 21% No
- 12% Yes

Which do you prefer?

![Pie Chart]

- 55% I prefer drilling in lab by doing the lab exercises found in the manual.
- 27% I prefer drilling in lab by taking online quizzes.
- 18% I don’t really care.

I learned about value parameters through:

- Reading the book
• Listing to/going to lecture

![Bar graph showing student opinion on going to lecture.]

- Strongly Disagree: 12
- Disagree: 48
- Neutral: 36
- Agree: 50
- Strongly Agree: 154

• Reviewing the lecture slides

![Bar graph showing student opinion on reviewing lecture slides.]

- Strongly Disagree: 55
- Disagree: 76
- Neutral: 135
- Agree: 110
- Strongly Agree: 9

• The lab exercises last week

![Bar graph showing student opinion on lab exercises last week.]

- Strongly Disagree: 13
- Disagree: 13
- Neutral: 72
- Agree: 193
- Strongly Agree: 96
• Help from the TA in lab

![Bar Chart]

• Help from the TA during office hours

![Bar Chart]

If there are more online quizzes, I would prefer doing the quizzes:

- 20% during the laboratory
- 60% sometime after the laboratory
- 20% sometime before the laboratory
- 8% don't care
- 12% don't know

A.4 Virtual Office Hours Questionnaires

Teaching Assistant Questionnaire

1. What night did you hold your office hours?
2. Between what hours did you hold your office hours?
3. How many people contacted you total during your office hours?
4. What types of questions did they ask you?
5. Did the students feel as though the Virtual Office Hours served their needs
6. What did you think about the Virtual Office Hours?
7. Did you feel as though you were genuinely able to help the students using only chat and instant messaging?
8. What problems did you encounter? (or, what features would you add/change to make virtual office hours better, etc)

**Student Questionnaire/Survey**

**Text of Survey**

Did you find Virtual Office Hours helpful?
- Yes
- No
- Neutral

Did you feel as though your questions were answered?
- Yes
- No
- Neutral

Would you use Virtual Office Hours if offered in the future?
- Yes
- No
- Maybe

*The following are free response questions.*

When should these office hours take place?

What do you think would make virtual office hours better?

**Results of Survey**

Did you find Virtual Office Hours helpful?

- Yes: 90%
- No: 10%

Did you feel as though your questions were answered?

- Yes: 85%
- No: 15%
Would you use Virtual Office Hours if offered in the future?

![Pie chart showing the distribution of responses]

The following are the student responses gathered. I thought these should be listed here because there were only a few.

When should these office hours take place?
- At Night
- Maybe spread out through the afternoon
- I think 9 - 11 are fairly good, since this is when I'm usually concentrating on homework or studying.
- Late on Wednesday nights
- Sometime late in the evening after most people are back from class

What do you think would make virtual office hours better?
- More hours maybe
- I think that they are great the way they are, just don't take them away!!!
- I think we need to keep them
- Make use of the "send file" function on IMs, then the TA can see exactly what part of your program you are talking about.
- Maybe more nights a week