JP- 202 - 51

# ONLINE STATISTICS LABS

An Interactive Qualifying Project Report

submitted to the Faculty
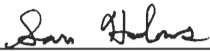
of the

WORCESTER POLYTECHNIC INSTITUTE

in partial fulfillment of the requirements for the

Degree of Bachelor of Science

by

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**Abstract**

For years, students have used the SAS statistical computer package in the laboratories that accompany the introductory statistics courses at WPI. SAS has two main drawbacks in this role: (1) Students find it difficult to use; (2) It is not accessible off-campus. In order to address these drawbacks, we have adapted three SAS-based labs to web-based versions. By surveying the students, as they used the new and old systems, we established that students found the new labs easier to use, easier to understand, and more accessible.

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## I: Introduction

Our project objective is to redesign several of the current WPI statistics labs to run as internet applications. The statistics labs currently use SAS statistical software, and it is felt that the complexity of the interface, and the lack of off-campus accessibility is an impediment to the students. An online version of the labs also offers opportunities to make the interface more interactive.

### Goals of the project

The two main goals of this project are

- To improve three of the current labs used in the introductory statistics course at WPI.
- To make the results of our work available to future developers.

### Improve the current statistics labs

One of the main goals of this project is to improve the current statistics labs. There are three main ways the project accomplishes this. The first is to change the means of delivery for the labs, the second is to improve the clarity

and interface of the labs, and the third is to improve the accessibility of the labs.

This project changes the means by which the lab material is delivered. The original statistics labs for the chapters our group covered require students to use SAS statistical software on UNIX machines. To access the required software, students use their UNIX login information at terminals located on campus.

Although the students do get a fair amount of exposure to the UNIX environment while at WPI, there is no guarantee the student will have a familiarity with or ability to easily use the UNIX systems. In fact, anecdotal information indicates that student familiarity with UNIX has declined in the years since these labs were first introduced. There is concern that the lack of familiarity with UNIX and SAS may interfere with student learning in the labs. This project eliminates this issue by moving the labs to an online internet-based platform with which a larger number of students are familiar.

The second improvement on the current statistics labs results from improving the interface and clarity of the labs. Although they are not asked to use SAS extensively,

many students find SAS difficult to use because of the large numbers of windows in its interface, and the large number of analysis choices available. In addition, both students and instructors find the handouts of detailed written lab instructions awkward. To address these problems, the labs produced in this project have a simpler, web-based interface that includes lab instructions. This interface allows students to focus on the concepts and ideas the labs present.

The new labs also improve the accessibility the students have to the lab material. As the SAS software is installed on WPI computers, the students are required to use a UNIX terminal in one of the academic buildings to access the labs. As other groups from the campus also require time in the labs, and many students do not live on campus, spending additional time in the labs outside of the scheduled sessions can be difficult. Moving the labs to an online system alleviates this problem. Most students have internet access at their residence and are now able to access the labs from there. Additionally there are several alternate locations around the WPI campus with computers

that offer internet access. This increases the accessibility and convenience of the labs.

**Make the results available**

A second main goal of this project is to make the end result, the lab system and the labs themselves, available for use by other academic groups. This was done by constructing the lab system out of reusable and generic components and by posting the final labs online.

To allow other academic groups to benefit from the work done on this project, the lab system was constructed out of generic reusable components where possible. These components can be used either by themselves, rearranged, or incorporated into future versions of these or other labs. The data sets used by the online labs are kept separate from the workings of the lab and can be modified at any point by the professor.

The finished labs will also be posted in full online. This will allow professors outside of the WPI community to benefit from this work as well. The labs are constructed using common web techniques, which are compatible with many systems other universities may have.

## II: Background

**Technology standard**

Accessibility and presentation of material play a large part in a student's understanding of a topic. With the advent of the Internet and the proliferation of personal computers, an opportunity arises to incorporate academic exercises in a medium and format with which the student is familiar. One common technique for presentations of this nature is the use of Java applets embedded within HTML documents. Since Java applets and HTML documents can be used by the student with a minimum of setup effort and provide ample flexibility, they are a logical choice for such a project.

There are many ways Java applets are being utilized in online education. The most common technique involves a standalone applet with minimal supporting text. The applet is targeted to perform one specific task and will usually only contain instructions for its operation or a brief summary of the task it is to complete. It has been our experience that these types of applets are used by professors as in-class demonstrations or referenced in assignments as additional

examples of a topic. Examples of applets of this type can be found linked by statpages.net[1] or The University of New England Australia[2].

Although these materials aid the student in his understanding of the subject matter, we attempt to take online instruction to the point where statistics labs and reinforcement exercises are presented in their entirety, with instruction integrated with the appropriate applets. Some of the current laboratory exercises for introductory statistics at WPI make use of the SAS statistics software. While SAS is a useful statistics tool, there is the potential for an improvement in interface and presentation for introductory statistics students by making use of a web-based approach.

The web-based statistics exercises we found[3] were generally not accompanied by very much explanation. This lack of explanation can confuse the student and make what may already be difficult concepts even harder to grasp. For our project, the labs and reinforcement exercises make use of the instruction system that we create to provide a smooth and understandable path through the subject matter.

**Mechanics of Learning**

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[1] http://www.statpages.net
[2] http://www.une.edu.au/WebStat/others/tutorials_online.htm
[3] http://www.math.wpi.edu/Course_Materials/MA2611B01/main.html

Although learning is in some sense unique to each individual, there are elements of learning that are common to all. Defining these common traits can be advantageous in the creation of an online lab system that benefits as many students as possible. One interpretation of the learning process breaks the learning process down into three stages:

- decoding
- accumulation and chunking
- learning[4]

We will discuss each and then present how our online environment takes advantage of and supports these stages.

On the physical level, the student first perceives information through his senses. While observing material and identifying the elements that compose a display, the student places information into various categories. The student quickly recognizes some of the information as familiar elements he has seen before. Other information is set apart by its unfamiliarity. The student processes this new information to see if it is perhaps a new form of something he has seen before. If it is not, the brain stores details about this new element in short term memory.

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[4]Computer-based instruction, Pages 129-141

There are several ways we use these properties of perception to make the online learning experience as natural as possible. Because the student needs to first perceive the information, the display should be as clear and readable as possible. To this end the interface is designed to be as easy on the eyes as possible and contain standard interface conventions. The colors chosen provide contrast without straining the eyes. One example of this type of ergonomic display is choosing an off-white color as the background of the web pages. Contrast is preserved without the colors being unnecessarily harsh. As the student will recognize familiar elements, the interface is designed to resemble known computer interfaces. An example of this is to have all buttons look like standard graphical buttons with which all computer users are familiar. This ensures the student spends a minimum amount of time interpreting the interface and a larger portion examining the material being presented.

Once the student perceives the elements of a presentation, these elements are then placed in short term memory. Elements or concepts that are familiar to the student may be grouped to conserve short-term memory in an operation referred to as "chunking." A common example of this is the process of remembering a phone number. Often the first three digits are a familiar area code, in which

case they can be reduced to a single 'element' which needs to be remembered.

There is also an issue of how much information the student can perceive at one time. One way to reduce the amount of information the student needs to remember at one time is the support for non-ASCII characters in the text portion of the lab. This way the student will not need to interpret the text version of standard math characters, as he will be able to see the versions he is accustomed to. To reduce the amount of information the student has to remember, the lab system displays more than one step at a time. This allows the student to see the previous and upcoming steps of the lab and maintain a more continuous progression.

Once the patterns have been fully perceived, the student performs what is traditionally thought of as learning. The student compares the elements of the display to known patterns and relationships and attempts to form new relationships with the information. The student's impression of the format of the learning exercise, his sense of goals, and progress towards completing these goals governs this procedure of forming new relationships. By having multiple steps of the lab visible at one time as described in the previous paragraph, the student can see connections between the steps naturally.

Often, after concluding a lab, the student can be left mystified as to just what it is he has just accomplished. The goals and objectives of the laboratory exercises can be lost in the tangle of procedures and instructions. One of the common complaints is that the labs don't seem to be accomplishing anything other than using up time. We sought to eliminate this sense of uselessness by consistently reinforcing the reasons behind the lab. As is done with current labs, the student is presented with a set of goals at the beginning of the exercise. As the lab progresses the steps make references to these goals to maintain the student's focus. At the conclusion of the lab the goals are presented again along with further explanation regarding the meaning behind what the student just did.

**Design Considerations**

Along with researching how students learn and interact with material, we address several more general interface design considerations.

The technology needs to be creatively used to enhance the learning experience.[5] The use of current technology in presenting material online needs to be driven by the student's education, not by

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[5] Interactive learning, Page 63

the desire to use said technology. To this end our work with the statistics labs began by defining the goals of the lab and the material to be presented. The student's interaction with the online program was then laid out through storyboards to ensure that the labs are designed with the material as the focus.

The presentation also needs to make use of traditional human computer interaction design considerations. These include standard layout of text, careful and meaningful emphasis, obvious indication of what is changing, and explicit matching of text and corresponding graphics.[6] In order to minimize confusion, the text layout is consistent so that directions are always in the same location on the screen. To emphasize the object or property that the user is manipulating, the interface either makes use of boldface type or outlines the appropriate section graphically. To make the changes in the interface as clear as possible, only one visible feature changes at one time. This method of displaying changes is applicable mostly to sections where the user is making a selection or modification to the interface. Descriptive text follows the same approach as the directions of the lab in that it appears in consistent locations on the screen.

The student's use of the online material needs to be interactive enough to maintain the student's attention to and comprehension of

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[6] Computer-based instruction, Page 370

the material being presented.[7] If the presentation is too automated, the student will be tempted to simply coast through the activity without actually learning anything. On the other hand, with too little guidance, the student may become lost or confused. We strive to find the right amount of guidance in our lab system. The instructions for the lab are explicit and clearly convey to the student the procedure for the lab and the concepts it involves. The interface interaction also requires the student to select the operation he is going to perform as a way of reinforcing the concepts he must learn. All the labs include a section where the student performs calculations and procedures offline to ensure his involvement and understanding.

The online educational environment needs to be utilized by the professors[8] and students[9] for it to be useful. Unless required to, it is unlikely that a majority of students will take the initiative and use a given online resource. To increase their utilization, our online systems are integrated into several labs. By making use of a  generally designed program that can be easily configured using templates and configuration files, the system is also designed in a way that allows for changes or additions to be easily made. This extensibility will encourage professors to continue to use the online system when future updates require changes. The various components of the online

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[7] Online learning: Ways to make tasks interactive

system are also as configurable as possible so that they can be used together or alone in new activities.

## Java vs. CGI

When developing the lab system there were several choices as to which language would actually be used to implement the labs online. After considering several options the choice came down to a decision between using java applets embedded in html documents or a combination of perl scripts and html documents.

There are several advantages and disadvantages to a lab system written using java applets embedded in html documents. One advantage of using java applets is in the interactivity of the graphics. Perl scripts are limited in that any changes to graphics need to be done in javascript in the resulting html document after the perl script has been run. This means that the changes need to be pre-calculated and anticipated, where a java applet can perform calculations and display results in real-time. One disadvantage of java applets is the robustness of calculations that they can perform. As the java applet runs on the client machine, any calculations that need to be performed

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[8] Interactive learning, Page 39

have to be performed by the client, which could result in problems for any users using lower-end computers.

The perl scripts also have the advantage of being able to run more uniformly across the computer systems one would expect to find at different universities. Because java applets run on the client machine, they are subject to the changes in versions and techniques of each browser the client may be using. Perl scripts, because they run on the server, have a more stable and higher regulated running environment. This not only makes them more stable, but also increases their lifespan, as changes in technology are less likely to have an impact on their performance. Another reason for using perl scripts is that the group members had a large amount of previous experience programming web applications using perl, and a minimal amount using java applets.

Perl scripts have one additional advantage over java applets. Previous IQP groups had a large amount of difficulty getting graphs from their java applets to print due to security restrictions placed on outside code being run on a client machine. Perl scripts do not have this problem, as the pages they produce are flat html documents or standard images. These can be printed directly from the browser or saved and included in a student's report.

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[9] Interactive learning, Page 21

## III: Procedure

### Project progress

Project progress was measured in different ways during different phases of the project. During the background research, progress was measured based on how well the project members understood the area as well as the necessary programming techniques. While developing storyboards and prototypes, progress was measured as the amount of improvement in the interface. Development of the lab systems themselves was straightforward as far as goals are concerned and progress for them was measured as time to completion. When testing the labs with a group of students and revising the labs, progress was measured in terms of student feedback about the lab system and in terms of implementation of those changes.

### Project execution

The execution of this project involved the following tasks, in chronological order:

- Background research
    - What has been done before
    - Background on the learning process
    - Technological research
- Written proposal
- Storyboarding
    - Develop storyboards
    - Examine layout and functionality
    - Revise storyboards
- Prototypes
    - Develop prototypes
    - Examine prototypes
    - Revise prototypes
- Develop labs
    - Program lab systems
    - Make appropriate instructions
    - Make any modifications needed
- Develop surveys

- - o Create online survey system

    o Create survey questions

  - Try labs with groups of statistics students

    o Attend lab sessions to make observations

    o Collect survey results

  - Revise lab system

    o Make changes based on feedback from students

  - Written final report

    o Project background information

    o Project execution information

    o Project results and conclusions

## Storyboarding

During the design stage of creating the lab system, storyboards were used to layout the format for the labs before any programming took place. These storyboards outlined the flow of execution and format for the display as a student progressed through the labs.

There are several benefits to using storyboards. One obvious benefit to their use is an increased ability to visualize the look and

execution of the completed project before programming begins. The image everyone involved has of the interface will also be more unified than is likely from a text-only description. Well-designed storyboards also eliminate ambiguity in how an interface should look or function. Without clear definition of how items should appear or function, a project has a tendency to drift away from its goals and optimum configuration. Storyboarding also allows designers to quickly locate problem areas of an interface before programming has begun. For example, a section of a presentation that contains too much text to fit in the given screen space will be seen before that section is created and has to be fixed later.

Although storyboards are beneficial to the design process, there are several things to consider. Storyboards are limited in that they can only show the interface at an instant in time. Although diagrams could be used to describe motion or animation in the interface, a storyboard isn't capable of reproducing this interaction with complete accuracy. Another property of storyboards is that they can be misleading. Unless careful attention to scale is maintained, unrealistic assumptions can be made, such as how much text will fit in a given area or how large an image or graph will really appear on the finished screen. Storyboards can also be misleading with regard to functionality. When designing a system using storyboards it is easy to incorporate features and

functions, which are not reproducible in the real system during the project time frame.

All things considered, storyboards proved to be a useful technique during our creation of the lab system. By knowing the limitations of storyboards we were able to gain the benefits of this technique of software design.

**Mockups and intermediate stages**

During the creation of the lab system two techniques for examining preliminary results were used. Mockups of the user interface were used to view the layout and flow of the pages. Intermediate stages of the lab programming were setup as standalone sections to check their functionality and appearance.

There were several benefits to designing mockups of the user interface before the final lab system was completed. One benefit was the ability to get a general sense of the flow and execution of the lab system before any effort was expended to create a completed program that did not suit the interface goals of the project. This strategy allowed us to quickly eliminate poor design choices, which may have looked good in the storyboards, but were not suitable for the web

environment. By creating mockups of the interface we were also able to determine which features from the storyboard could not be recreated online. This saves time by preventing the development of an interface that relies on features that cannot be implemented.

There were several benefits to designing the lab system in intermediate stages. By testing and examining each component of the final product as it was completed, we were able to keep our development in line with the goals of the project at all stages. Running each part of the lab system online, as it became available, we were able to quickly identify which components of the system were liable to fail. By identifying the problem areas of the programming as early as possible, we were able to better focus our efforts towards producing the working system. Dividing the overall lab system into components we were able to split the work amongst ourselves as well, which allowed programming for various components to be done in parallel.

The mockups we produced and the testing of the intermediate stages enabled us to quickly identify the problem areas of our implementation and avoid a false sense of progress.

## Compatibility across browsers

As one of the goals of this project was to make the labs available in a wider range of environments, we did a lot of work to ensure the compatibility of the labs across the various browsers that the students use.

When dealing with problems of browser incompatibility, the issues we encountered were differences between Microsoft's Internet Explorer and Netscape Navigator. These differences needed to be fully explored because, although the lab system ran as a perl script independent of the browser the student was using, browser differences were so severe they affected even basic HTML formatting. These differences were caused by variations in the syntax and HTML tag name conventions used by the browsers.

The impact of browser incompatibilities on the project was to dramatically increase the time it took to develop the online lab system. In most cases the HTML syntax for Netscape Navigator needed to be very particular and specific, above the set standards for HTML documents. Also, many of the requirements Netscape puts on the documents they will display are not documented. This increased our development time as in many cases every HTML page displayed had at

least one specific nuance that had to be discovered in order for the pages to work with across all browsers.

**Usability on various systems**

### Accessibility

One of the large concerns with the SAS system for running the labs was that the labs were not usable on very many systems. A student who wanted to work on a statistics lab at times other than the scheduled sessions would have to use either a computer that supported SAS or log in remotely. Logging in remotely does not work for all students as the full GUI needed is too bandwidth intensive for dial-up modems. By moving to a web-based system this situation should be improved.

For remote users, web pages offer an advantage over full GUI logins, as they are not time dependent. If a student has a slow internet connection they will simply have to wait a longer period of time for a page to display. Once this delay is over, the student is free to interact with the displayed material smoothly.

Accessibility is also improved with a web-based system because the labs may be run on any system that has a web browser and a connection to the internet, rather than only systems that have access to the SAS package specifically. Once the browser complications described in the previous section are overcome, the number of computers that can access and run the labs increases considerably over those that could do so when it was run under SAS.

## System requirements

A second consideration when examining the usability of the labs on various computer systems is the computing power available. This applies to computers running SAS, and to the differences between using java applets and perl scripts.

One possibility for a student who wants to run the statistics labs remotely would be to install SAS on their machine. This is not a reliable option because the student may not be able to obtain a copy of the software, and they may not have the required system to run it. SAS is also a fairly expensive software package and it is not likely that the average student will purchase it.

The difference between using perl scripts and java applets becomes apparent here as well. Although not a major hurdle, running java applets in some cases requires the student to install the java runtime environment. This does not seem like a difficult task to a CS major, but can be a frustration to students less familiar with computers. However, this is becoming less of an issue as java applets become more popular online.

Java applets and perl scripts also differ in where any calculations needed are actually carried out. As java runs on the student's machine, any calculations that are needed are done by the student's computer. Perl scripts run on a university's web server and it is safe to assume in many cases that machine will be much more robust than the student's own. This avoids the potential problem of a student with an older computer being unable to run the labs

One concern with using the perl script approach to the labs is the possibility of serious degradation in server performance due to many users running the lab simultaneously during lab periods. Based on our in-lab tests of the software, this is not a problem with the stat labs at WPI.

## IV: Results

The following charts display the responses to the first survey filled out by the students upon completion of their labs. The bar graphs represent the distributions of the responses to the survey. The scatterplots compare student rating of their the before-lab and after-lab comprehension of the material. Note that for some survey results – most notably the SAS version of the 5.3 lab – such graphs are neither necessary nor especially useful because of the small numbers of responses; however, in the interest of consistency and to better show the differences between the SAS and Web version of the lab, these were included. Please see Appendix A for the surveys used.

**SAS - Lab 4.5**
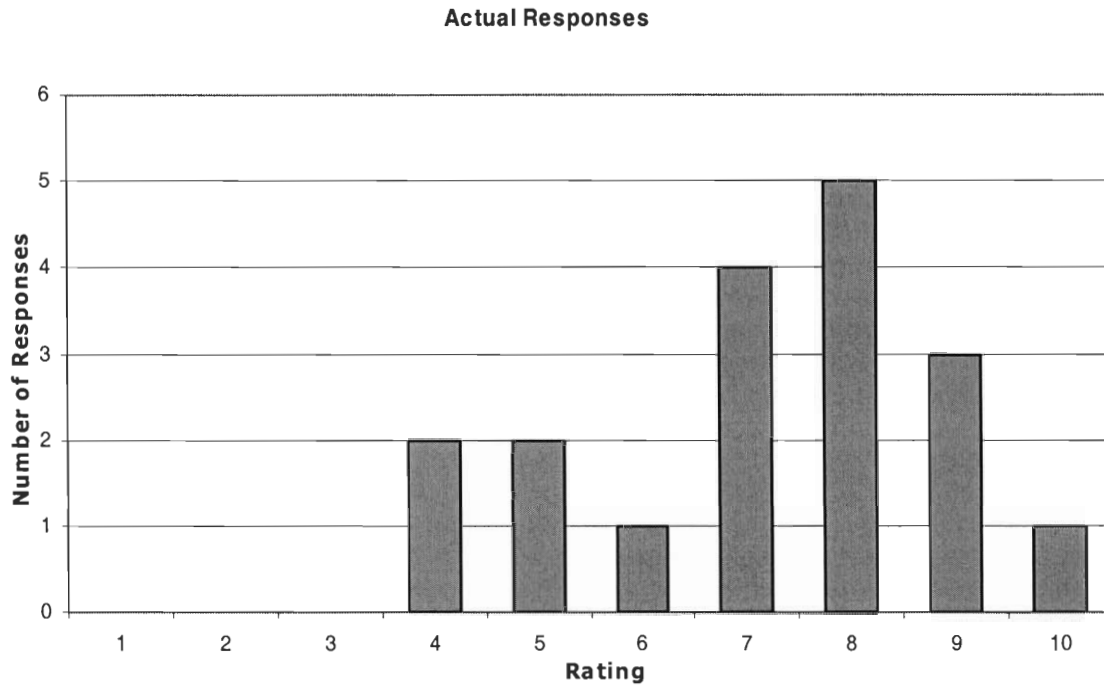*Question 1: Rate how well you comprehended the material taught in the lab before you did it.*

**Actual Responses**



**Figure 1**

**SAS - Lab 4.5**
*Question 2: Rate how well you comprehend the material taught in the lab now.*

**Actual Responses**



**Figure 2**

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**SAS – Lab 4.5**
***Comparison – Rated Comprehension Before vs. Rated Comprehension After***

| | | After | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **10** | | | | | | | | | | 1 |
| | **9** | | | | | | | | | 2 | 1 |
| | **8** | | | | | | | | 1 | 3 | |
| | **7** | | | | | | | 1 | 2 | 1 | |
| | **6** | | | | | | 1 | | | | |
| **Before** | **5** | 1 | | | | | | 1 | | | |
| | **4** | | 1 | 1 | | | | | | | |
| | **3** | | | | | | | | | | |
| | **2** | | | | | | | | | | |
| | **1** | | | | | | | | | | |
| | **Lab 4.5** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |

**Figure 3**

**SAS - Lab 4.5**
*Question 3: Rate your comprehension of the lab process (i.e. how well you understood how to do the lab).*
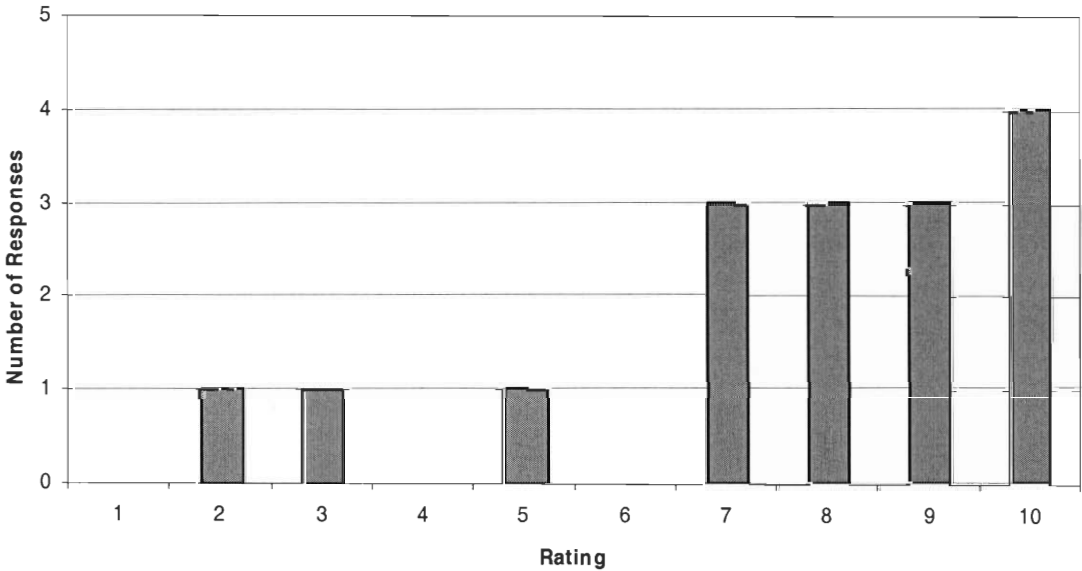
**Actual Responses**



**Figure 4**

**SAS - Lab 4.5**
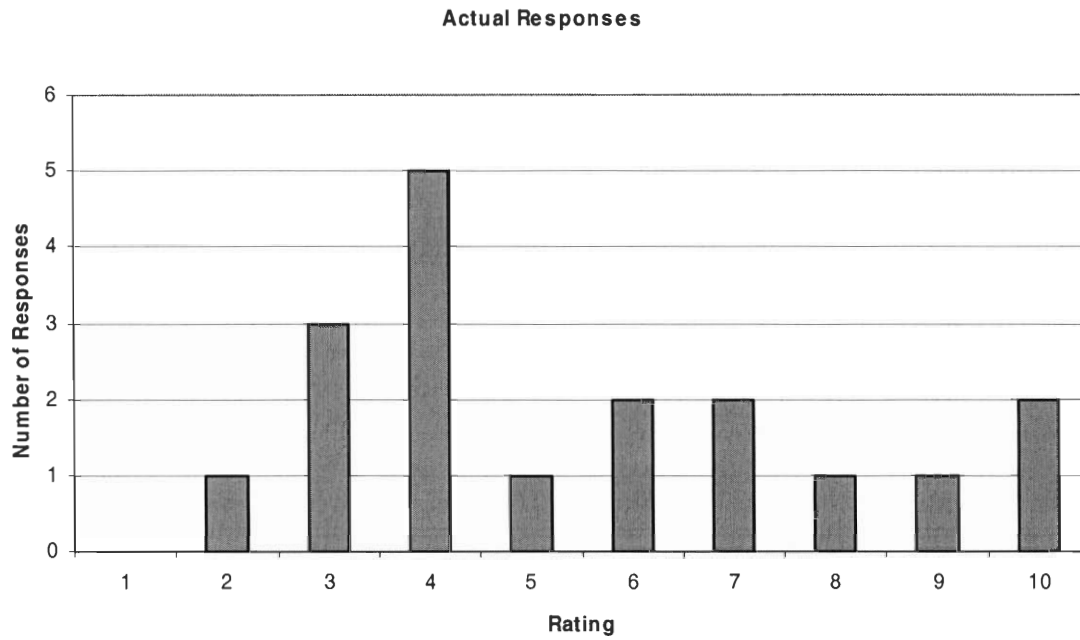*Question 4: How difficult to use was the lab interface (i.e. the program you used to run the lab)?*

**Actual Responses**



**Figure 5**

**SAS - Lab 4.5**
*Question 5: How difficult was the lab material (i.e. the concepts being taught)?*
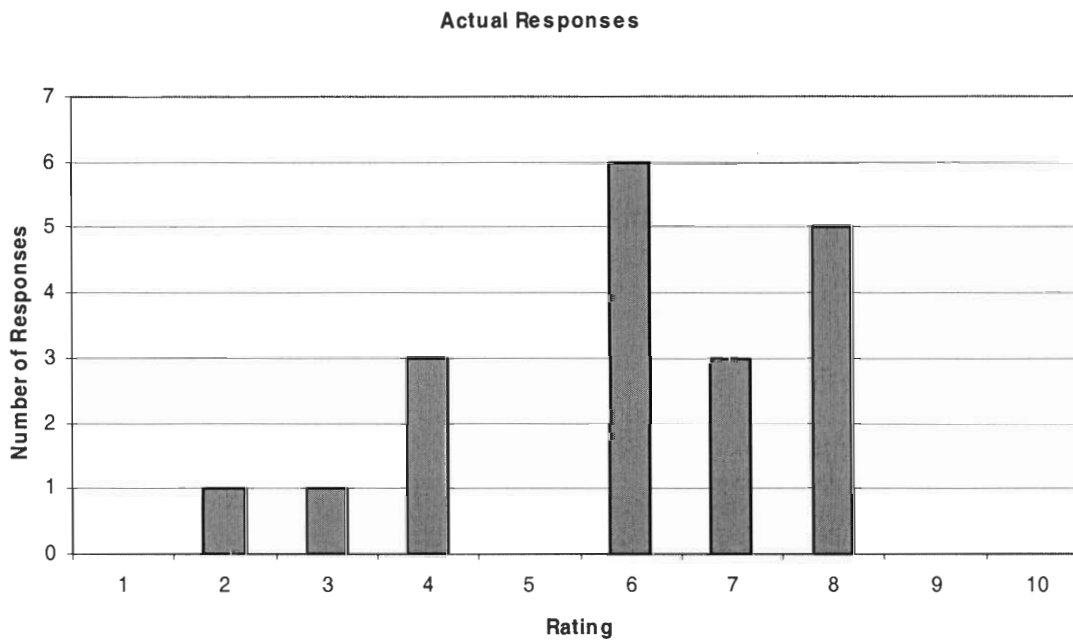
**Actual Responses**



**Figure 6**

**Web - Lab 4.5**
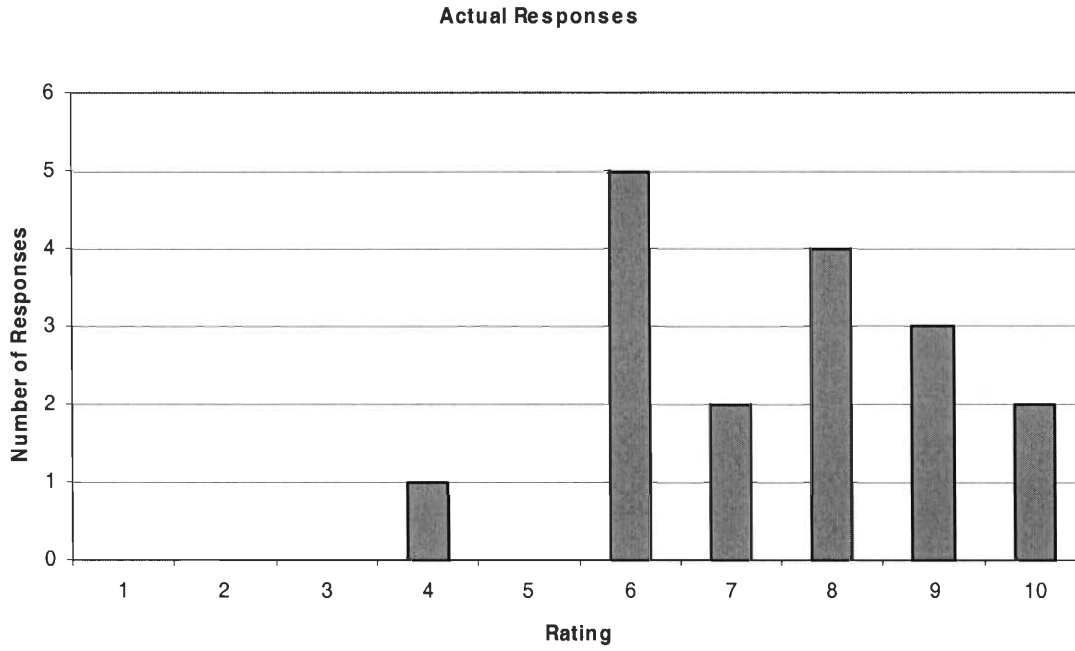*Question 1: Rate how well you comprehended the material taught in the lab before you did it.*

**Actual Responses**



**Figure 7**

**Web - Lab 4.5**
*Question 2: Rate how well you comprehend the material taught in the lab now.*

**Actual Responses**
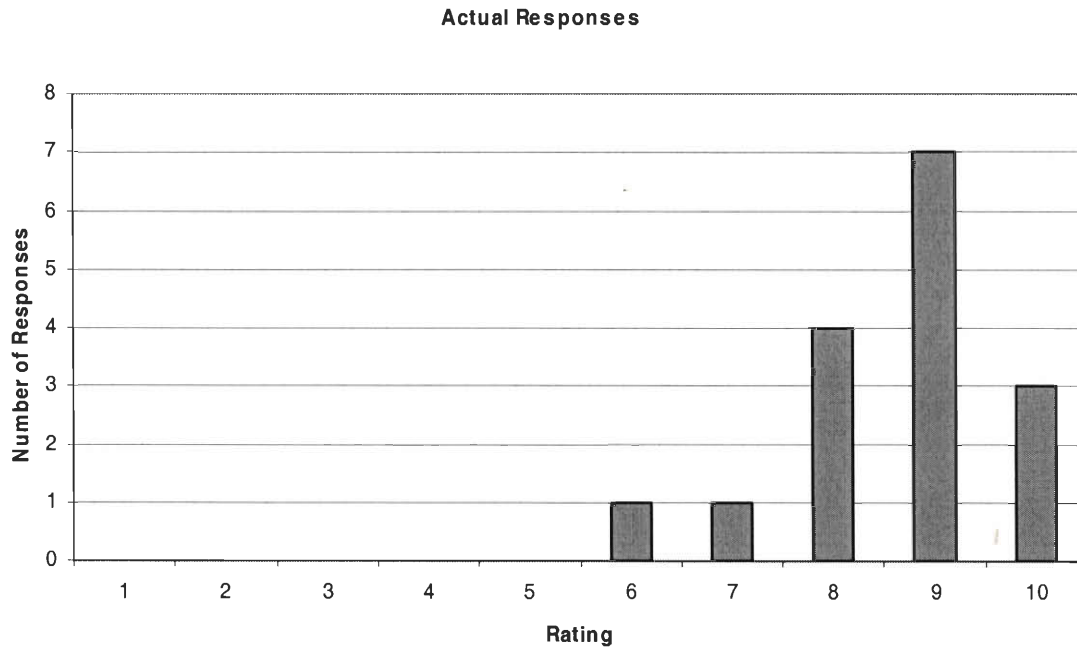


**Figure 8**

**Web – Lab 4.5**
*Comparison – Rated Comprehension Before vs. Rated Comprehension After*

| | | | | | | | After | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 10 | | | | | | | | | | | 2 |
| | 9 | | | | | | | | | | 3 | |
| | 8 | | | | | | | | | 2 | 1 | |
| | 7 | | | | | | | | | 1 | | 1 |
| | 6 | | | | | | | 1 | 1 | 1 | 2 | |
| Before | 5 | | | | | | | | | | | |
| | 4 | | | | | | | | | | 1 | |
| | 3 | | | | | | | | | | | |
| | 2 | | | | | | | | | | | |
| | 1 | | | | | | | | | | | |
| | Lab 4.5 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

**Figure 9**

**Web - Lab 4.5**
*Question 3: Rate your comprehension of the lab process (i.e. how well you understood how to do the lab).*
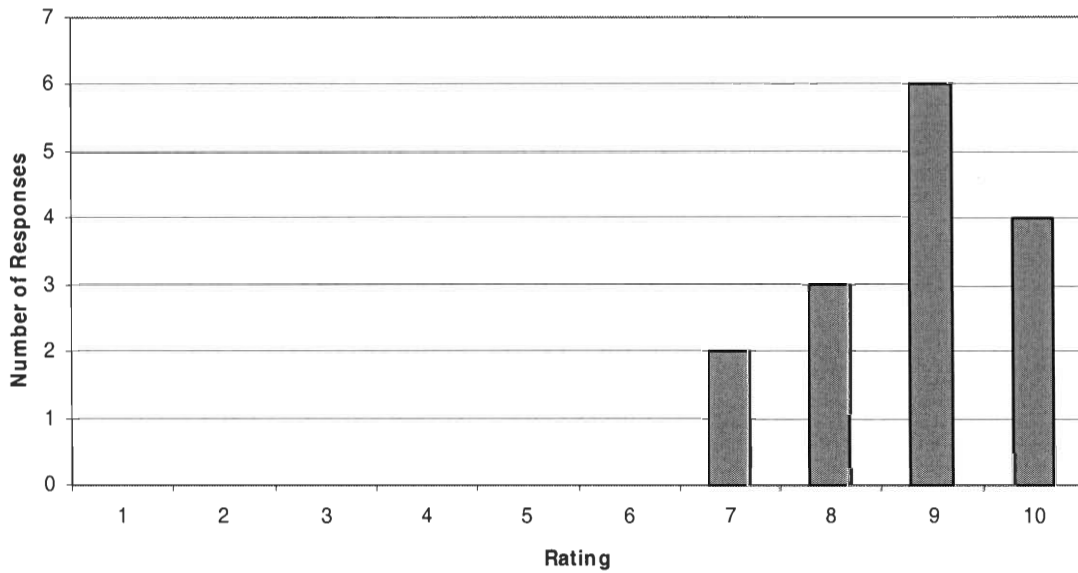
**Actual Responses**



**Figure 10**

**Web - Lab 4.5**
*Question 4: How difficult to use was the lab interface (i.e. the program you used to run the lab)?*
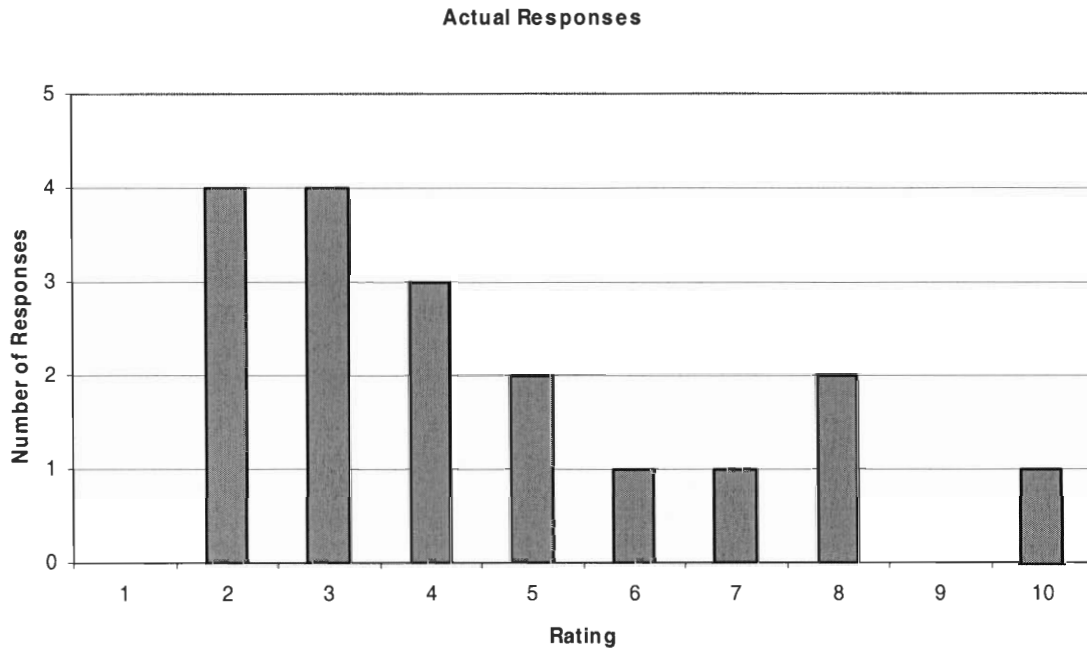
**Actual Responses**



**Figure 11**


**Web - Lab 4.5**
*Question 5: How difficult was the lab material (i.e. the concepts being taught)?*

**Actual Responses**



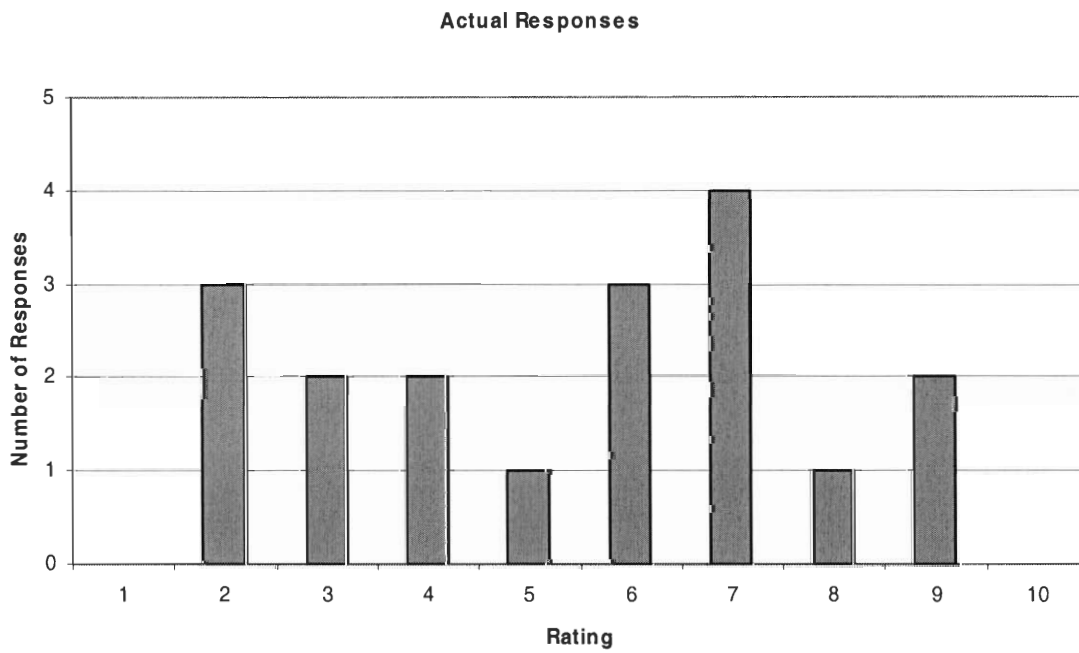**Figure 12**

**SAS - Lab 4.6**
*Question 1: Rate how well you comprehended the material taught in the lab before you did it.*

**Actual Responses**
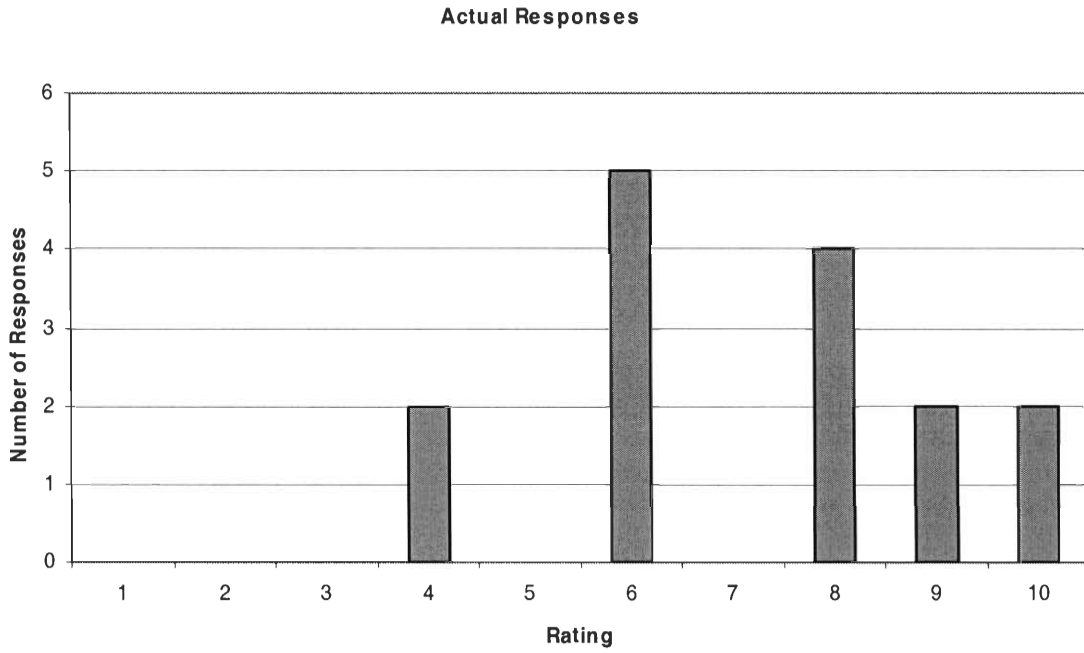


**Figure 13**

**SAS - Lab 4.6**
*Question 2: Rate how well you comprehend the material taught in the lab now.*

**Actual Responses**
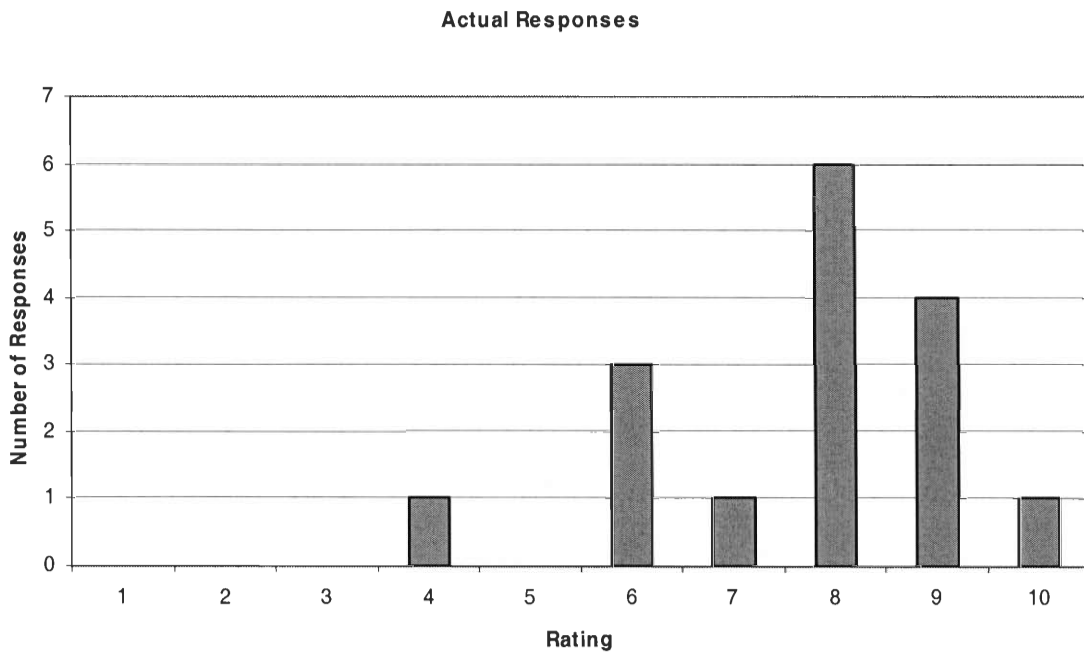


**Figure 14**

**SAS – Lab 4.6**
***Comparison – Rated Comprehension Before vs. Rated Comprehension After***

|  |  | After |  |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|  | 10 |  |  |  |  |  | 1 |  |  |  | 1 |
|  | 9 |  |  |  |  |  |  |  | 1 | 1 |  |
|  | 8 |  |  |  |  |  |  | 1 | 1 | 2 |  |
|  | 7 |  |  |  |  |  |  |  |  |  |  |
|  | 6 |  |  |  |  |  | 2 |  | 2 | 1 |  |
| Before | 5 |  |  |  |  |  |  |  |  |  |  |
|  | 4 |  |  |  | 1 |  |  |  | 1 |  |  |
|  | 3 |  |  |  |  |  |  |  |  |  |  |
|  | 2 |  |  |  |  |  |  |  |  |  |  |
|  | 1 |  |  |  |  |  |  |  |  |  |  |
|  | Lab 4.6 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

**Figure 15**

**SAS - Lab 4.6**
*Question 3: Rate your comprehension of the lab process (i.e. how well you understood how to do the lab).*
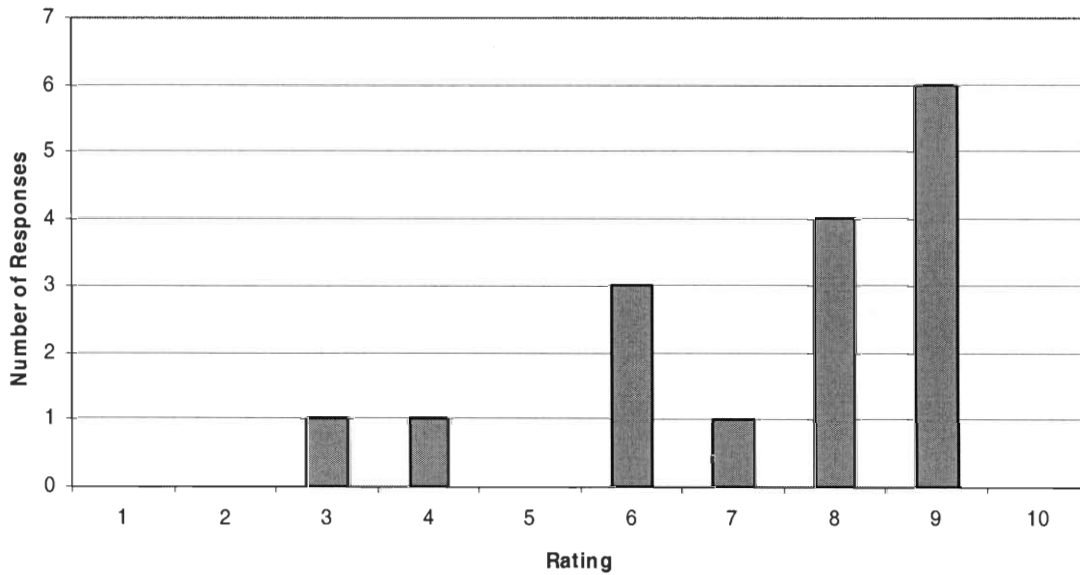
**Actual Responses**



**Figure 16**

**SAS - Lab 4.6**
*Question 4: How difficult to use was the lab interface (i.e. the program you used to run the lab)?*
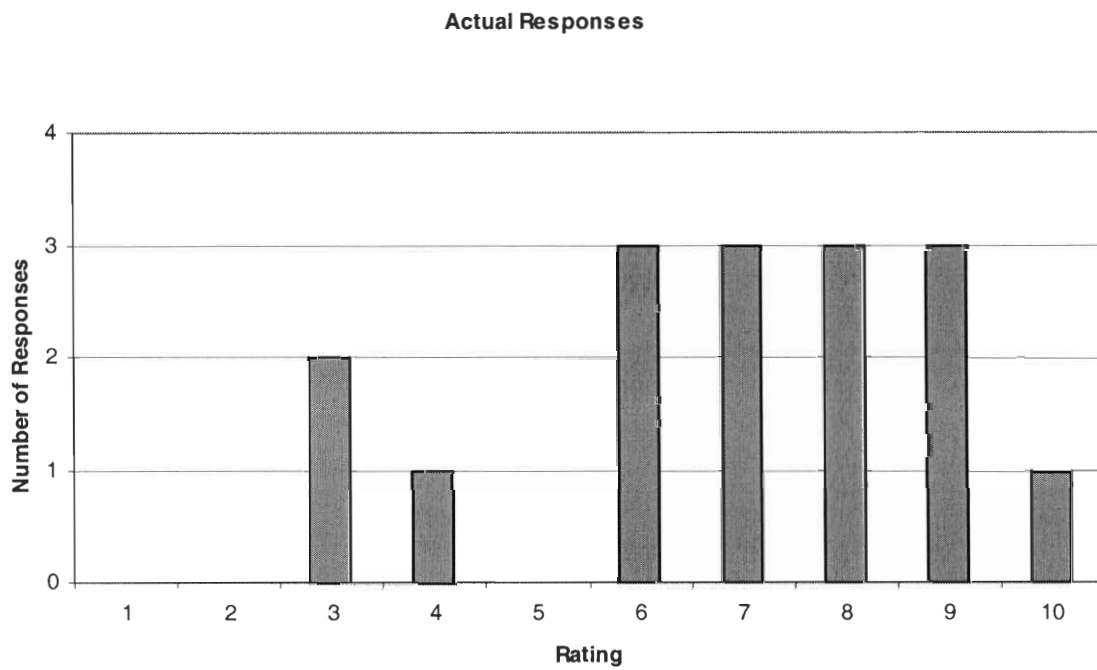
**Actual Responses**



**Figure 17**

**SAS - Lab 4.6**
*Question 5: How difficult was the lab material (i.e. the concepts being taught)?*
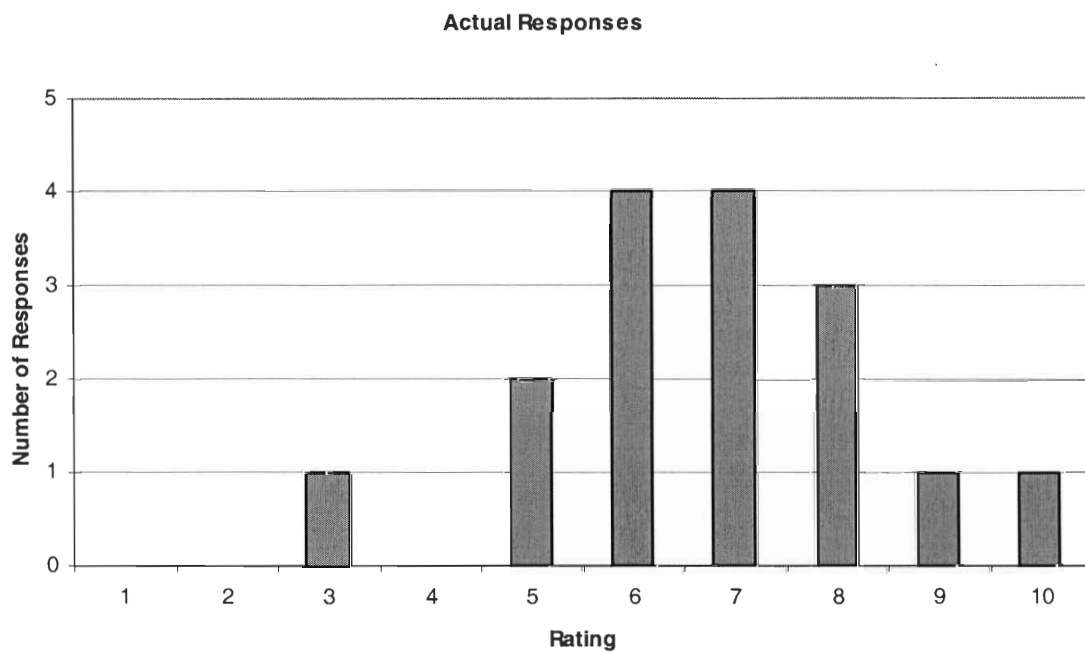
**Actual Responses**



**Figure 18**

**Web - Lab 4.6**
*Question 1: Rate how well you comprehended the material taught in the lab before you did it.*

**Actual Responses**
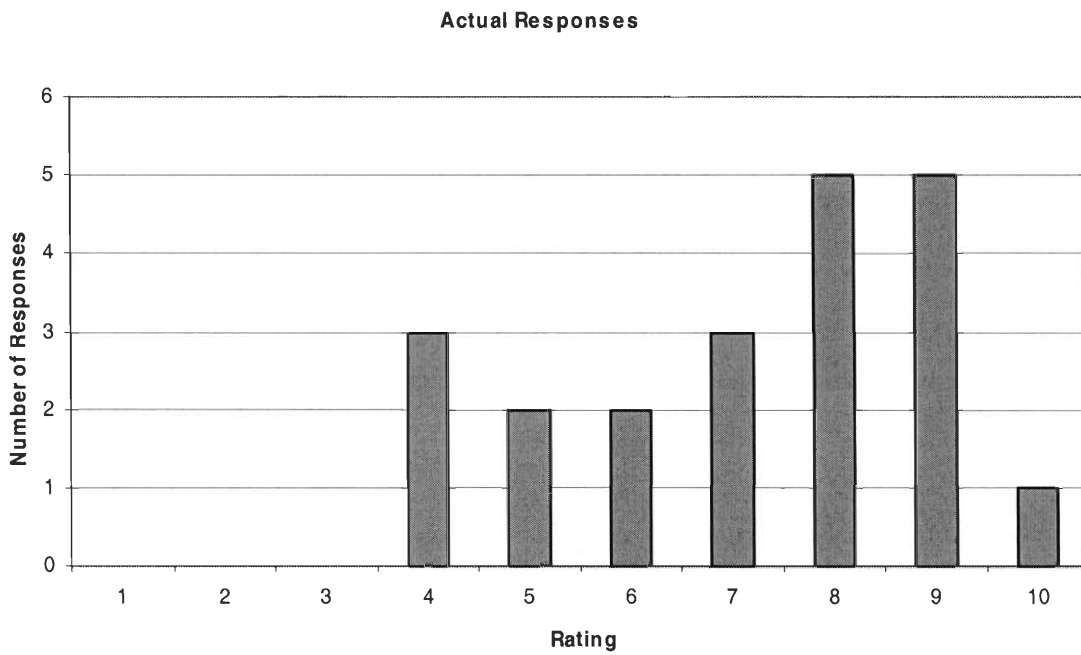


**Figure 19**

**Web - Lab 4.6**
*Question 2: Rate how well you comprehend the material taught in the lab now.*

**Actual Responses**
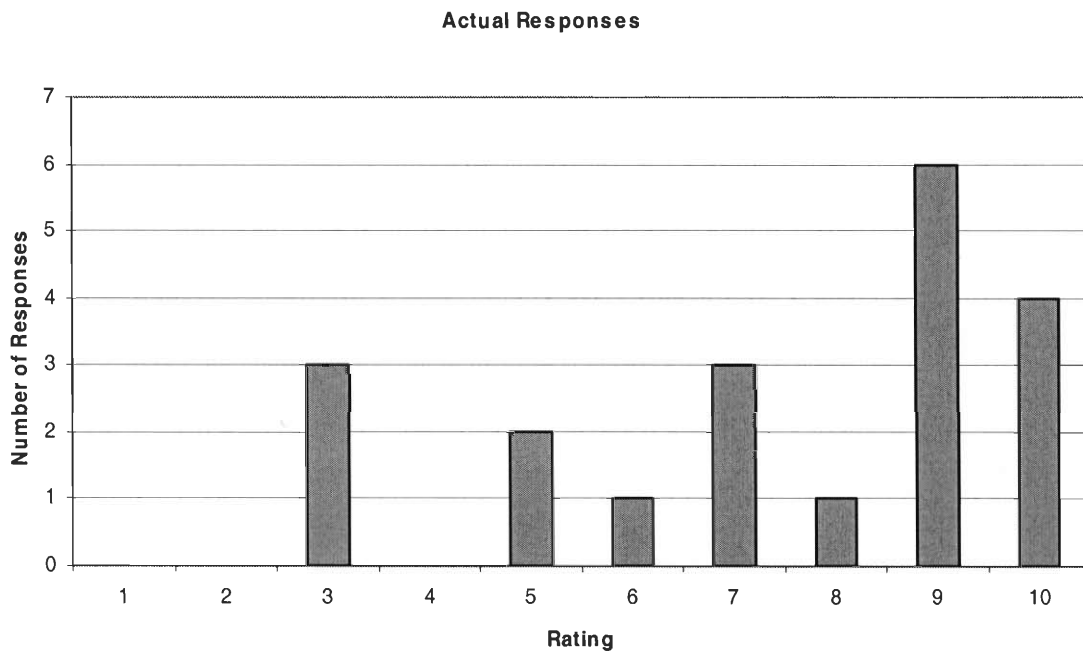


**Figure 20**

**Web – Lab 4.6**
***Comparison – Rated Comprehension Before vs. Rated Comprehension After***

| | | After | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 10 | | | | | | | | | | 1 |
| | 9 | | | | | 1 | | | | 2 | 2 |
| | 8 | | | | | | | | 1 | 2 | 1 |
| | 7 | | | | | | | 1 | | 2 | |
| | 6 | | | 1 | | | | 1 | | | |
| Before | 5 | | | | | 1 | 1 | | | | |
| | 4 | | | 2 | | | | 1 | | | |
| | 3 | | | | | | | | | | |
| | 2 | | | | | | | | | | |
| | 1 | | | | | | | | | | |
| | Lab 4.6 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

**Figure 21**

**Web - Lab 4.6**
*Question 3: Rate your comprehension of the lab process (i.e. how well you understood how to do the lab).*

**Actual Responses**



**Figure 22**

39

**Web - Lab 4.6**
*Question 4: How difficult to use was the lab interface (i.e. the program you used to run the lab)?*

**Actual Responses**



**Figure 23**

**Web- Lab 4.6**
*Question 5: How difficult was the lab material (i.e. the concepts being taught)?*

**Actual Responses**
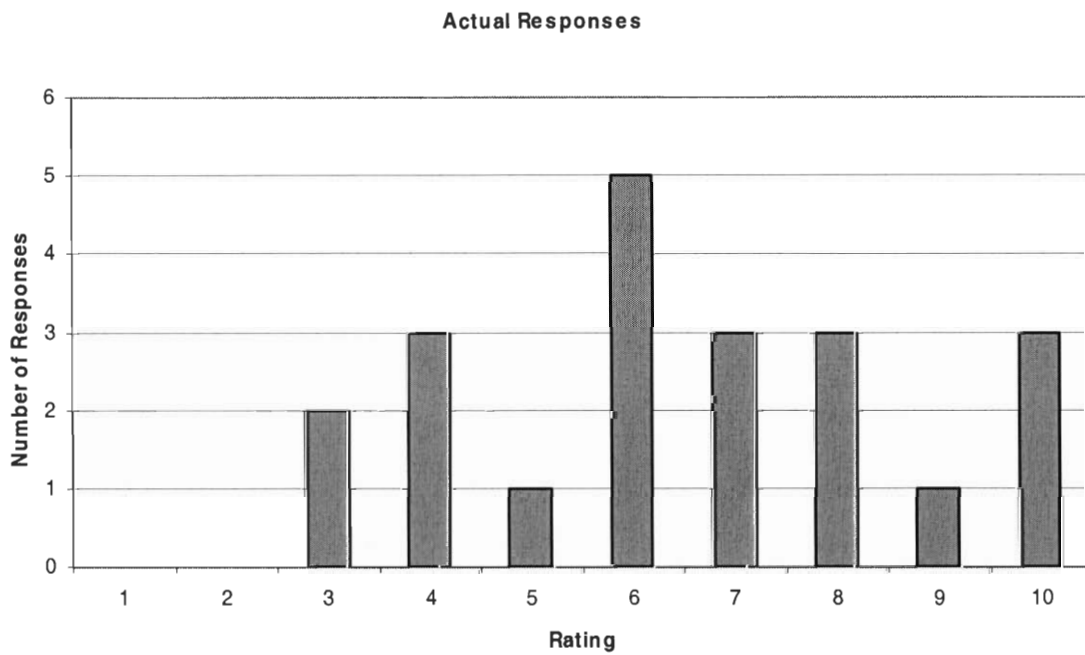


**Figure 24**

**SAS - Lab 5.3**
*Question 1: Rate how well you comprehended the material taught in the lab before you did it.*

**Actual Responses**
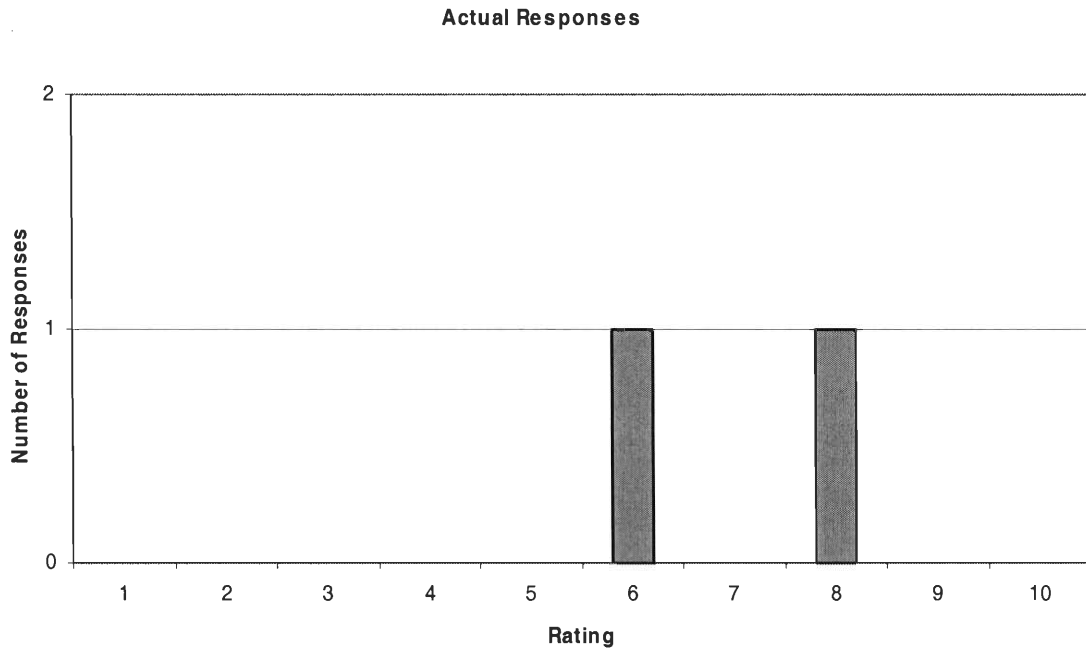


**Figure 25**


**SAS - Lab 5.3**
*Question 2: Rate how well you comprehend the material taught in the lab now.*

**Actual Responses**
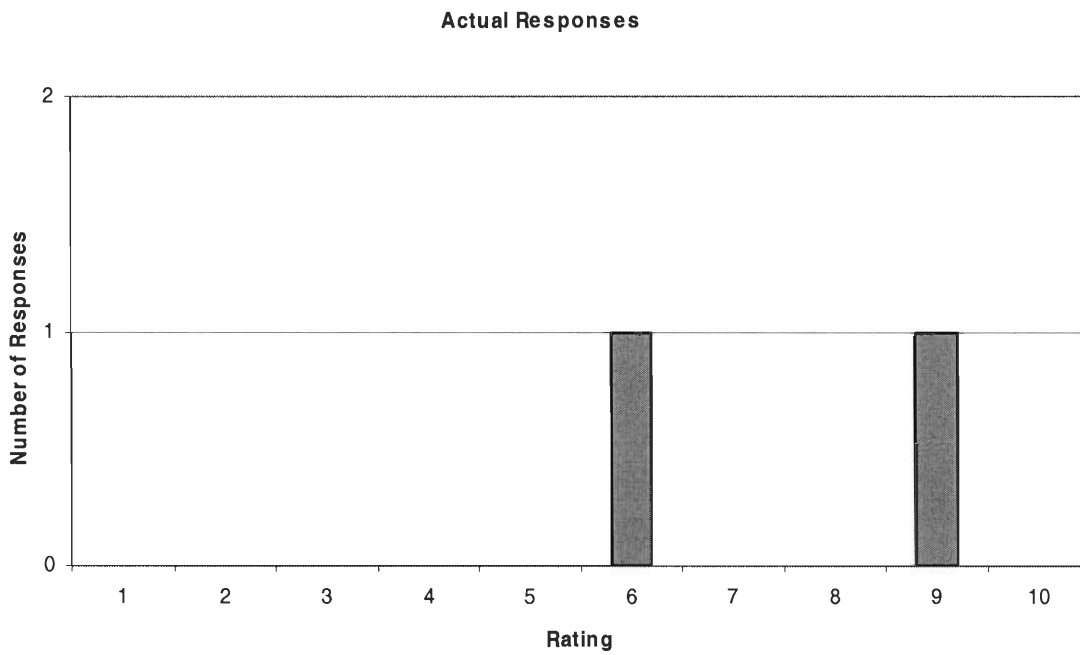


**Figure 26**

**SAS – Lab 5.3**
*Comparison – Rated Comprehension Before vs. Rated Comprehension After*

| | | | | | After | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 10 | | | | | | | | | | |
| | 9 | | | | | | | | | | |
| | 8 | | | | | | | | | | 1 |
| | 7 | | | | | | | | | | |
| | 6 | | | | | | 1 | | | | |
| Before | 5 | | | | | | | | | | |
| | 4 | | | | | | | | | | |
| | 3 | | | | | | | | | | |
| | 2 | | | | | | | | | | |
| | 1 | | | | | | | | | | |
| | Lab 5.3 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

Figure 27

**SAS - Lab 5.3**
*Question 3: Rate your comprehension of the lab process (i.e. how well you understood how to do the lab).*
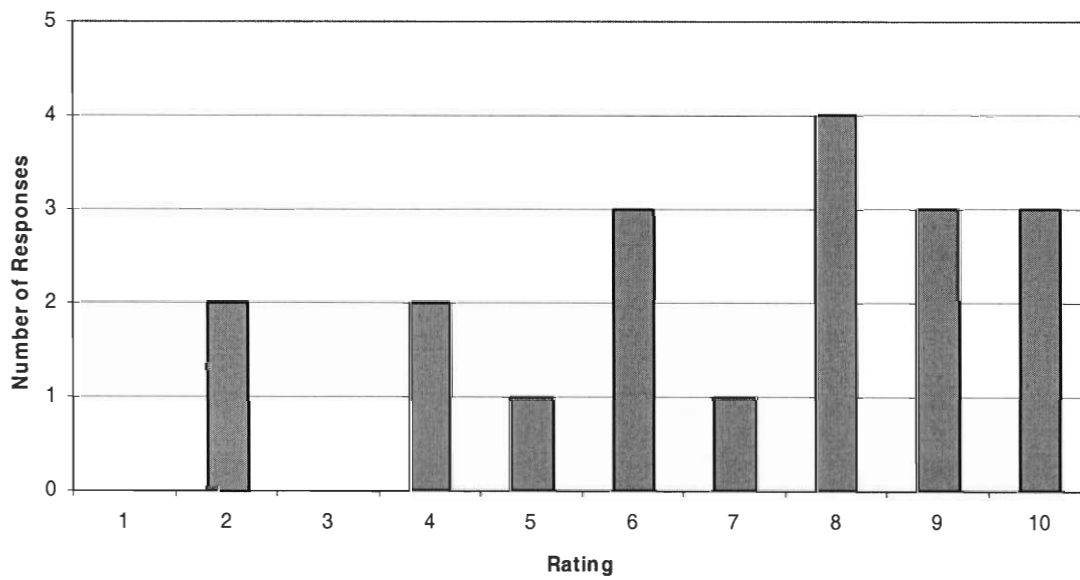
**Actual Responses**



Figure 28

42

**SAS - Lab 5.3**
*Question 4: How difficult to use was the lab interface (i.e. the program you used to run the lab)?*
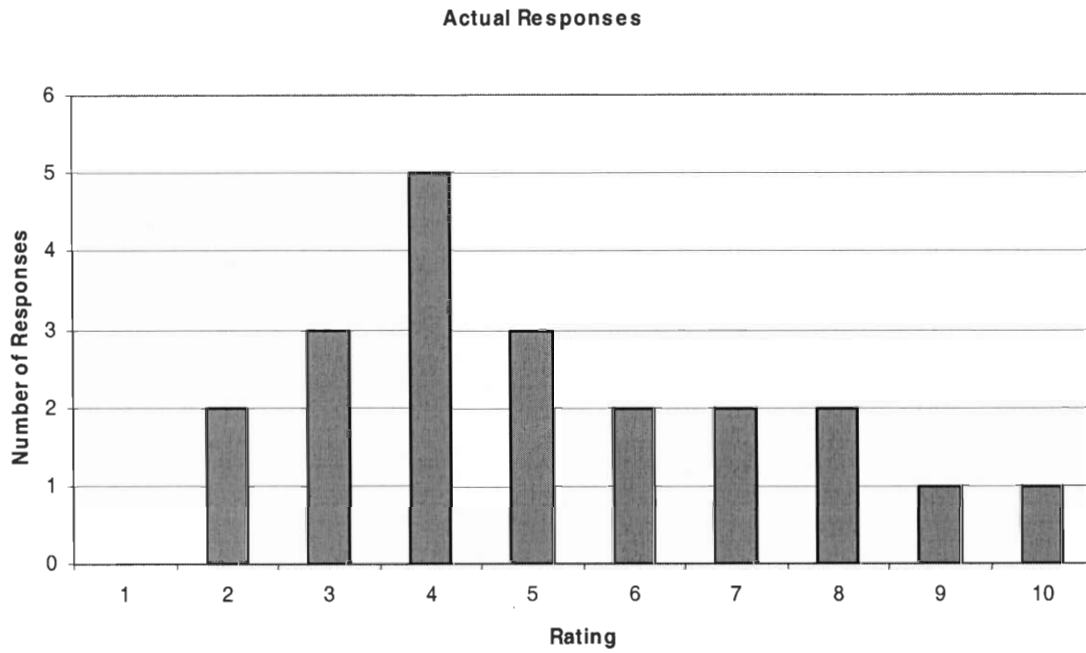
**Actual Responses**



**Figure 29**

**SAS - Lab 5.3**
*Question 5: How difficult was the lab material (i.e. the concepts being taught)?*

**Actual Responses**



**Figure 30**

43
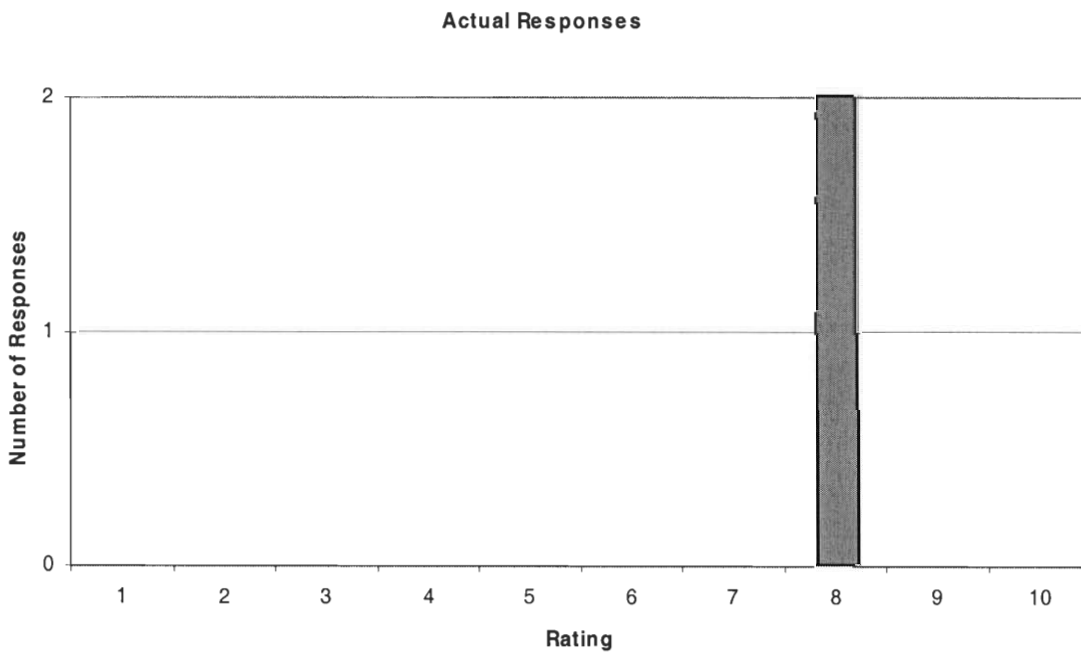
**Web - Lab 5.3**
*Question 1: Rate how well you comprehended the material taught in the lab before you did it.*

**Actual Responses**
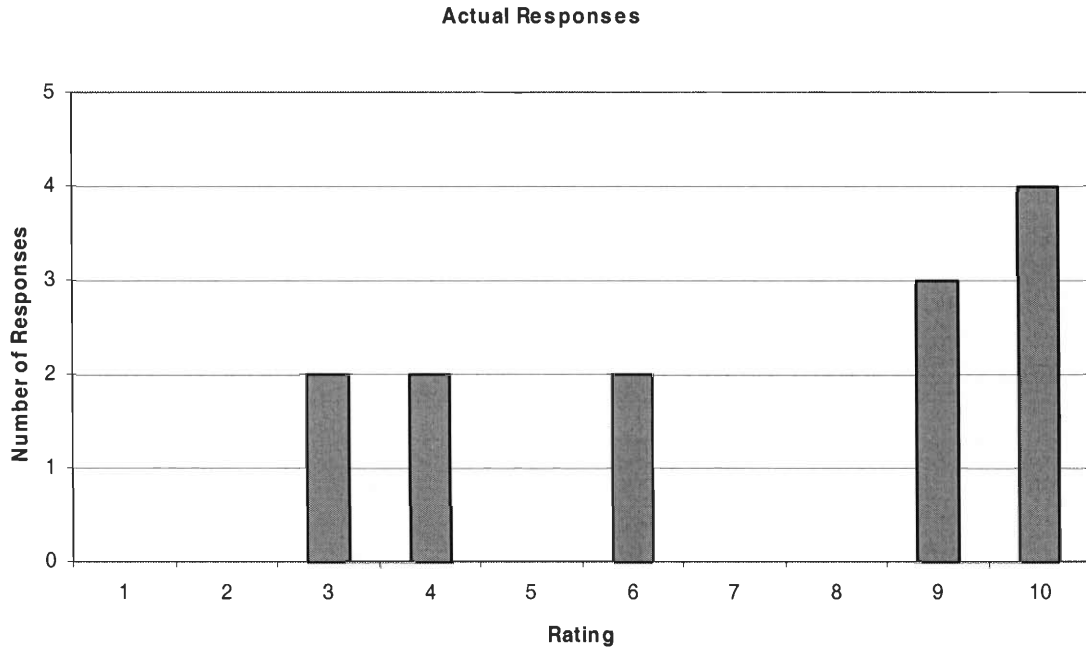


**Figure 31**

**Web - Lab 5.3**
*Question 2: Rate how well you comprehend the material taught in the lab now.*

**Actual Responses**



**Figure 32**

44

**Web – Lab 5.3**
*Comparison – Rated Comprehension Before vs. Rated Comprehension After*

| | | After | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 10 | | | | | | | | | | 2 |
| | 9 | | | | | | | | 1 | 2 | |
| | 8 | | | | | | | | | | |
| | 7 | | | | | | | | | | |
| | 6 | | | | | | 1 | | | 1 | |
| Before | 5 | | | | | | | | | | |
| | 4 | | | | | | | 1 | 1 | | |
| | 3 | | | | | 2 | | | | | |
| | 2 | | | | | | | | | | |
| | 1 | | | | | | | | | | |
| | Lab 5.3 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

**Figure 33**

**Web - Lab 5.3**
*Question 3: Rate your comprehension of the lab process (i.e. how well you understood how to do the lab).*
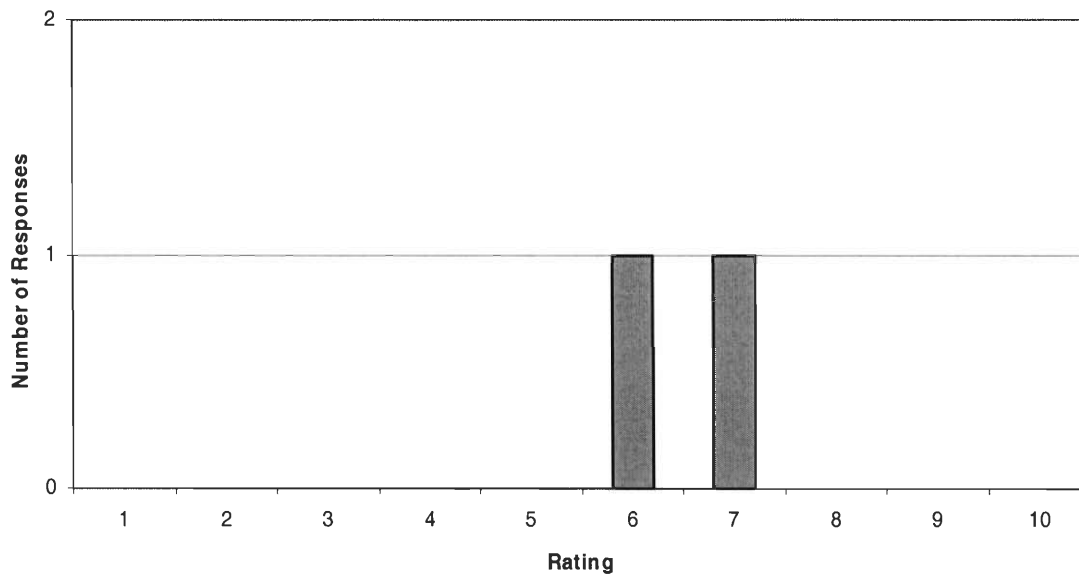
**Actual Responses**
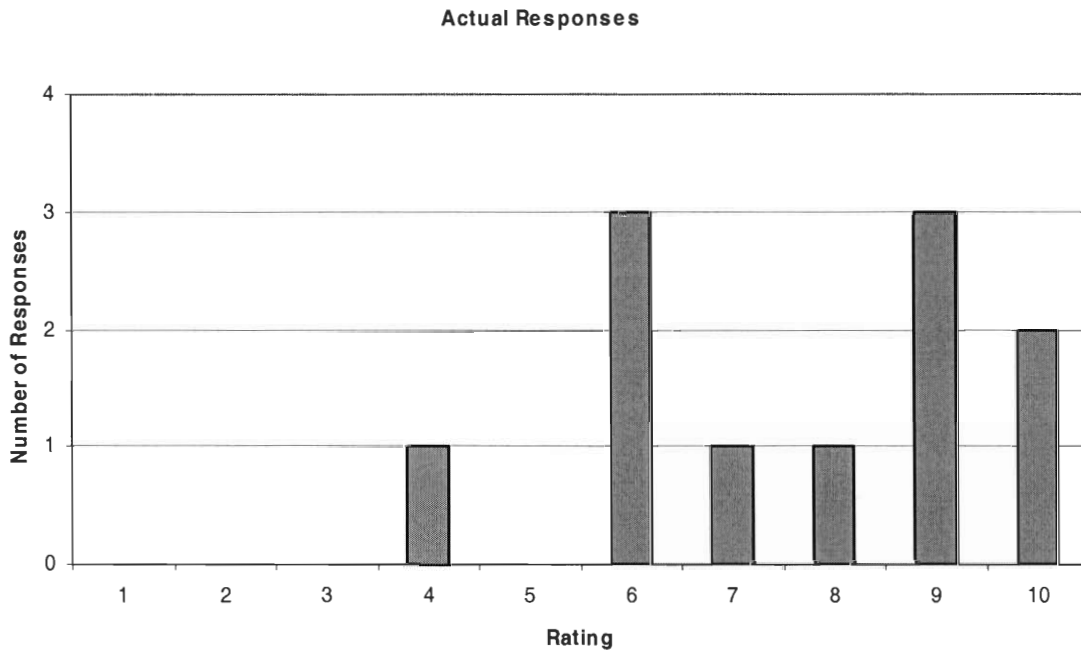


**Figure 34**

**Web - Lab 5.3**
*Question 4: How difficult to use was the lab interface (i.e. the program you used to run the lab)?*
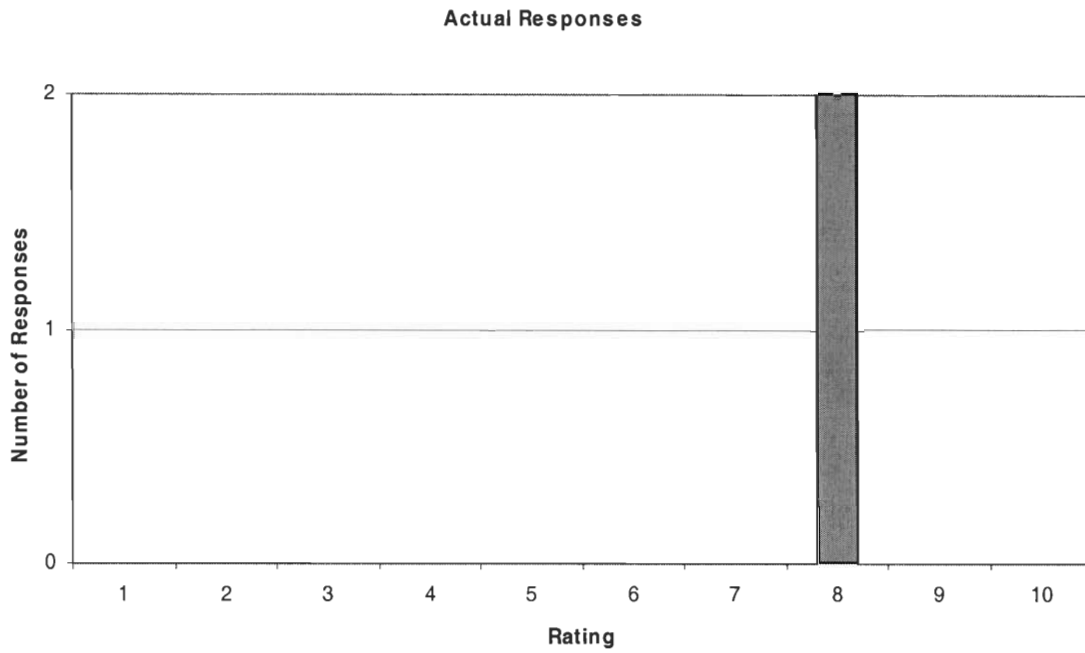
**Actual Responses**
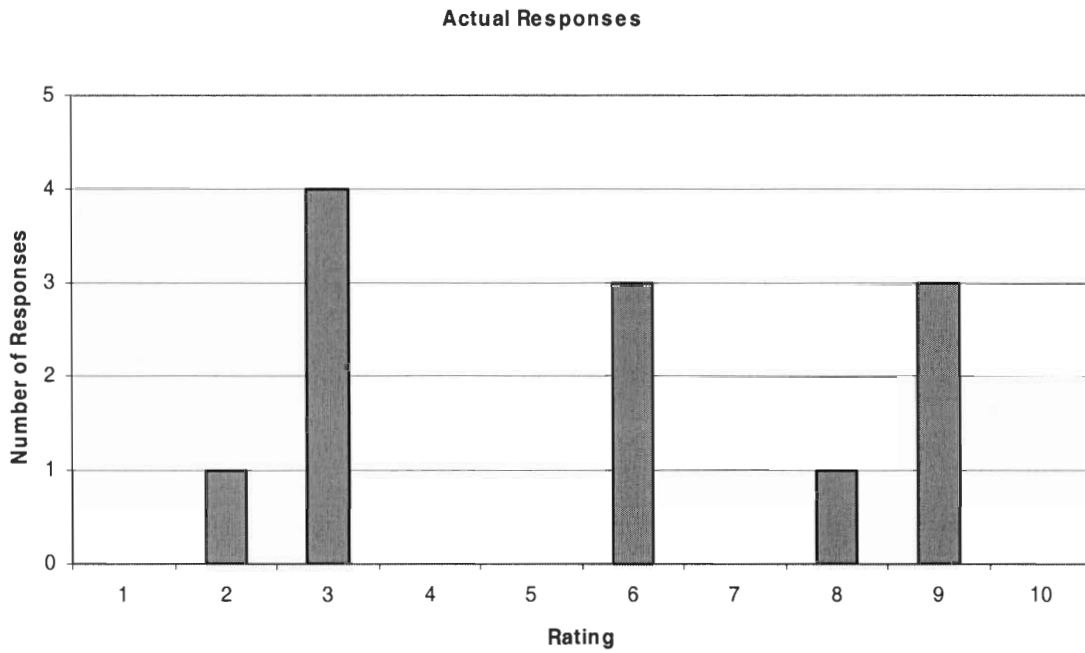


**Figure 35**

**Web - Lab 5.3**
*Question 5: How difficult was the lab material (i.e. the concepts being taught)?*

**Actual Responses**
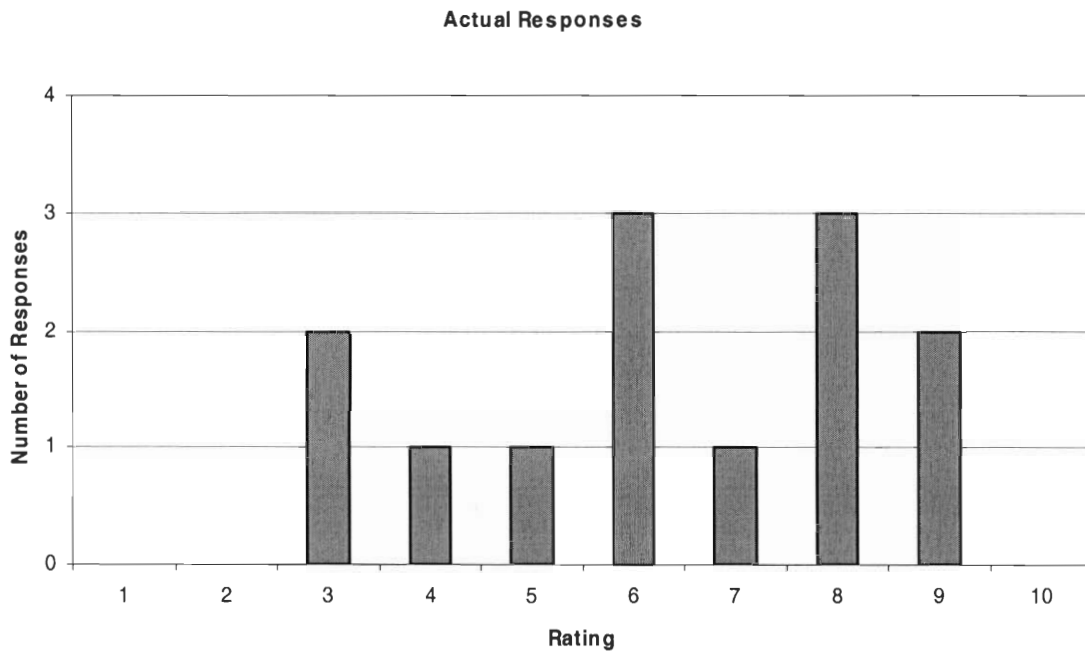


**Figure 36**

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## V: Analysis of Results

### Lab 4.5

One of the main goals in the lab was to help increase the students' understanding of the material. Questions 1 and 2 of the post-lab surveys were aimed at gauging the students' assessments of their comprehension of the lab material before and after the lab (see Chapter 6 for a further explanation of the results).

The SAS version of Lab 4.5 had some success in this endeavor; prior to the lab, 13 of the 18 respondents rated their understanding a 7 or higher [Fig. 1]. While the number of the 17 respondents who rated their understanding after completing the lab a 7 or higher was also 13 [Fig. 2], the ratings within this range grew significantly. The number of "9" ratings more than doubled from 3 to 7, and the number of "10"s grew from 1 to 2. Meanwhile, the "7"s and "8"s shrunk from 4 and 5 to 2 and 3, respectively. Further, when the comparison chart of before and after ratings is examined [Fig. 3], we note that 8 of the surveyed students increased their ratings afterwards, and of these 8, , 2 jumped more than one rating level.

However, not all responses were this favorable. In fact, the SAS version of this lab seemed to only increase the confusion of those students rating their understanding at 5 and below. Whereas prior to

doing the lab they had rated themselves as "4"s or "5"s, after completing it they rated themselves *lower*, with one of the students dropping from a "5" to a "2" and another from a "4" to a "3". While the lab was perceived as aiding comprehension by those students who said they already had a decent understanding of the material, a significant number of those students who felt they had trouble with the concepts already– 2 of the 4 who rated their comprehension at "5" or below" - felt that it did not adequately aid them.

The web version of the lab, however, showed markedly different results than the SAS one. First, the 17 students who did this lab rated their comprehension prior to completing the lab as approximately the same as those who used the SAS version [Fig 7]. 11 of them rated their understanding before at "7" or higher, while only 1 placed it below 5, and 5 rated it as a "6". So, while the proportion of "7 or greater" ratings were less than those in the SAS lab, the majority of the remaining students weren't far behind in their estimation of comprehension prior to completing the lab. Most important, however, were the results *after* the students had completed it [Fig. 8]: only 1 placed their comprehension below a "7" and that student rated it as a "6". Moreover, the number of "9"s and "10"s increased; "10"s went from 2 to 3 and "9"s from 3 to 7. The comparison charts [Fig. 9], meanwhile, show that 8 of the students rated their comprehension at a

higher level after completing the lab, and 5 of these jumps were of two rating levels or greater. Further, no students rated themselves lower afterwards than they did before. In other words, the web lab produced a perceived comprehension rating superior to the SAS one and, unlike the SAS lab, this was true even for those students who prior to the lab thought they least understood the material.

When asked how well they understood how to do the lab, students who used SAS rated it fairly well [Fig. 3]. Only 3 of the 16 respondents placed it as 5 or below, while the rest – 13 - rated it as a "7" or above. However, the student evaluations of their understanding of how to do the web version of Lab 4.5 was higher than for the SAS version. The web lab was so effective at making the operations easy to do that all 16 students who took the survey placed their rating as a "7" or above, and only 2 rated it a "7" [Fig. 10]. This rating isn't very surprising; SAS is an extremely open-ended tool designed for advanced statistics operations, while the web lab provided relatively few choices. The instructions for both labs included a "walkthrough" that guided the students through the lab procedures, but the web lab restricted the actual operations that were available. Though the students were guided through the SAS interface, the other options and functionality were still present and visible to the user. This open-ended interface can be daunting, to say the least. The web interface, on the

other hand, limited the user's choices to those which were relevant to the lab material itself, providing a simpler, less confusing and potentially less daunting experience. Granted, there is some leeway for the student – without the instructions also present, the user can select whatever they'd like – but it is limited. Still, it is somewhat surprising to see that *everyone* who used the web lab rated their understanding of the process high; usually there is some proportion – even an extremely small one – that does not fully grasp what it is they are to do. It is possible that some of the students had so little idea what they were doing that they did not realize that they did not know what to do. Nonetheless, the lab accomplished its goal of making the interface easy enough for everyone to use effectively.

There is a difference between understanding how to make the interface operate and its ease of use; a system could be designed with an easily understood but difficult to operate front-end, an obviously undesirable mix. Of the 18 groups who used the SAS 4.5 lab, 10 stated that the difficulty of the interface was a "5" or less [Fig. 4]. Again, this rating is not too surprising; the lab was not an especially complex one and the students had a walkthrough guide at hand to help them through it. Meanwhile, of the 18 who used the web lab, 13 rated its difficulty as a "5" or less, nearly a 50% increase in "ease of use" rating versus the SAS one [Fig. 11]. Of the rest, only 1 rated it a

"10" or "Most difficult to use", versus 2 for the SAS version. Finally, we asked the students how difficult the lab material to be learned was. Of the 19 students who completed the SAS lab, 5 rated the difficulty of the material at "4" or below [Fig. 5]. However, no students at all placed the difficulty at "9" or "10", while most rated it as an 8 or a 6 (5 and 6 students, respectively). This is striking in comparison with the 18 who used the web lab. There, although a greater percentage rated the material's difficulty as "4" or below (7), there were fewer people who found it more difficult than an "8" [Fig. 12]. This difference can be interpreted two ways. While the material is to some extent divorced from the program that implements it, it is difficult to completely separate one from the other. Fewer students found the web lab material extremely difficult, implying one of two things. Either the web interface itself helped to make the lab easier – by removing the students' focus from making the program do what they wanted and instead allowing them to concentrate on the material - or the students completing the web lab simply found the material itself easier. Because of the previous survey results ranking the web lab as easier to use than the SAS one and as providing much greater aid to  the students' comprehension, it seems likely that the former would hold true; the students found the web interface easier to comprehend and so they

could spend less time trying to make it do what they wanted and more time working to understand the material presented to them.

All in all, lab 4.5 emerged as a success. There was a noticeably larger increase in the students' perceived understanding of the material before and after they used the web lab as opposed to the SAS version. Moreover, all of the students using the web lab rated the lab process straightforward and easy to comprehend, versus 13 of those 16 students using SAS. The difference between the two should only increase as more difficult labs are introduced to the students, asking them to make use of SAS' more complex functionality. While the difference in rated ease of use of the two labs' interfaces was not as markedly different as was intended, it seems likely that the relative simplicity of this lab versus the later ones contributed to the students' similar ratings between the SAS and web versions. Again, it seems likely that this difference will increase as the students progress. Finally, the students rated the lab material *easier* under the web system; the number of users who ranked the difficulty as "8" and above under the SAS system was 5 compared with 3 of the web lab users .. Nonetheless, more students rated the material easier under the web system than the SAS one, indicating we had achieved the goal of an easier, more productive, user-friendly, and useful version of the lab.

**Lab 4.6**

Prior to lab 4.6, those students using the SAS version rated their comprehension of the lab material. Of the 15 groups that responded to the survey, 8 rated their understanding as a "7" or better, and even of those whose ratings were under that level, 5 gave themselves a "6", with the remainder – 2 - being "4"s [Fig. 13]. Moreover, their comprehension ratings jumped significantly after completing the lab. The students who rated themselves "7" or greater numbered 12, with 3 as "6"s, and only 1 remaining as "4"s [Fig. 14]. However, there were some noticeable drops; 1 of the respondents, for instance, *downgraded* their rating from a "10" to a "6", another went from a "9" to an "8", and a final 1 went from an "8" to a "7" [Fig. 15]. By and large the students increased their ratings after doing the lab; for instance, 1 jumped from a "4" to an "8", and another 2 from "6" to "8". 6 of the participants increased their ratings, while 3 decreased them. Moreover, of those lowered ratings, one fell more than one level.

The web version of the lab offered similar results. Before performing the lab, 14 of the 21 students rated their understanding of the material at a "7" or above [Fig. 19]. Moreover, of the remaining students, most were in the "4" and "5" level (5). However, *after* the

lab, many of these lower-level ratings dropped lower [Fig. 20]; whereas before there were 3 "4"s, there were now 3 "3"s. 2 students dropped from "4" to "3", 1 from "6" to "3", and 1 from "9" to "3" [Fig. 21]. The level of "5"s stayed the same, while "6"s dropped – moving upwards into the "7 or above" range. It seems that the web version of lab 4.6 suffered the same fate as the SAS version of 4.5; rather than aid the people whose understanding of the material was already shaky, it confused them further. This effect was not limited to those students already in the lower rating levels; 5% of the students dropped from "9" to ""5". However, not all the rating changes were this negative; some of those who initially rated themselves below "5" increased their rating afterwards (1 went from "5" to "6" and another from "4" to "7") , and the upper-level ratings increased significantly; the number of "10"s quadrupled to 4, while "9"s also grew a bit, "8"s dropped, and "7"s stayed roughly the same. The cause of this change was a fairly constantly up-shifting of the perceived comprehension level; the "6"s turned into "7"s (1), the "7"s into "9"s (2), the "8"s into "9"s (2) or "10"s (1), and the "9"s into "10"s (1). Just like SAS lab 4.5, students who felt that their comprehension was already fairly high – above the "5" level" – also felt this lab helped improve that comprehension, while those who initially felt their comprehension was low later felt that the lab caused their comprehension to decline. This

perceived decline, though unfortunate and unwelcome, is understandable; the material is becoming progressively more challenging and those students having trouble with the material (i.e. those with a lower comprehension rating) are unable to "keep up". The ratings for the SAS version of this lab confirms this possibility; there, the ratings were lowered only for those students who had initially ranked their understand high, while the web version suffered from the reverse; several of the students who ranked themselves lower initially decreased their ratings afterwards. A possible  explanation is that these students neglected to even look at the material prior to coming to the lab; they were naturally confused by the lab and became aware of just how little they knew. Though we attempt to help the students learn the material, they still need to put some effort into it; without that effort, they'd accomplish little.

The level of understanding the students recorded for the SAS lab process – that is, how well they understood how to do the lab – was remarkably good [Fig. 16]. Of the 16 groups that responded, 11 rated their understanding as a "7" or greater. Moreover, only 2 rated themselves as a "5" or lower. In comparison, the web lab students who rated themselves as a "7" or above were only 11 of the 19 total responses, and even then 5 rated their understanding at "5" or below [Fig. 22]. Again, the web lab process is more confusing for students

than the SAS lab process. It's possible that because the SAS labs have been in use for so long, the instructions for it are more refined and aid the user in better understanding what he or she is doing, as opposed to the web labs, which have only been used by a student class a handful of times. Nonetheless, it's disappointing that the process we had hoped to streamline and make *easier* for the student actually operated in reverse, being *more* difficult for the user to comprehend. Though the majority of students felt they did understand what they were doing very well – 3 rated their understanding as a "10" versus none in the SAS lab, for instance – there were still more users who rated the SAS process easier to understand.

Understanding what to do, however, is, again, not the same as making the interface easy to use. When asked how difficult the SAS interface was, 10 of the 16 respondents rated it as a "7" difficulty or above. Furthermore, another 3 rated the difficulty as a "6", leaving only 3 of the total respondents to find the difficulty level as a "4" or below [Fig. 17]. Only 5 out of a total of 21 responses - less than half the proportion of the SAS results – rated the web interface as a "7" or above in difficulty [Fig. 23]. Furthermore, 13 placed the level of difficulty of the web interface at a "5" or below. Though these results are not surprising – SAS is again well-known for its confusing interface – they are reassuring; these labs were intended to be easy to use and

it's satisfying to note that they function this way. Despite the fact that earlier the students had rated their understanding of the web lab process as lower than that of the SAS lab, when ease of use is taken into account, the web version rates higher than the SAS lab.

The results of question 5 indicate that students felt the web-based lab was easier to use than the SAS-based one. 9 of the 16 SAS respondents rated the difficulty of the lab material as a "7" or above, while only 3 placed it at "5" or below [Fig. 18]. In the 21 responses to the web version, however, only 10 rated the difficulty at "7" or above and 6 placed it at "5" or below [Fig. 24], while the same number of people rated it "6" in both versions. Although the web lab did have significantly more "10"s than the SAS one, the difficulty ratings for the web lab were lower overall than the ratings given for the SAS lab. Furthermore, though the difficulty of the lab is related to the difficulty of the interface, there is also the point at which no matter how easy the interface is to use, the material can still prove challenging. The web respondents had a larger portion of people than the SAS respondents who did not understand the material well and this diversity is reflected here where more people found the lab material more challenging. Despite that increase over the SAS lab, there were still more people who rated the material at an "easy" level in the web version.

## Lab 5.3

Due to the length of lab 5.3, the students were allowed to use either the web or the SAS version, depending upon their preference. Not surprisingly, the majority of students chose the web lab. While this may have been convenient for the students, it leaves the survey results somewhat lopsided; there were only two submissions for the SAS 5.3 lab survey. Nonetheless, the results of the survey are still useful and so are presented here.

Prior to completing the lab, the two SAS students rated their understanding as a "6" and an "8" [Fig. 25]. After completing the lab and being asked their level of comprehension, the first remained at "6" while the other moved up a notch to "9" [Fig. 27]. The results of the web lab, meanwhile, fulfilled the lab's expectations. Prior to completing it, 7 of the 13 students rated their understanding as a "7" or above, while 2 placed it at "4" or below [Fig. 31]. Afterwards, a total of 8 of the respondents rated their understanding at a "7" or above level [Fig. 32]. Furthermore, the responses of "3"s and "4"s were removed entirely; the lowest understanding rate given after the lab was performed was a "5". The comparison chart [Fig. 33] shows that the smallest rating jump was by 2 levels: 2 increased their rating from "3" to "5". Further, one  of the two "6"s jumped to a "9" , and even the

"4" jumped significantly, with 1 of the two students going from "4" to "7" and the other from "4" to "8". The rest of the respondents either kept their rating the same or increased it. It is satisfying to note that students who thought they understood the material poorly felt that this lab helped increase their understanding.

The responses to the question asking the students to rate their comprehension of the lab process fit into the expected results. One of the students using SAS rated it "6" and the other "7" [Fig. 28]. Of the 11 web respondents, meanwhile, 7 rated their comprehension at a level of "7" or greater, and of the remainder only 1 placed it below a "6" [Fig. 34]. The lab itself is a fairly long, multi-part affair; it's not surprising that some students were less than clear on just what to do. Though the lab was simplified and "boiled down" into a format that makes it easier and faster to do, there is still a lot of material in the lab and it is understandable that all of it might not be clear. Still, only 1 found it confusing enough to rate it below a "6"; if this lab had been completed in SAS by the same group, we believe that the comprehension factors for that group would have been noticeably lower.

SAS' difficulty level is notorious, especially among students who have  not had extensive experience with it. Even the students who selected SAS as their medium of choice for lab 5.3 gave it high marks

for difficulty; both ranked the difficulty level at an "8" [Fig. 29]. Of the 12 web respondents, meanwhile, only 4 ranked the interface's difficulty at "7" or above [Fig. 35]. In fact, 5 placed it at "3" or below, while the remainder (3) ranked it a "6".

Again, the difficulty of the material does have some effect upon the lab interface, and vice versa. Both SAS students ranked the material's difficulty as an "8" [Fig. 30], while of the web students, 6 of the 13 students placed it at a "7" or above [Fig. 36]. Surprisingly, a large portion – 4 - ranked it at "5" or below. The material is challenging, but students felt that the web interface aided them in digesting it. The students who chose SAS for this lab did it knowingly, and they *still* found the material challenging, while those who used the web version found the material less difficult than they otherwise would have.

Lab 5.3 did indeed meet its goals. Not only was the students' comprehension rating of the material drastically improved after working through the lab, but the students who were having the most trouble with the content received enough help from the lab to push the lowest material comprehension rating over the "5" marking. Furthermore, the interface comprehension ranking was very high, with only 1 of the responses ranking it below a "6". This was further corroborated by the high ease of use rating that the interface received.

While there were some students who found web-based lab 5.3 difficult, it aided even these students in learning the material. Had these students used SAS for the lab, we believe that the students would have gotten far less out of the lab than they did.

## Chapter VI: Conclusions and Recommendations

SAS is not an especially well-liked tool among statistics students. While it is powerful and customizable, the interface is often difficult for the average student to get used to; many students are used to the refined interface design of Microsoft Windows applications and, though SAS does resemble a Windows application, it has some confusing quirks and features that can baffle the average student. Even relatively minor things, such as the look or feel of window, menu, or selection box can cause a user to feel lost, disoriented, and confused. Further, because of SAS' Unix X-Windows base, it is limited to the campus network or, at least, to those students who have access to an X-Terminal emulator from their home machines; even then, without a high-speed connection, the experience is slow, to say the least. It is because of these difficulties that these three web-based labs were conceived: transferring the labs to the web would solve the accessibility problem, and creating an improved interface would hopefully remove the students' focus from the interface and place it instead on the material being presented.

Though every attempt was made to simplify and streamline the interface, there is a difference between understanding how to do the lab and actually performing the operations. For instance, a user could

understand what it is they have to do within the lab – which operations to perform – but then find it difficult to carry these out because of the complexity of the interface. Because of this difference, students were asked how well they comprehended *how* to do the lab as well as how difficult they found the interface. Most importantly, however, was the students' general comprehension of the material presented by the labs; the labs could be the most graceful and easy-to-use programs, but if they did nothing to help the students learn the presented materials, they would be useless.

For our purposes in this lab, we used a scale of "1" to "10" to judge the results of students' surveys. A "1" was the lowest possible rating, while a "10" was the highest. Though ratings of an "10" would be ideal – except, of course, for the fourth and fifth questions, which asked the students to rate the difficulty of the interface and lab material; in that case, a "1" would be the best possible situation - realistically there is little chance of such a goal being achieved, especially on the first edition of these labs. Therefore, as a compromise, we used a rating of a "7" as a goal (except in questions 4 and 5, where instead the *ideal* goal was a rating of "3" or below). One of the most important qualifications to make in this analysis is the difference between a "true" measure of student comprehension of lab material or process and the ratings the students recorded. Short of

giving each student a test after the lab in order to gauge their true comprehension of the labs, materials, and information, it is difficult to get a "real" measure of a lab's score; instead, we only asked the students what they *perceived* these to be. There are several drawbacks to using this sort of system, the most important being that it is possible for the perceived ratings to be different from the actual quantity being asked about (this would be especially noticeable in the comprehension test, where a student's rating of the level of his comprehension is not the same as the true level of his comprehension). Nonetheless, testing the students in order to determine their true comprehension was outside the scope of this project; instead, we made do with their subjective ratings, which we believe (and hope) to be a valid measure of student perception.

**Lab Process**

In lab 4.5, many of the students using SAS stated that they understood how to do the lab. In fact, only 3 of 16 respondents rated their comprehension below a "7". However, when compared with the web lab, it is clear that SAS was seen as more confusing than the web version. All students rated their comprehension of the web version as a "7" or above and even then only 2 of 16 placed it at "7". This rating, however, is not too surprising; not only was the lab material itself fairly basic, but the web lab provides a rigid set of guidelines that,

when combined with the instructions, all but forces the students to step through the lab. Regardless, the web version solidly outperformed the SAS one in the survey.

The web version of lab 4.6, however, was not quite as successful. The SAS respondents rated their understanding remarkably high; 11 of 16 respondents placed it at a "7" level or greater, while only 2 rated it as a "5" or lower. The web lab, meanwhile, *did* have a higher percentage of students ranking it at the highest possible comprehension level – 3 for the web versus none for SAS – but fared less well in the low ends; 5 of the students placed their understanding at "5" or below (versus SAS' 2). The difference between the two is probably due to the level of refinement that the SAS lab offers that the web lacks. The SAS labs have been around for years and have been through numerous refinements intended to aid the students' comprehension, while this run was the first for the web. Although with additional refinements (see below: "Recommendations"), we believe that this lab's comprehension rating would improve significantly, we must admit that the SAS version "beat" the web one in this test.

The evaluation of Lab 5.3 was troubled primarily by one thing; the number of students who performed the lab with SAS was extremely low. In fact, there were only 2 respondents to the survey for the SAS lab, versus the 12 respondents for the web version, leaving

the results somewhat lopsided. Despite that dichotomy, the lab results of the web 5.3 lab show that the goals of the lab were indeed met. Further, we believe that were a true comparison possible, the web version would stand (at the very least) a good chance of proving superior in user comprehension of the lab process.

Lab 5.3 continued the trend of success on the part of the web labs. Of those students who used SAS, one rated their understanding of the lab process as a "6" and the other as a "7". On the web version, however, 7 of the 11 respondents ranked their comprehension level at a "7" or greater, and of the remainder, only 3 placed it below a "6". The lab does contain a lot of material and there are numerous steps to work through; it is unsurprising that some students would not understand the lab process as well as others. Nonetheless, the majority of students said that they comprehended it extremely well and the results we *did* receive combined with the SAS results from the other labs hint that had there been a fully populated SAS survey for comparison, the web lab would have proven easier to use and more helpful at helping the students believe they had learned the material.

**Lab Interface**

The three labs did accomplish the goal of making the interfaces more accessible, though with varying degrees of success. In lab 4.5,

for instance, the disparity between the SAS and web labs was not as high as hoped; 10 of the 18 respondents to the survey rated the difficulty of the SAS interface as a "5" or less, while 13 of 18 rated the web version the same way. While these statistics make it clear that the web version was perceived as easier to use, it had been hoped that the difference between the two versions would be greater. However, though disappointing, it is not altogether unexpected. Lab 4.5 was not an especially complicated lab, and the students were provided an instructional guide for both the web and SAS versions of the program, effectively walking them through the steps. Still, an increase in the perceived ease of use by the 25% shown here does qualify as a success.

Lab 4.6, meanwhile, achieved the desired goal of interface usability. Fewer than half the proportion of people who rated the SAS lab as a "7" level of difficulty did the same for the web version. Furthermore, the majority of students who used the web version placed the difficulty level below a "5". Although it would have been nice to been able to have *all* the students rate the level this low, when compared with the SAS lab's ratings it is clear that the web version presented the material in a manner the students considered much easier to use.

Even though there were only two responses to the SAS lab 5.3 survey, these provide a useful basis for comparison. Even those two students  who had willingly chosen to use SAS acknowledged the interface's complexity, rating it as an "8" on a difficulty scale. Of the web lab respondents only 4 of 12 respondents placed the difficulty level above a "7". 5 ranked the difficulty at "3" or below, and even the remainder of the students placed it at a "6". Though the goal was to increase the lab's understandability and ease of use for every student, the data fits with the assumptions made about the lab; it contains a lot of material and despite the fact that every effort was made to present it in a comprehensible and usable fashion, it is extraordinarily difficult to make it equally accessible for *everyone*. Despite the 4 of students who found the web interface somewhat difficult to use, both the remainder of the students who did not and the results of the other parts of the survey validate student opinion of the lab.

Ease of use does not override the importance of comprehension of the material itself. A program could be the most intuitive, easy to use application ever created, but if the user gets nothing from it but an appreciation for its interface design, the application is all but useless. At the same time, however, it is still important to give the users an interface they can understand and use without extensive training, especially in an application such as this, where the user is expected to

quickly gain his footing and proceed to study the material. Further, a clear interface can often aid the user's attempt to understand the material by removing his focus from the application's interface and allowing him to instead concentrate on the material itself. By examining the users' reactions to both the interface design and their perceived comprehension of the material, we hope to make a system that optimally balances the two factors.

**Material Comprehension**

The goal of most any project in the educational sphere is to aid students in digesting, processing, and understanding the material being presented. Obviously, these labs would serve little point if, though easy to use, they hindered the student's ability to learn the material. Although an understanding rating equal to that of the SAS labs would be acceptable, it was hoped that the web labs would surpass the SAS labs in improving the students' perceived comprehension. According to the students' ratings, these labs did indeed help them learn.

Lab 4.5 held up the belief that an easy to use interface gave the students' more of an ability to focus on the material itself. Of the students who participated in the SAS version, those who had rated their understanding of the material at a "7" or above before doing the

lab afterwards all increased their rating upwards. The problem, however, came with those students who had initially ranked their understanding below that level. These students felt they were only confused by the SAS lab and, afterwards, actually indicated that they understood the material *less* than they had initially. The web lab, meanwhile, aided all the students in believing they were learning the material; whereas prior to the lab 11 of the 17 respondents placed their understanding at "7" or above, afterwards there was only 1 who placed it *below* that level, and that had an understanding ranking of "6". In other words, student reports indicated that the web lab was superior to the SAS version at aiding their understanding of the material.

Lab 4.6 was partially successful, meanwhile. In the SAS version, there was a noticeable jump in the proportion of students who rated their understanding at "7" or above before and after – from 8 of 15 before to 12 after. Furthermore, only 1 respondent rated their understanding afterwards below a "6". Obviously the SAS lab is doing something right; it significantly aided the students' perceived comprehension of the material. The web lab, however, is slightly different. Prior to performing the lab, 14 of the 21 students rated their understanding of the material at a "7" or above, with most of the remainder (5) ranking it at the "4" or "5" level. Though afterwards the

upper comprehension levels did grow – the number of "10"s, for instance, quadrupled to 4 - below "6" the lab seemed to suffer the same fate as the SAS 4.5 one. Those students who felt most in need of help felt they were only confused more by the lab; in fact, whereas the lowest before rating level was "4" (3), afterwards it dropped to a "3" (3). Though disappointing, this drop is not altogether unexpected; as the labs progress, the material grows increasingly difficult, and those students whose grasp was already shaky were not helped by the web interface as much as was hoped. Despite this drawback, however, those students who believed they already had at least a basic grasp of the concepts being presented felt that the web lab noticeably aided them.

Finally, lab 5.3 proved to be a success in aiding the students' perceived comprehension. Prior to completing the lab, 7 of the 13 respondents rated their understanding at "7" or above, while 2 placed it at "4" or below. Afterwards, their rating level jumped significantly; gone were the "3"s and "4"s, and instead the lowest rating given was a "5". Furthermore, although the number of "10"s dropped (from 4 to 2), 8 of all the web respondents placed their understanding above a "7" level. This drop can possibly be attributed to the students' realization that there was more to the material than originally thought, making them revise their original belief that they knew much of the

lab's materials. Despite that, however, the overall comprehension rating of the lab material improved, even for those students who initially rated their understanding as fairly low – "5" or less. Though their perceived understanding may not be as great as other students, the lab *did* help them feel that they had gotten at least a basic grasp of it.

## Steps Taken to Address Problems

Though the survey included a section allowing the users to record their specific opinions about the survey and make recommendations, these recommendations were relatively useless. Many of the students commented on their inability to save or print the graphs that they generated using the web labs; this was a known bug that existed when that lab group had used the lab. We had been rushing to finish the program before that term's lab  and had postponed implementing these features until later. Another student commented that he had attempted to run the lab using Netscape version 4.0 and had to give up because of its complete illegibility. Again, this was a known issue; because of the age of the Netscape 4.0 rendering engine and the difficulty in coding for what would essentially be an entirely different, uncommon, and outdated platform, we had decided not to support it. Although at the time we neglected to

mention the inability to save and print and the incompatibilities with Netscape 4, this oversight as since been corrected. Another complaint was the size of the instruction window in the web application. Because we had attempted to fit everything onto one screen to reduce the amount of "window flipping" – that is, changing between windows in the application – we had placed the instructions inside a frame that was somewhat small. In response to this complaint, however, we have since allowed the user to open the instructions in an entirely new and larger window if they feel the need.

There was a more relevant problem, however, that we have taken steps to solve; several users complained about the somewhat confusing design of lab 4.6. This factor could have played a role in the lowered perceived comprehension ratings that lab 4.6 received. In an effort to address this problem and make the lab more usable, user-friendly, and helpful to the student learning the material, we have attempted to rework parts of the lab that we believe were confusing; the links to different sections of the lab were removed from the lower part of the screen and instead placed inside the instruction window, inline with the steps. Further, the windows themselves were enlarged to make use of the additional free space, allowing the user the ability to view more of the lab at once. Lastly, the variables in the steps were added to the instructions as images in order to reinforce the concepts.

We hope that our perspective as non-math majors has enabled us to accomplish our goal of simplifying and clarifying this material in lab 4.6.

**Recommendations**

Perhaps the thing these labs could benefit from most would be further refinement. Because of the limited number of real-world testers – the labs are only run once per term, and even then the students are grouped so that the feedback is reduced – the revision cycle was too long to allow more than one or two revisions of the material. There were several times that this lack of refinement became clear, especially in lab 4.6 where the students who least understood the material were most confused by the lab. With more revisions and a more conclusive test of the user's comprehension (i.e. finding their "true" comprehension rating versus their perceived rating), we could hope to reverse the deficiencies in 4.6 and bring it into line with the other labs. Further refinement would allow us to pinpoint these problems and alter the material to better aid those students most in need of it.

Further, it was difficult to get a truly accurate comparison between the two different lab types. Ideally, each student would use first one lab, then the other, and compare the two systems. However,

a number of things prevented such a test. First, the lab periods were simply not long enough to let every student perform both versions of every lab. Secondly, each class was split into groups that varied from week to week; although we had requested that each member of the group fill out a survey, oftentimes the groups simply returned one with all their names on it, making it difficult, if not impossible, to get an adequate measure of how each student perceived the lab. We would have liked to have had more definitive, conclusive, and objective tests of the factors we asked the students to rate.

We had originally hoped to be able to make a modular system that could be reconfigured to match the needs of the lab. In the system we had imagined, there would be a number of different modules that could be assembled together to produce a lab, regardless of the content. Realistically, however, this idea was unfeasible. Many of the labs have entirely different material, and even if every single piece of the lab was customizable, down to the functions being run, we would hit the problem of making it *too* open-ended., which would place a difficult learning curve before the users.. Furthermore, such a system would be functionally similar to any of the professional-grade statistics computer programs and obviously incredibly difficult and time-consuming to develop. Some attempts were made to allow this portability – for instance, the population file used in lab 5.3 can be

easily altered – but the original goal of complete modularity was discarded.

One of the things we would like to have implemented is a system that would automatically record and update the student responses in lab 5.3. We had originally intended – and the lab even states in the instructions – that the student responses will be filled in to generate a data set for the next class. However, because of the difficulty in validating the submissions and the confusion that bad data could cause, it was even decided to scrap this idea. Much of the code had already been implemented and was fully operational for this design. Sadly, it never came to fruition because of the difficulties in validating student submissions, yet it would be a welcome addition to the lab at a later point.

All in all, the lab itself could just use more polish and refinement. As we had progressed we had learned more and more about the type of coding involved; the code at the beginning of the project is markedly different – less polished and less elegant – than that at the end. Had we the time, it would be nice to be able to go back through and redo all the code with the new tricks and techniques we learned over the course of the project. However, this is more an aesthetic problem with code that the users will never actually see, and as such is relatively unimportant in the lab's functionality.

# Chapter VII: Bibliography

### Print references

- Denis Lander Ph.D. *Online Learning: Ways to Make Tasks Interactive*. RMIT, 1999.

- David G. Brown. *Interactive Learning: Vignettes from Americas's most Wired Campuses*. Anker Publishing Company, 2000.

- Andrew S. Gibbons & Peter G. Fairweather. *Computer-Based Instruction: Design and Development.* Educational Technology Publications, 1998.

- John Bourne. *Online Education.* Sloan Center for Online Education, 2001

- Ben Shneiderman. *Designing the User Interface: Strategies for Effective Human-Computer Interaction.* Addison-Wesley, 1998

- Alfred Bork. *Learning with Computers.* Digital Equipment Corporation, 1981

### Internet references

- http://www.statpages.net

- http://www.une.edu.au/WebStat/others/tutorials_online.htm

## Appendix A: Lab 4.5/4.6 Survey 1

Name: _____     Sex:   ○ Male    ○ Female

Major: _____     Class Year:   ○ 2003   ○ 2004   ○ 2005   ○ 2006

Lab: ○ 4.5    ○ 4.6     Lab Format:   ○ SAS    ○ Web

---

Rate how well you comprehended the material taught in the lab before you did it (10 is the "totally comprehend", 1 is the "clueless")

○ 1    ○ 2    ○ 3    ○ 4    ○ 5    ○ 6    ○ 7    ○ 8    ○ 9    ○ 10

---

Rate how well you comprehend the material taught in the lab now (10 is the "totally comprehend", 1 is the "clueless")

○ 1    ○ 2    ○ 3    ○ 4    ○ 5    ○ 6    ○ 7    ○ 8    ○ 9    ○ 10

---

Rate your comprehension of the lab process (i.e. how well you understood how to do the lab - 10 is the "total comprehension", 1 is "clueless")

○ 1    ○ 2    ○ 3    ○ 4    ○ 5    ○ 6    ○ 7    ○ 8    ○ 9    ○ 10

---

How difficult to use was the lab interface (i.e. the program you used to run the lab - 10 is the most difficult, 1 is the easiest)?

○ 1    ○ 2    ○ 3    ○ 4    ○ 5    ○ 6    ○ 7    ○ 8    ○ 9    ○ 10

---

How difficult was the lab material (i.e. the concepts being taught - 10 is the most difficult, 1 is the easiest)

○ 1    ○ 2    ○ 3    ○ 4    ○ 5    ○ 6    ○ 7    ○ 8    ○ 9    ○ 10

---

Did you have any problems with the lab? If so, what were they?

What did you like about this lab interface?

[ text input box ]

What did you dislike about this lab interface?

[ text input box ]

What improvements could be made to the lab interface?

[ text input box ]

Realistically, do you think the option of being able to run this on any computer with Internet Explorer or Netscape is useful? Why or why not?

[ text input box ]

## Lab 4.5/4.6 Survey 2

Name: _____

Sex: ○ Male
○ Female

Major: _____

Class Year:
○ 2003
○ 2004
○ 2005
○ 2006

**Which version of 4.5 did you do:** ○ Web ○ SAS

| Question | Web | SAS | No Difference |
|---|---|---|---|
| Which interface was easier to use? | ○ | ○ | ○ |
| Which lab taught the material better? | ○ | ○ | ○ |
| Which lab satisfied the objectives better? | ○ | ○ | ○ |
| From which lab did you learn more? | ○ | ○ | ○ |
| Which lab focused your attention more on the statistical concepts involved? | ○ | ○ | ○ |
| Which lab do you feel is more useful? | ○ | ○ | ○ |
| If you were trying to help a friend learn the material, which lab would you advise they use? | ○ | ○ | ○ |

## Lab 5.3 Survey

Name:

Major:

Sex: ○ Male ○ Female

Class Year: ○ 2003 ○ 2004 ○ 2005 ○ 2006

**Lab Format:** ○ SAS   ○ Web

---

Rate how well you comprehended the material taught in the lab before you did it (10 is the "totally comprehend", 1 is the "clueless")

○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ 6   ○ 7   ○ 8   ○ 9   ○ 10

---

Rate how well you comprehend the material taught in the lab now (10 is the "totally comprehend", 1 is the "clueless")

○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ 6   ○ 7   ○ 8   ○ 9   ○ 10

---

Rate your comprehension of the lab process (i.e. how well you understood how to do the lab - 10 is the "total comprehension", 1 is "clueless")

○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ 6   ○ 7   ○ 8   ○ 9   ○ 10

---

How difficult to use was the lab interface (i.e. the program you used to run the lab - 10 is the most difficult, 1 is the easiest)?

○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ 6   ○ 7   ○ 8   ○ 9   ○ 10

---

How difficult was the lab material (i.e. the concepts being taught - 10 is the most difficult, 1 is the easiest)

○ 1   ○ 2   ○ 3   ○ 4   ○ 5   ○ 6   ○ 7   ○ 8   ○ 9   ○ 10

---

Did you have any problems with the lab? If so, what were they?

What did you like about this lab interface?

What did you dislike about this lab interface?

What improvements could be made to the lab interface?

Realistically, do you think the option of being able to run this on any computer with Internet Explorer or Netscape is useful? Why or why not?

## Appendix B: <u>**Technical Notes for labs 4.5 and 4.6**</u>

### General layout

There are three different general file types that compose the system for labs 4.5 and 4.6. The .cgi files are the perl scripts for the various graphs, images, and instructions. The .html files form the framework and control the general layout of the labs. The .dat files contain the instructions and database information used to create the graphs.

### File list and descriptions - Lab 4.5

| | |
|---|---|
| First.cgi | Displays the initial 'welcome' screen to the student based on the lab data file. |
| Gd_print1.cgi | The printing code for plain_histogram.cgi |
| Gd_print2.cgi | The printing code for plain_histogram2.cgi |
| Gd_print3.cgi | The printing code for plain_curves.cgi |
| Gd_print4.cgi | The printing code for samp_histogram.cgi |
| Gd_print5.cgi | The printing code for samp_histogram2.cgi |
| Instructions.cgi | Perl script that displays the instructions for the lab based on the lab datafile. |
| Plain_curves.cgi | Perl script that graphs curves and finds areas under them. |
| Plain_histogram.cgi | Perl script that graphs histograms of the household size dataset. |
| Plain_histogram2.cgi | Perl script that graphs histograms of the household income dataset. |
| Samp_histogram.cgi | Perl script that samples and creates histograms over the household size dataset. |
| Samp_histogram_p.cgi | Alternative printing code for samp_histogram.cgi that produces html page output instead of the image output used in the final version of the labs. |
| Samp_histogram2.cgi | Perl script that samples and creates histograms over the income dataset. |
| Samp_histogram2_p.cgi | Alternative printing code for samp_histogram2.cgi that produces html page output instead of the image output used in the final version of the labs. |
| Test.cgi | Small example showing how to output an image as it used for making the printable graphs. |
| Data.dat | Data file containing the household size data. Data is stored in the format of one record per line. |
| Data2.dat | Data file containing the household income data. Data is stored in the format of one record per line. |
| Lab45.dat | Data file containing the lab instructions and objectives. Data is stores as html formatted text with "eoo" placed between each step. |

| Background.gif | Image file used as the background of some pages. |
|---|---|
| Bar.gif | Dark blue image used in the creation of the graphs. |
| Bar2.gif | Light blue image used in the creation of the graphs. |
| Bar3.gif | Red image used in the creation of the graphs |
| Spacer.gif | Transparent gif image used to separate other images on the screen. |
| Curve.html | Html file containing the form prompting the user for the information used by curve.cgi |
| Histogram.html | Html file containing the form prompting the user for the information used by plain_histogram.cgi |
| Histogram2.html | Html file containing the form prompting the user for the information used by plain_histogram2.cgi |
| Index.html | Html file that sets up the overall layout of frames used by the labs and launches the initial perl scripts. |
| Lab45more1.html | Additional lab instructions that are opened in the main view frame when the student click the link from the instructions. |
| Lab45more2.html | Additional lab instructions that are opened in the main view frame when the student click the link from the instructions. |
| Samp1.html | Html file containing the form prompting the user for the information used by samp_histogram.cgi |
| Samp2.html | Html file containing the form prompting the user for the information used by samp_histogram2.cgi |
| Overlib.js | Library used to implement the mouseover information provided by some of the graphs. |
| Overlib_mini.js | Library used to implement the mouseover information provided by some of the graphs. |
| Gd.pm | Perl module that implements the image outputting used to create print/saveable graphs. |
| Gd.xs | Perl module that implements the image outputting used to create print/saveable graphs. |
| | |

### File list and descriptions - Lab 4.6

| First.cgi | Displays the initial 'welcome' screen to the student based on the lab data file. |
|---|---|
| Gd_print2.cgi | The printing code for plain_histogram2.cgi |
| Gd_print3.cgi | The printing code for plain_curves.cgi |
| Gd_print5.cgi | The printing code for samp_histogram2.cgi |
| Instructions.cgi | Perl script that displays the instructions for the lab based on the lab datafile. |
| Norm_histogram.cgi | Perl script for graphing histograms with normal distribution curves superimposed. |

| | |
|---|---|
| Nqp.cgi | Perl script for producting normal quantile plots |
| Plain_curves.cgi | Perl script that graphs curves and finds areas under them. |
| Plain_histogram2.cgi | Perl script that graphs histograms of the household income dataset. |
| Samp_histogram2.cgi | Perl script that samples and creates histograms over the household size dataset. |
| Samp_histogram2_p.cgi | Alternative printing code for samp_histogram.cgi that produces html page output instead of the image output used in the final version of the labs. |
| Submit.cgi | Perl script that handles class data being submitted to save in a datafile. |
| Data2.dat | Data file containing the household income data. Data is stored in the format of one record per line. |
| i.dat | Datafile used during testing of perl scripts, but not currently used in the labs. |
| Lab46.dat | Data file containing the lab instructions and objectives. Data is stores as html formatted text with "eoo" placed between each step. |
| P10.dat | Data file containing means of sample size 10. |
| P5.dat | Data file containing means of sample size 5. |
| P50.dat | Data file containing means of sample size 50. |
| Background.gif | Image file used as the background of some pages. |
| Bar.gif | Dark blue image used in the creation of the graphs. |
| Bar2.gif | Light blue image used in the creation of the graphs. |
| Bar3.gif | Red image used in the creation of the graphs |
| Spacer.gif | Transparent gif image used to separate other images on the screen. |
| Curve.html | Html file containing the form prompting the user for the information used by curve.cgi |
| Histogram2.html | Html file containing the form prompting the user for the information used by plain_histogram2.cgi |
| Index.html | Html file that sets up the overall layout of frames used by the labs and launches the initial perl scripts. |
| Lab46more1.html | Additional lab instructions that are opened in the main view frame when the student click the link from the instructions. |
| Lab46more2.html | Additional lab instructions that are opened in the main view frame when the student click the link from the instructions. |
| Previous1.html | Html file containing the form promting the user for the information used by norm_histogram.cgi |
| Previous2.html | Html file containing the form promting the user for the information used by norm_histogram.cgi |
| Previous3.html | Html file containing the form promting the user for the information used by norm_histogram.cgi |

| Previous4.html | Html file containing the form promting the user for the information used by norm_histogram.cgi |
| --- | --- |
| Samp2.html | Html file containing the form prompting the user for the information used by samp_histogram2.cgi |
| Submit.html | Html file containing the form prompting the user for the information used by submit.cgi |
| Overlib.js | Library used to implement the mouseover information provided by some of the graphs. |
| Overlib_mini.js | Library used to implement the mouseover information provided by some of the graphs. |
| Img1.png | Image used in the additional information pages for non-ascii characters. |
| Img2.png | Image used in the additional information pages for non-ascii characters. |
| Img3.png | Image used in the additional information pages for non-ascii characters. |
| Img4.png | Image used in the additional information pages for non-ascii characters. |
| Img5.png | Image used in the additional information pages for non-ascii characters. |
| Img6.png | Image used in the additional information pages for non-ascii characters. |
| Img7.png | Image used in the additional information pages for non-ascii characters. |
| Img8.png | Image used in the additional information pages for non-ascii characters. |
| Class_data.txt | File where submitted class data is saved. |
|  |  |

**Additional file format information**
- Data files for income and household size: data is stored in a flat text file with one record per line.
- Lab instruction files: Data files are at their core a text file containing the instructions with "eoo" places between steps and at the end of the objectives. As this text is placed straight into the instruction frame in the browser, html tags will be displayed as well.

# <u>Appendix C:</u> **Technical Notes for lab 5.3**

## **General layout**

There are three different general file types that compose the system for labs 5.3. The .cgi files are the Perl scripts for the various graphs, images, and instructions. The .html files form the framework and control the general layout of the labs. The .dat files contain the instructions and database information used to create the graphs. The .gif files are the images used in the lab.

### **File list and descriptions – Lab 5.3**

| | |
|---|---|
| 53instruct.html | The instructions for the lab |
| bar – bar10.gif | Images used for the bars in the various charts |
| browser.cgi | Detects which browser being used – IE or Netscape compatible – and redirects to appropriate lab file |
| confgraph-ie.cgi | Contains the bulk of the lab. Tells how to set up the lab inside the main form, displays graphs, receives input from user, etc. Internet Explorer version. |
| confgraph-n6.cgi | Contains the bulk of the lab. Tells how to set up the lab inside the main form, displays graphs, receives input from user, etc. Netscape version. |
| conf-info.html | The popup window displayed when the user requests more information on computing the confidence interval. |
| conf-info-1.jpg | The formula used in the conf-info.html file |
| datasubmit.cgi | Handles the submission of user data |
| GD.pm | Part of the system used to generate images of the graphs |
| GD.xs | Part of the system used to generate images of the graphs |
| gd_example.cgi | Handles the creation of images of the graphs |
| graph.css | Stylesheet for parts of the lab shown within the main frame |
| img1-27.png | Images of formulas, equations, and special characters - used in the instructions |
| index.html | Default file. Redirects to browser.cgi. |
| index-ie.html | Initial page viewed by lab users. Receives user's name and begins lab. Internet Explorer version. |
| index-n6.html | Initial page viewed by lab users. Receives user's name and begins lab. Netscape version. |
| lab5_3.dat | Data filed used to create graphs |
| lab53.css | Primary stylesheet used in lab |
| lab53-ie.cgi | Contains layout and controls for the lab. Creates the 3 frames: one for instructions, one for controls, one for main graph display. Internet Explorer version. |

| | |
|---|---|
| lab53-n6.cgi | Contains layout and controls for the lab. Creates the 3 frames: one for instructions, one for controls, one for main graph display. Netscape version. |
| pred-info.html | The popup window displayed when the user requests more information on computing the prediction interval. |
| subconfidence.dat | Contains data submitted by user about the confidence interval they computed. |
| subprediction.dat | Contains data submitted by user about the prediction interval they computed. |
| subtolerance.dat | Contains data submitted by user about the tolerance interval they computed. |
| tdist.html | Popup window displayed when user requests the values of the t distribution |
| tolcalculate.cgi | Script that runs and calculates the tolerance interval with the user specified parameters |
| tol-info.html | The popup window displayed when the user requests more information on computing the tolerance interval. |
| tol-info2.html | Second file displayed when the user requests information on computing the tolerance interval. |
| tolvalues.html | Table of constants for normal-theory tolerance intervals. |

**Additional file format information**

- Data files: data is stored in a flat text file with one record per line. Tabs separate different fields.
- Lab instruction files: These files are simple HTML files. Basic HTML rules apply.

## <u>Appendix D</u>: **Pitfalls and Advice**

- Unfortunately there isn't a general rule of thumb that can be used to handle the differences between Internet Explorer and Netscape Navigator. Generally speaking however, Netscape Navigator is much weaker when it comes to handling cases in a html file where there are any slight deviations from the standard format. IE is fairly robust in that you can make a lot of errors, or format your html in ways that are technically incorrect, and it will still display it correctly. One tip that we can pass along is that Netscape will often require methods and properties that IE can apply to any object be applied to a link. For example, our labs used mouse-over code to display messages when the mouse cursor was over a particular object on the page. IE was able to display the code when the mouse was placed over an image, Netscape Navigator was not. To solve the problem we enclosed the image in a link, allowing Netscape Navigator to apply the method, and then used javascript to disable the link functionality.
- When designing the labs the focus should be on the final result that is presented to the students. If the group focuses on this too much they may overlook the most time-effective method for implementing a given problem. An example of this is when we designed the labs then went back and implemented saving and printing in a different manner after we found out that our original implementation would not work. The method we came up with for implementing the printing and saving would have made the overall system much easier to use had we realized it at the beginning. Although there is no guaranteed way to know the most efficient way to solve a problem immediately, perhaps more effort in this direction would have saved some time.
- One positive tip we have is that saving and printing an image was much more straightforward using perl than using javascript. Although our original idea turned out to not be the best approach due to the complexity of the graphs formed solely out of html, the final approach, using image files, did not have any security issues. Previous IQP groups who had developed their graphs using javascript had considerable difficulty allowing the user to save and print the graphs because browsers are naturally untrusting of arbitrary javascript code they are executing. As our perl approach produced flat image files, which were passed to the browser, there aren't any issues where the browser will not let the user save or print the images.
- Initially we had planned to implement an automatic way for student-submitted data to be automatically used in the generation of graphs. However, we decided against this due to the difficulty of

ensuring the submitted data was valid. Still, much of the code necessary to make the changes is included in the file (confgraph-ie and n6.cgi) and are simply commented out. Though it is not complete, it is a good start for any future work