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**THE EFFECTIVENESS OF INTERNET SUPPORT TO INCREASE STUDENT'S
GRADES IN AN INTRODUCTORY HUMAN ANATOMY AND PHYSIOLOGY
LABORATORY**

A STUDY PRESENTED TO THE GRADUATE FACULTY OF THE
DEPARTMENT OF OCCUPATIONAL AND TECHNICAL STUDIES
OLD DOMINION UNIVERSITY

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE
MASTER OF SCIENCE IN OCCUPATIONAL AND TECHNICAL STUDIES

BY
SHAWNGELA F. PIERCE

AUGUST 2003

APPROVAL PAGE

This project was prepared by Shawngela F. Pierce under the direction of Dr. John Ritz in OTED 636, Problems in Occupational and Technical Studies. It was submitted to the Graduate Program Director as partial fulfillment of the requirements for the Degree of Master of Science in Occupational and Technical Studies.

APPROVAL BY:  _____
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DATE: 8-5-03

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CHAPTER I

INTRODUCTION

Since its inception in 1992 the World Wide Web (WWW) has become a repository of an abundant array of information on a myriad of subjects (Lovell, 2000). This has created many opportunities for teachers to use this new medium in the pursuit of educating students. This can be accomplished in several ways, such as designing a website. Within this category the instructor can choose to utilize the website in different manners. The website can be used to provide links to information on the web to enhance student's comprehension of the class material. This can allow the instructor to address the multiple learning styles of students. The website can also be used as a supplemental tool to enhance the teaching of a course, presenting study guides, quizzes and/or tutorials for the students to have at their disposal.

Despite the views of many educators that the Internet is the best-available tool to enhance instructional methods (Rice, 1998), it is important to determine its true effectiveness. The research conducted in this study focuses on using a website as an instructional tool. The study compares one laboratory course taught without using the website and one taught with the website.

STATEMENT OF THE PROBLEM

The purpose of this study was to determine the effect of using the Internet on grades of students in an introductory human anatomy and physiology laboratory course at Tidewater Community College.

RESEARCH GOALS

The following hypothesis was used in this study:

H₁: The use of the Internet will increase the grades of students in an introductory human anatomy and physiology laboratory course.

BACKGROUND AND SIGNFICANCE

Anatomy and Physiology II was the second of a two-semester course taught by the Biology Department at Tidewater Community College in Norfolk, Virginia. The course consisted of a lecture and a laboratory section. The Fall 2002 laboratory was taught using anatomical models, human cadavers and lectures. The Spring 2003 laboratory was taught using the website in addition to the anatomical models, human cadavers and lectures.

The website was an aid to the laboratory so students had to take the initiative to access the site. Therefore, students were encouraged to become active learners. Students perform better when they are placed in an active role as opposed to a passive role.

The website contained information, such as pictures from the human cadavers and models. This would also seem to benefit the students because these were the cadavers and models actually used on the tests as opposed to the anatomical atlases that had more information than the students had to learn and better dissected cadavers.

Despite the assumption that students using the Internet will benefit, there is a lack of information concerning its use in an anatomy and physiology laboratory. There are numerous resources on the use of the Internet in a biology lecture

(Lovell, 2000; King et al, 2001) but limited information regarding the laboratory.

This study will address this gap in information.

LIMITATIONS

There are several limitations to this study:

- The researcher taught the two classes.
- The researcher maintained the website.
- This research studied only one laboratory course, Anatomy and Physiology.
- This was the first year the instructor taught an Anatomy and Physiology laboratory.
- Only two courses were compared, one from the Fall 2002 semester and one from the Spring 2003 semester.
- This study did not measure possible differing characteristics of the students.
- The Anatomy and Physiology laboratory was an evening course.

ASSUMPTIONS

The following assumptions were made in this study:

- All students downloaded anatomy pictures and other information from the website.
- All students in the experimental group knew how to use the Internet and had access, either at home, library or work.

- The educational backgrounds of the students were diverse.
- A variety of anatomical atlases were used by the control and experimental group.

PROCEDURES

This study was conducted at Tidewater Community College in Norfolk, Virginia. The researcher instructed both laboratories, Fall 2002 and Spring 2003. All of the students received the same instruction, assignments and tests. The control group, Fall 2002, did not have access to the website to assist in instruction. The experimental group, Spring 2003, had access to a website created by the researcher. The website contained the course and laboratory syllabi, a semester calendar, student grades, class updates and the instructor's email address. The website also contained the following information that could be downloaded by the students: pictures of anatomical models, pictures of human cadavers used in the lab, study guides and practice quizzes. The students were encouraged to use the website throughout the semester.

Students in the laboratory received six grades. The grades were from quizzes, two dissection tests, a blood tracing test, a presentation/paper and dissection/peer teaching. The final and individual grade averages from the three tests from the experimental group were compared to students from the control group. The data were collected from approximately 16 students in each group.

DEFINITION OF TERMS

The following terms were defined to assist the reader in reviewing the report.

Email (electronic mail) – a feature that lets a computer user send a message to someone at another computer or terminal (American Heritage Dictionary, 1998, p. 87).

Human Anatomy – the study of the structure of the human body and the relationship to its function.

Human Physiology – the investigation of the processes or functions of the human body.

Internet – a matrix of networks that interconnects millions of supercomputers, mainframes, workstations, personal computers, laptops and even pocket radios (American Heritage Dictionary, 1998, p. 140).

World Wide Web (WWW) – an Internet information server that uses hypertext as its primary navigation tool (American Heritage Dictionary, 1998, p. 297).

OVERVIEW OF CHAPTERS

Chapter I is an introduction to the problem, which is whether or not the use of the Internet will effect the grades of students in an introductory human anatomy and physiology class. Lack of research in using the Internet for a laboratory has warranted the need for this study. In addition to the introduction, Chapter I presented the researcher's hypothesis, the background and significance of the study, the assumptions used and the limitations of the project.

Chapter I also defined specific terms used in the report and presented a brief outline of the procedures.

The remaining chapters will review the literature related to this study, document the methods and procedures used, as well as present the findings. The end of the report will summarize the entire research project and make conclusions and recommendations for future research studies.

CHAPTER II

REVIEW OF LITERATURE

This chapter will outline the current literature on the use of the Internet to improve science education. Specifically the literature will focus on using the Internet as a resource to enhance the learning environment, the effect of using the Internet on student learning and examples of teachers using web pages as an enhancement to classroom instruction.

INTERNET USE AS A SUPPLEMENTAL TOOL

The Internet has several advantages over traditional teaching resources for enhancing education. One of which is that the Web allows the user to control the pace and order that the content is presented. This creates a learning environment tailored to the students' needs. Another advantage of the Internet is the abundance of free educational content, including online news stories, interactive resources, library information and virtual museums. This creates a great opportunity to expand student access to educational material not presented in their textbooks (Carpi, 2001). In fact, many textbook publishers now have Web sites that supplement their books. These websites feature chapter highlights, additional study questions and answers, video presentations and links to other relevant areas (Lovell, 2000). The Internet is also a source for the most up-to-date information. Some information in textbooks is usually out-of-date by the time it is published.

As a communication tool with students, the Internet is very beneficial. Using the Internet as a communication tool, i.e., email, allows students to have around-the-

clock availability to instructors (McDonald, 2001). Students do not have to worry about trying to find an instructor or wait for the traditional office hours; they can just email the instructor and wait for a response.

Correspondence through email may also reduce the anxiety felt by some students who may be shy and may feel intimidated by confronting the instructor (Lovell, 2000). The relatively anonymous nature of email can reduce this tension and still allow the student to actively engage in classroom activities. In fact, in one science class, an additional 5% of students contacted the instructor via email, while the office-hour meetings before and after the website remained relatively constant at about 18% (Capri, 2001).

EFFECT OF INTERNET USE ON STUDENT LEARNING

Internet use can have a very positive effect on student learning. In one science class the average scores on two of three exams were significantly higher than in the one semester prior to the launch of the course website (Carpi, 2001). The scores on exams 1 and 3 were 8 and 11 points higher. The overall course performance also improved after the launch of the website. Eighty-two percent of students in Fall 1998 and seventy-four percent in Spring 1999 received a letter grade of C or better. This is in comparison to only sixty-eight percent in Fall 1997 before the website was introduced. Course failures also decreased from 8.5% prior to the website and 4.2% and 5% in the two semesters following site launch. In another introductory biology course, it was found that the website had a highly positive effect on student learning and development of problem-solving skills and critical-thinking skills (Sanders & Morrison-Shetlar, 2001).

In addition to the increased test results, student attitudes about incorporating web components into the classroom are generally positive. Seventy-five percent of students who used the class website in one science class stated that the Web site was more helpful than the required textbook (Carpi, 2001). These same students felt that using the website had improved their grades in the class.

EXAMPLES OF INTERNET USE

There are many excellent examples of using the Internet as a resource. For instance, one instructor in an introductory Anatomy and Physiology course used the Internet to study the Human Genome Project, view chromosome maps, study recently cloned genes and learn about diseases associated with specific genes (Palladino, 2002). Students in this class chose a chromosome or gene of interest in the beginning of the semester and had to continually monitor information about “their” chromosome or gene. At the end of the semester the students wrote an abstract about what they learned and presented it to the class.

Another instructor used the Internet while studying HIV. During class an educational video was shown describing the HIV infectious process. The video showed the virus infecting the cell, which gave a dramatic visual presentation of the process (Francis, 2000). Another website used by an instructor included animations that helped students to understand dynamic scientific concepts such as electron orbital theory, chemical bonding and protein synthesis. This site also contained interactive exercises to allow students to learn by doing. The instructor also provided external links for students. The external links served two

purposes. One was to provide students struggling with the needed material background information on the subject. The other was to provide advanced readings to students who were particularly interested in the subject (Carpi, 2001).

SUMMARY

The Review of Literature, Chapter II, examined Internet use as a supplemental tool and the effects of the Internet on student learning. This chapter also listed examples of science educators using the Internet in the classroom. Chapter III will address the methods and procedures used to collect data for this research study.

CHAPTER III

METHODS AND PROCEDURES

This chapter describes the research methods and statistical procedures used to collect and analyze the data from a Human Anatomy and Physiology laboratory course at Tidewater Community College in Norfolk, Virginia. A quasi-experimental study was conducted to gather information from student grades from two sections of a course for the 2002-2003 school year. Sections on population, instrument use, classroom procedures, methods of data collection, statistical analysis and a summary are included in this chapter.

POPULATION

The population used in this study consisted of two sections of an undergraduate Anatomy and Physiology laboratory course at Tidewater Community College for the Fall 2002 through Spring 2003 school year. The control group consisted of 15 students that enrolled in the Fall 2002 semester and the experimental group consisted of 19 students that enrolled in the Spring 2003 semester. The experimental group had access to course web pages designed by the instructor.

INSTRUMENT USE

The instrument used to measure student learning were grades from the two dissection tests, the blood tracing test and the final grade averages. In both classes the students were subjected to the same questions, grading scale, assignments and expectations. The instructor created the blood-tracing test and was involved with another instructor in the creation of the dissection tests. The

instructor administered all tests. The instruments were designed to measure the students' knowledge and understanding of the subject matter.

CLASSROOM PROCEDURES

The classes at Tidewater Community College were taught at the Norfolk Campus in the Andrews Building. The instructor used classroom lecture, discussion, cadaver and model identification, and individual and group activities throughout the course. Each student was required to complete nine quizzes, two dissection tests, a blood tracing test, a presentation/paper and dissection/peer teaching project. The students used anatomical atlases recommended in the syllabus to assist with studying for the course.

Each group had the same instructor and had the same assignments and tests. Even though all of the students did not use the same anatomical atlases, the same two or three atlases were used by all of the students. The experimental group had access to web pages designed by the instructor that consisted of downloadable study guides, pictures of anatomical models, pictures of the human cadavers used in the lab and practice quizzes. The website also contained an e-mail link to the instructor, student grades, class updates and the laboratory syllabi.

METHODS OF DATA COLLECTION

Students' scores throughout the semester for the 2002 – 2003 school year were recorded for the data in this study. The three tests were given throughout the semester, one in the beginning and two at the end. The students were divided into teams (groups) and each team dissected twice during the semester.

The students also presented their individual papers as a team. All of the scores were averaged into a final number that was applied to the students' lecture grade.

STATISTICAL ANALYSIS

The collected data were entered into a Microsoft Excel worksheet where a record for each group was established. The records were analyzed using the statistical t-test for student learning. The sample means of each test and the total scores were calculated for each group. The sample means of the experimental and control group values of a t-test (one-tailed) were used to determine the significant difference between the two instructional groups.

SUMMARY

The research methods and statistical procedures described in Chapter III included population, instrument design and methods of data collection. The three tests and the final grade averages were the instruments used in this study. Statistical data obtained from each research instrument will be analyzed. Then the findings of each research instrument will be compared to provide the necessary data to address the research goals of the problem statement. The results of the statistical analysis will be discussed and compared in Chapter IV.

CHAPTER IV

FINDINGS

The purpose of this study was to determine the effect of using the Internet on grades of students in an introductory human anatomy and physiology laboratory course at Tidewater Community College. This chapter is a presentation of the findings determined through the research. An explanation of the methodology used to calculate the research findings is also presented.

ANALYSIS OF DATA

The findings were based on data collected from 33 students. Fifteen students from the Fall semester, the control group, and eighteen from the Spring semester, the experimental group. The average grade for the blood tracing test for the control group (M_1) and the experimental group (M_2) was 35.2000 and 40.4583 respectively (Appendix A). The t-ratio was calculated to be -1.3693 (Table 1).

The 1st practical average grade for the control group was 48.8833. The average for the experimental group was 59.6111 (Appendix B). The t-ratio was calculated to be -1.9759 (Table 1).

The average grade for the 2nd practical for the control group was 58.0000 and the experimental group was 58.4167 (Appendix C). A t-ratio of $-.07777$ (Table 1) was calculated based on the data.

The final grades average for the control group and the experimental group were 68.0444 and 67.5498 respectively (Appendix D) with a t-ratio of $.1030$

(Table 1). The degree of freedom for the study ($N_1 + N_2 - 2$) was 31 and the level of significance at .05 for a one-tailed test was 1.697.

Table 1 Averages and t-Ratios

| | Control Group | Experimental Group | t-Ratio |
|---------------------------|----------------------|---------------------------|----------------|
| | M₁ | M₂ | |
| Blood Tracing Test | 35.2000 | 40.4583 | -1.3693 |
| Practical I | 48.8833 | 59.6111 | -1.9759 |
| Practical II | 58.0000 | 58.4167 | -.07777 |
| Final Grades | 68.0444 | 67.5498 | .1030 |

SUMMARY

Chapter IV documented the findings for the study. The findings were based on a study of the grades from three tests and a final grade of 33 students. A t-test was calculated and determined for the three tests and the final grade. Chapter V will include the summary, conclusions and recommendations of this study.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter summarizes the study. It also draws conclusions based on the findings and makes recommendations.

SUMMARY

The research conducted in this study focused on using a website as an instructional tool. It then compared one laboratory course taught without using the website and one taught with the website. The comparison was made to determine if the web support increased student performance.

The quasi-experimental study was conducted at Tidewater Community College in Norfolk, Virginia, in the Fall 2002 and Spring 2003 sessions. All of the students received the same instruction, assignments and tests. The control group, Fall 2002, did not have access to the website to assist in instruction. The experimental group, Spring 2003, had access to a website created by the researcher. The website contained the course and laboratory syllabi, a semester calendar, student grades, class updates and the instructor's email address. The website also contained the following information that could be downloaded by the students: pictures of anatomical models, pictures of human cadavers used in the lab, study guides and practice quizzes. Throughout the semester the students were encouraged to use the website.

Fifteen students from the control group and eighteen students from the experimental group participated in the study. The data were collected from the final and individual grade averages from three tests of each group. The results

were then compared to each other. A t-test ratio was calculated and the level of significance for a one-tailed test was compared at the .05 level of significance.

CONCLUSIONS

The following hypothesis was used in this study: H_1 : The use of the Internet will increase the grades of students in an introductory human anatomy and physiology laboratory course.

The t-ratio result for practical 1 was 1.9759 and it did exceed the .05 level of 1.697 on the table of critical values for a degree of freedom of 31. The t-ratio for practical 2 and blood tracing were .07777 and 1.3693 respectively. These values did not exceed the .05 level of confidence. The t-ratio for the final average, which represents all of the tests, was .1030 and did not exceed the .05 level of confidence. Based on the results of three of the four averages, the researcher must reject the hypothesis. Therefore, it can be concluded that students who had access to the Internet did not have significantly higher grades than students who did not have access.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are made:

1. This study was conducted with 33 students. Future studies should incorporate a larger population including first semester human anatomy and physiology students.
2. Future studies should determine how much the students used the Internet and for what purpose related to the tested studies.

3. A follow-up study should be conducted to evaluate attitudes and opinions of the students that are enrolled in classes with Internet support.

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APPENDICES

APPENDIX A Blood Tracing Grades

APPENDIX B Practical 1 Grades

APPENDIX C Practical 2 Grades

APPENDIX D Final Grades

APPENDIX E t-Ratio Calculations

APPENDIX F Critical Values of t

APPENDIX A

BLOOD TRACING GRADES

| Fall Semester Control Group | | | Spring Semester Experimental Group | | |
|-----------------------------|----------------|------------------|------------------------------------|--------|------------------|
| Blood Tracing | d | d ² | Blood Tracing | d | d ² |
| 32.0000 | 3.20 | 10.2400 | 56.0000 | 15.54 | 241.5434 |
| 31.5000 | 3.70 | 13.6900 | 55.5000 | 15.04 | 226.2517 |
| 33.0000 | 2.20 | 4.8400 | 47.0000 | 6.54 | 42.7934 |
| 43.0000 | -7.80 | 60.8400 | 25.0000 | -15.46 | 238.9601 |
| 28.0000 | 7.20 | 51.8400 | 49.5000 | 9.04 | 81.7517 |
| 49.0000 | -13.80 | 190.4400 | 34.0000 | -6.46 | 41.7101 |
| 25.0000 | 10.20 | 104.0400 | 57.0000 | 16.54 | 273.6267 |
| 35.0000 | 0.20 | 0.0400 | 44.5000 | 4.04 | 16.3351 |
| 56.5000 | -21.30 | 453.6900 | 39.5000 | -0.96 | 0.9184 |
| 31.0000 | 4.20 | 17.6400 | 37.5000 | -2.96 | 8.7517 |
| 21.5000 | 13.70 | 187.6900 | 43.5000 | 3.04 | 9.2517 |
| 47.0000 | -11.80 | 139.2400 | 47.0000 | 6.54 | 42.7934 |
| 38.5000 | -3.30 | 10.8900 | 26.2500 | -14.21 | 201.8767 |
| 35.5000 | -0.30 | 0.0900 | 21.0000 | -19.46 | 378.6267 |
| 21.5000 | 13.70 | 187.6900 | 38.5000 | -1.96 | 3.8351 |
| | | | 19.5000 | -20.96 | 439.2517 |
| | | | 48.0000 | 7.54 | 56.8767 |
| | | | 39.0000 | -1.46 | 2.1267 |
| Average | 35.2000 | | 40.4583 | | |
| Sum | | 1432.9000 | | | 2307.2813 |
| Number | 15.0000 | | 18.0000 | | |

APPENDIX B

PRACTICAL 1 GRADES

| Fall Semester Control Group | | | Spring Semester Experimental Group | | |
|-----------------------------|----------------|------------------|------------------------------------|----------|------------------|
| Practical 1 | d | d ² | Practical 1 | d | d ² |
| 62.5000 | 13.6167 | 185.4136 | 78.5000 | 18.8889 | 356.7901 |
| 51.2500 | 2.3667 | 5.6011 | 80.5000 | 20.8889 | 436.3457 |
| 56.5000 | 7.6167 | 58.0136 | 59.5000 | -0.1111 | 0.0123 |
| 37.0000 | -11.8833 | 141.2136 | 43.0000 | -16.6111 | 275.9290 |
| 39.2500 | -9.6333 | 92.8011 | 87.0000 | 27.3889 | 750.1512 |
| 61.7500 | 12.8667 | 165.5511 | 50.5000 | -9.1111 | 83.0123 |
| 39.2500 | -9.6333 | 92.8011 | 84.5000 | 24.8889 | 619.4568 |
| 52.7500 | 3.8667 | 14.9511 | 66.0000 | 6.3889 | 40.8179 |
| 58.0000 | 9.1167 | 83.1136 | 67.0000 | 7.3889 | 54.5957 |
| 56.5000 | 7.6167 | 58.0136 | 46.5000 | -13.1111 | 171.9012 |
| 39.2500 | -9.6333 | 92.8011 | 46.0000 | -13.6111 | 185.2623 |
| 68.5000 | 19.6167 | 384.8136 | 62.5000 | 2.8889 | 8.3457 |
| 41.5000 | -7.3833 | 54.5136 | 43.5000 | -16.1111 | 259.5679 |
| 27.0000 | -21.8833 | 478.8803 | 18.5000 | -41.1111 | 1690.1235 |
| 42.2500 | -6.6333 | 44.0011 | 64.0000 | 4.3889 | 19.2623 |
| | | | 54.5000 | -5.1111 | 26.1235 |
| | | | 77.0000 | 17.3889 | 302.3735 |
| | | | 44.0000 | -15.6111 | 243.7068 |
| Average | 48.8833 | | 59.6111 | | |
| Sum | | 1952.4833 | | | 5523.7778 |
| Number | 15.0000 | | 18.0000 | | |

APPENDIX C

PRACTICAL 2 GRADES

| Fall Semester Control Group | | | Spring Semester Experimental Group | | |
|-----------------------------|----------------|-----------------|------------------------------------|----------|------------------|
| Practical 2 | d | d ² | Practical 2 | d | d ² |
| 67.0000 | 9.0000 | 81 | 76.5000 | 18.0833 | 327.0069 |
| 51.0000 | -7.0000 | 49 | 77.5000 | 19.0833 | 364.1736 |
| 54.5000 | -3.5000 | 12.25 | 55.5000 | -2.9167 | 8.5069 |
| 51.2500 | -6.7500 | 45.5625 | 34.5000 | -23.9167 | 572.0069 |
| 46.7500 | -11.2500 | 126.5625 | 72.5000 | 14.0833 | 198.3403 |
| 73.0000 | 15.0000 | 225 | 37.5000 | -20.9167 | 437.5069 |
| 34.0000 | -24.0000 | 576 | 74.5000 | 16.0833 | 258.6736 |
| 67.2500 | 9.2500 | 85.5625 | 69.0000 | 10.5833 | 112.0069 |
| 57.0000 | -1.0000 | 1 | 41.0000 | -17.4167 | 303.3403 |
| 56.2500 | -1.7500 | 3.0625 | 73.0000 | 14.5833 | 212.6736 |
| 71.7500 | 13.7500 | 189.0625 | 63.0000 | 4.5833 | 21.0069 |
| 68.2500 | 10.2500 | 105.0625 | 70.5000 | 12.0833 | 146.0069 |
| 82.5000 | 24.5000 | 600.25 | 45.5000 | -12.9167 | 166.8403 |
| 39.5000 | -18.5000 | 342.25 | 20.0000 | -38.4167 | 1475.8403 |
| 50.0000 | -8.0000 | 64 | 52.0000 | -6.4167 | 41.1736 |
| | | | 60.5000 | 2.0833 | 4.3403 |
| | | | 70.0000 | 11.5833 | 134.1736 |
| | | | 58.5000 | 0.0833 | 0.0069 |
| Average | 58.0000 | | 58.4167 | | |
| Sum | | 2505.625 | | | 4783.6250 |
| Number | 15.0000 | | 18.0000 | | |

APPENDIX D

FINAL GRADES

| Fall Semester Control Group | | | Spring Semester Experimental Group | | |
|-----------------------------|----------------|------------------|------------------------------------|----------|------------------|
| Final | d | d ² | Final | d | d ² |
| 74.0000 | 5.9556 | 35.4686 | 88.6100 | 21.0602 | 443.5316 |
| 65.1667 | -2.8777 | 8.2814 | 87.4233 | 19.8735 | 394.9556 |
| 68.5000 | 0.4556 | 0.2075 | 69.2833 | 1.7335 | 3.0050 |
| 63.2500 | -4.7944 | 22.9867 | 48.3600 | -19.1898 | 368.2489 |
| 56.4167 | -11.6277 | 135.2045 | 87.0333 | 19.4835 | 379.6063 |
| 83.5000 | 15.4556 | 238.8741 | 54.3433 | -13.2065 | 174.4119 |
| 50.0000 | -18.0444 | 325.6021 | 88.4567 | 20.9069 | 437.0980 |
| 74.9167 | 6.8723 | 47.2279 | 76.0833 | 8.5335 | 72.8204 |
| 76.8333 | 8.7889 | 77.2439 | 63.2267 | -4.3231 | 18.6893 |
| 69.2500 | 1.2056 | 1.4534 | 65.8567 | -1.6931 | 2.8666 |
| 66.3333 | -1.7111 | 2.9280 | 61.8000 | -5.7498 | 33.0603 |
| 82.8333 | 14.7889 | 218.7102 | 75.9933 | 8.4435 | 71.2925 |
| 76.4167 | 8.3723 | 70.0946 | 51.2000 | -16.3498 | 267.3163 |
| 53.2500 | -14.7944 | 218.8757 | 30.2000 | -37.3498 | 1395.0084 |
| 60.0000 | -8.0444 | 64.7131 | 67.3833 | -0.1665 | 0.0277 |
| | | | 57.5667 | -9.9831 | 99.6625 |
| | | | 81.1167 | 13.5669 | 184.0605 |
| | | | 61.9600 | -5.5898 | 31.2460 |
| Average | 68.0444 | | 67.5498 | | |
| Sum | | 1467.8717 | | | 4376.9078 |
| Number | 15.0000 | | 18.0000 | | |

APPENDIX E

t-RATIO CALCULATIONS

$$t = \frac{M_1 - M_2}{\sqrt{\left(\frac{\sum d_1^2 + \sum d_2^2}{N_1 + N_2 - 2} \right) \left(\frac{N_1 + N_2}{N_1 N_2} \right)}}$$

Blood Tracing:

$$t = \frac{35.2000 - 40.4583}{\sqrt{\left(\frac{1432.9 + 2307.2813}{15 + 18 - 2} \right) \left(\frac{15 + 18}{15 * 18} \right)}}$$

$$t = -1.3693$$

Practical 1:

$$t = \frac{48.8833 - 59.6111}{\sqrt{\left(\frac{1952.4833 + 5523.7778}{15 + 18 - 2} \right) \left(\frac{15 + 18}{15 * 18} \right)}}$$

$$t = -1.9759$$

Practical 2:

$$t = \frac{58.0000 - 58.4167}{\sqrt{\left(\frac{2505.625 + 4783.625}{15 + 18 - 2} \right) \left(\frac{15 + 18}{15 * 18} \right)}}$$

$$t = -.0777$$

Final:

$$t = \frac{68.044 - 67.5498}{\sqrt{\left(\frac{1467.8717 - 4376.9078}{15 + 18 - 2} \right) \left(\frac{15 + 18}{15 \cdot 18} \right)}}$$

$$t = .1030$$

APPENDIX F

Critical Values of t

| Level of significance for one-tailed test | | | | | | |
|---|-------|-------|--------|--------|--------|---------|
| | 0.100 | 0.050 | 0.025 | 0.010 | 0.005 | 0.001 |
| Level of significance for two-tailed test | | | | | | |
| (df) | 0.200 | 0.100 | 0.050 | 0.020 | 0.010 | 0.001 |
| 1 | 3.078 | 6.314 | 12.706 | 31.821 | 63.657 | 636.619 |
| 2 | 1.886 | 2.920 | 4.303 | 6.965 | 9.925 | 31.598 |
| 3 | 1.638 | 2.353 | 3.182 | 4.541 | 5.841 | 12.941 |
| 4 | 1.533 | 2.132 | 2.776 | 3.747 | 4.604 | 8.610 |
| 5 | 1.476 | 2.015 | 2.577 | 3.365 | 4.032 | 6.859 |
| 6 | 1.440 | 1.943 | 2.447 | 3.143 | 3.707 | 5.959 |
| 7 | 1.415 | 1.895 | 2.365 | 2.998 | 3.499 | 5.405 |
| 8 | 1.379 | 1.860 | 2.306 | 2.896 | 3.355 | 5.041 |
| 9 | 1.383 | 1.833 | 2.262 | 2.821 | 3.250 | 4.781 |
| 10 | 1.372 | 1.812 | 2.228 | 2.764 | 3.169 | 4.587 |
| 11 | 1.363 | 1.796 | 2.201 | 2.718 | 3.106 | 4.437 |
| 12 | 1.356 | 1.782 | 2.179 | 2.861 | 3.055 | 4.318 |
| 13 | 1.350 | 1.771 | 2.160 | 2.650 | 3.012 | 4.221 |
| 14 | 1.345 | 1.761 | 2.145 | 2.624 | 2.977 | 4.140 |
| 15 | 1.341 | 1.753 | 2.131 | 2.602 | 2.947 | 4.073 |
| 16 | 1.337 | 1.746 | 2.120 | 2.583 | 2.921 | 4.015 |
| 17 | 1.333 | 1.740 | 2.110 | 2.567 | 2.898 | 3.965 |
| 18 | 1.330 | 1.734 | 2.101 | 2.552 | 2.878 | 3.922 |
| 19 | 1.328 | 1.729 | 2.093 | 2.539 | 2.861 | 3.883 |
| 20 | 1.325 | 1.725 | 2.086 | 2.528 | 2.845 | 3.850 |

| | | | | | | |
|----------|-------|-------|-------|-------|-------|-------|
| 21 | 1.323 | 1.721 | 2.080 | 2.518 | 2.831 | 3.819 |
| 22 | 1.321 | 1.717 | 2.074 | 2.508 | 2.819 | 3.792 |
| 23 | 1.319 | 1.717 | 2.069 | 2.500 | 2.807 | 3.767 |
| 24 | 1.318 | 1.711 | 2.064 | 2.492 | 2.797 | 3.745 |
| 25 | 1.316 | 1.708 | 2.060 | 2.485 | 2.787 | 3.725 |
| 26 | 1.315 | 1.706 | 2.056 | 2.479 | 2.779 | 3.707 |
| 27 | 1.314 | 1.703 | 2.052 | 2.473 | 2.771 | 3.690 |
| 28 | 1.313 | 1.701 | 2.048 | 2.467 | 2.763 | 3.674 |
| 29 | 1.311 | 1.699 | 2.045 | 2.462 | 2.756 | 3.659 |
| 30 | 1.310 | 1.697 | 2.042 | 2.457 | 2.750 | 3.646 |
| 40 | 1.303 | 1.684 | 2.021 | 2.423 | 2.704 | 3.551 |
| 60 | 1.296 | 1.671 | 2.000 | 2.390 | 2.660 | 3.460 |
| 12 | 1.289 | 1.658 | 1.980 | 2.358 | 2.617 | 3.373 |
| ∞ | 1.282 | 1.645 | 1.960 | 2.326 | 2.576 | 3.291 |