2002

Virtual, On-Line, Frog Dissection vs. Conventional Laboratory Dissection: a Comparison of Student Achievement and Teacher Perceptions among Honors, General Ability, and Foundations Level High School Biology Classes

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ABSTRACT

VIRTUAL, ON-LINE, FROG DISSECTION VS. CONVENTIONAL LABORATORY DISSECTION: A COMPARISON OF STUDENT ACHIEVEMENT AND TEACHER PERCEPTIONS AMONG HONORS, GENERAL ABILITY, AND FOUNDATIONS LEVEL HIGH SCHOOL BIOLOGY CLASSES

Dissecting animal specimens has long been a tradition in biology classes. Objections by students, based on religious or ethical grounds, have been raised regarding the dissections of animals in classroom laboratories. A number of states now have legal proceedings or statewide policies requiring that alternatives to the actual dissection of laboratory animal specimens be permitted in their school districts. Alternatives to actual dissections have been developed in recent years. For a variety of reasons, performing an actual or conventional animal dissection may not be a desirable option.

The purpose of this study was to investigate how a virtual On-line frog dissection compares with an actual laboratory dissection. What were the perceptions of the teacher’s using it? How does student achievement compare among three the different ability levels on a pre and posttest regarding basic frog anatomy? Is a virtual On-line dissection a suitable alternative for students who, for whatever reason, do not participate in the actual laboratory experience?

The subjects consisted of 218 biology students among three different ability levels, in a Northeastern suburban high school. Approximately half of the student groups participated in a virtual On-line dissection, the other half in an actual laboratory dissection. A pretest of basic frog anatomy was administered to the students two days before and the posttest one day after their dissection experience. Data were analyzed using matched pairs t-Tests, Analysis of Variance, Tukey HSD, and Squared Curvilinear
Coefficients. Survey questionnaires were administered to the teachers after the dissection experiences were completed.

There were no significant differences found in achievement between the virtual and conventional dissection groups. There were significant differences found in achievement score means among the three ability levels. There was no significant interaction between gender and achievement.

Perceptions of the teacher's facilitating the two instructional methods varied. The main area of agreement among them was that a virtual On-line frog dissection was a viable alternative for students who objected to doing a conventional dissection.
VIRTUAL, ON-LINE, FROG DISSECTION VS. CONVENTIONAL LABORATORY DISSECTION: A COMPARISON OF STUDENT ACHIEVEMENT AND TEACHER PERCEPTIONS AMONG HONORS, GENERAL ABILITY, AND FOUNDATIONS LEVEL HIGH SCHOOL BIOLOGY CLASSES

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Submitted in Partial Fulfillment of the Requirements for the Degree Doctor of Education
Seton Hall University

2002
ACKNOWLEDGEMENTS

Virginia’s Curry School of Education provides and maintains “Net Frog,” a valuable resource for both students and educators all over the World Wide Web. Dr. Mable Kinzie, and her associates, those within and those connected to the University of Virginia, have done important pioneering work in the field of virtual frog dissection simulations and have provided much valuable research for the educational community.

Boreal Laboratories Ltd., Tonawanda, NY, provided outstanding customer service and the use of their materials.

Dr. John W. Collins Jr., my mentor, has always been there when I needed him. His professionalism, expertise, dedication, and inspiration have made this task possible. My heartfelt thanks!

Dr. George Lindemer, his advise, professionalism, and eye for detail helped guide me thorough this process.

Dr. Steven Kaminsky, his thoughts, much needed and appreciated humor, and constant encouragement provided me with a tremendous amount of support throughout this journey.

Dr. Michael Kuchar, his cooperation, assistance, encouragement, and his “can do” spirit, provided valuable insights, counsel, and support.

Dr. James Caulfield, Pat Lisanti, each of my professors, my fellow colleagues, the memory of my colleague Alvarez Anderson, the high school Biology Department and students, helped make this experience enriching, rewarding and memorable. Thank you.

My dear Sandy, R.J., Kaci, Mom and Dad, have accommodated my priorities during these years in order that I may achieve this goal. Thank you, and God bless each of you.
DEDICATION

To my wife, Sandy,

My son, R.J.,

My daughter, Kaci,

My mother, Irene,

My father, Henry

Your love, patience, understanding and support made this work possible.
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CHAPTER I

Introduction

Dissecting animal specimens has long been a tradition in biology classes. Since the 1920's the scope of animal dissections in schools has increased (Orleans, 1991). For many students, the real or actual laboratory dissection was the only option available. More recently, animal dissections have become the subject of controversy. Objections based on religious or ethical grounds have been raised regarding the dissections of animals in classroom laboratories. In 1989 a New Jersey high school student's parents sued their local Board of Education regarding the actions taken against their daughter during 1988-89 for refusing to dissect a frog during a biology laboratory exercise. Ultimately, the parties involved agreed to a legal settlement. As part of the settlement, the school district adopted a policy providing properly supervised alternative assignments in lieu of actual dissection (J.G.M., on behalf of his minor child, M.M., Petitioner, v. Board of Education, Ronald Udy, Superintendent of Schools, Woodstown-Pilesgrove Regional Board of Education, Terrence J. Crowley, Principal, Woodstown High School, Respondents, 1989).

Since this important New Jersey ruling, alternatives to dissection have evolved. Computer technology has increasingly entered into classroom learning environments. Since the early 1990's CD-ROMs of frog dissection made their appearance into schools. Now, with the proliferation of the World Wide Web, virtual dissections can now be accessed On-line. An inquiry into the search-engine "GOOGLE" (2002) revealed 26,400
web pages dealing with ‘virtual dissections.’ A virtual frog dissection can now be accessed on-line via the Internet.

With this new technology increasingly available, and alternatives to dissection becoming necessary, questions regarding the efficacy of a virtual alternative arise. How does a virtual, on-line, frog dissection compare with an actual lab dissection? What are the perceptions of the teacher’s using it? How do students fare on a pre and posttest regarding basic frog anatomy that was derived from materials designed for an actual frog dissection? Is a virtual on-line dissection a suitable alternative for students who, for whatever reason, do not participate in the actual lab experience? Is virtual on-line dissection more suitable/acceptable for some ability levels/students than others?

Background of the Problem

For various reasons, performing an actual or conventional animal dissection may not be a desirable option. Some schools do not perform dissections in biology labs because of environmental concerns regarding the chemicals used to preserve the lab specimens, the decline in wild amphibian species, safety issues regarding the use of sharp instruments, the expense of the lab materials and specimens, and ethical objections by students. In “The Science Teacher,” an article appeared in the Commentary section, speaking out against “blanket requirements that dissection should be a right of passage through middle and high schools have no place in the US educational system” (Orlans, 1991, p. 14). Animal rights proponents have raised concerns about the ethical and psychological implications of dissection (Shapiro, 1991). “The Wall Street Journal” carried an article regarding a high-school sophomore’s refusal to dissect a frog based on moral reasons. She sued her school district after school authorities reduced her grade of
A to a C for refusing to dissect a frog. Her objection instigated the adoption of a law that now requires California school districts to provide students who have moral or religious objections, the right to an alternative to dissection. The article further states that Massachusetts already has a law regarding this matter (Wells, 1989). “The New York Times”, on May 29th, 1997 reports:

Many states are now pondering bills that would allow students to complete alternate work in science if they oppose dissection. Such laws have been enacted in California, Florida, Maryland, New York and Pennsylvania. The Illinois House of Representatives recently passed a similar bill, which is being debated in the State Senate. (Johnson, 1997, p. A 16)

The web site of “Educators for Animal Rights and Humane Education” (2001) indicates that the Illinois bill has subsequently become signed into law. This web site further indicates that Maine now has State department of education policy regarding dissection alternatives and Louisiana has a State resolution to this effect.

As mentioned in the Introduction, a student in a New Jersey high school refused to dissect a frog. The student was penalized for refusing to do so. The student’s parents entered into a settlement with the school district on July 25th, 1989. An Administrative Law Judge placed this settlement on the record. The student had her biology grade recalculated. The school district adopted a statement into their curriculum guide that provides the opportunity for alternative assignments and supervision to students who object for religious beliefs, during the class periods that dissections are being performed. The Board of Education agreed to pay the student’s legal costs and counsel fees. The terms of the settlement were approved by, Saul Cooperman, the Commissioner of the

Alternatives to dissection are also being sought at the college level. Sarah Paige, a senior biology major at Guilford College in North Carolina, is pursuing “a dissection choice policy written into the school syllabus for each class using animals. This way, students will know they can take the course without compromising their ethics” (Balcombe, 1994, p. 24). “As long as animals continue to be torn from their native habitats, raised in unacceptable conditions, killed by inhumane methods, and cut open for impressionable minds to see, the debate over dissection must be engaged” (Balcombe, 1994, p. 25).

Amphibian species, frogs being among them, have severely declined in numbers over the past few decades. There are different theories for this decline. They seem to vary by geographic area. This alarming decline has been documented throughout the world. Pesticide residues, increased exposure to ultraviolet radiation from a thinning ozone layer, reproductive cycle problems, habitat destruction, predators, disease and parasites have all been identified as possible causes. Permeable skin and multi-stage life cycles make amphibians particularly susceptible to changes in their environment. Frogs have show up with missing or deformed body parts. Population sizes have decreased, suggesting reproductive problems (Cone, 2000). “The problem is even worse than we imagined, and it’s getting worse” (Cone, 2000, p. A 29), said James Hankin, a herpetologist with Harvard University and Chairman on the international task force on this issue.
Murphy, Fortner (2001) report populations of anurans (frogs and toads), which have existed since the dinosaur days, are declining. Scientists believe that these anurans are indicators of environmental quality. Some 3,300 species exist worldwide. 92 species are reported in the United States. Anurans are all amphibians. It is estimated that out of the 5,000 species of amphibians that exist globally, 200 species face extinction (p. 670).

There are reports of unethical treatment to living animals by certain suppliers of dissection specimens (Jackson, 1991). Students who object to laboratory dissections, for whatever reasons, are urged by Jackson to “suggest a suitable alternative project, such as writing a paper, designing anatomical charts, or using one of the options listed in ‘Alternatives to Dissection’” (Jackson, 1991, p.18). This list includes computer-based programs as one of the alternatives, along with videotapes and books (Jackson, 1991).

“Most dissection exercises emphasize drawing and memorizations skills that could be learned just as easily, if not better, with diagrams and models than with a time consuming dissection lab” (Jackson, 1991, p. 18). According to the National Association of Humane and Environmental Education only 4% of fifth graders will obtain a college degree in science, “and not all of those will be in a medical field” (Jackson, 1991, p. 18).

The chemicals used to fix and preserve dissection specimens are potentially hazardous. Formaldehyde is often used at some point in the process of preserving specimens for laboratory dissections. For medical schools, solutions containing formaldehyde and phenol are traditionally used to embalm cadavers for dissection. “The Occupational Safety and Health Administration (OSHA) of the USA estimates that 1.3 million US workers are exposed to this chemical” (Oosthuizen, 1998, p. 47). The largest numbers of individuals in the United States occupationally exposed to formaldehyde
belong to the embalming and funeral service industries. Oosthuizen (1998) relates that exposure to formaldehyde, classified as a suspected carcinogen, is an increasing concern in anatomy laboratories. He recommends introducing alternate methods of teaching anatomy such as computer-aided methods to reduce formaldehyde exposure. He asserts that academic institutions have the obligation to control formaldehyde vapors. “Formaldehyde is responsible for a variety of symptoms such as nose and throat irritation, bronchitis, pulmonary oedema, chemical pneumonitis, irritation, coughing, chest pain, dyspnoea, tissue damage, sensitization and dermatitis” (Oosthuizen, 1998, p. 48).

Preserved frog specimens for laboratory dissection may now be shipped in solutions that are not made with formaldehyde. One such solution used by a supplier of preserved animal specimens is a mixture of chemicals that does not contain formaldehyde. According to the Material Data Safety Sheet (MSDS), included with a shipment of preserved frogs from this supplier, indicates that splash proof safety goggles should always be worn and protective gloves and lab coat are recommended. “The specimen will contain some residual formaldehyde (CAS# 50-00-0) from the fixation process. The amount of formaldehyde present is specific to the type of specimen and will vary with time” (Carolina Biological Supply Company, 1997). This MSDS further indicates that none of the components of the shipping/holding fluid itself are listed as carcinogens.

The experience of virtual dissections is currently in use in Medical schools. Medical schools are already using “virtual dissection.” First year medical school students are experiencing “virtual autopsy and pathology” along “with the actual dissection of a
cadaver (which) should help students better visualize the disease process and increase knowledge of anatomy.” The National Library of Medicine (NLM) in Bethesda, Maryland has digitized a male and female cadaver to help medical schools “create a three-dimensional (3D) “recyclable” cadaver on which students can perform virtual dissections. Stanford University has received a grant from NLM to begin work on a “living model”, one that has simulated functioning organs (Couzin, 1998, p. 1).

A January 3rd, 2002 visit to the National Association of Biology Teachers (NABT) web site bulletin board provides a policy statement, dated 1995, regarding “The Use of Animals in Biology Education:”

(The) NABT acknowledges that no alternative can substitute for the actual experience of dissection NABT acknowledges that no alternative can substitute for the actual experience of dissection or other use of animals and urges teachers to be aware of the limitations of alternatives. When the teacher determines that the most effective means to meet the objectives of the class do not require dissection, NABT accepts the use of alternatives to dissection including models and the various forms of multimedia. The Association encourages teachers to be sensitive to substantive student objections to dissection and to consider providing appropriate lessons for those students where necessary. (p. 1)

In “Sciences” (1996) James S. Sweitzer states that “Once only available to medical students, virtual dissection has been carried into the mainstream by a host of educational, moral and environmental issues.” (p. 1). Sweitzer further notes that both the Human Anatomy and Physiology Society and the National Association of Biology Teachers had
adopted policy statements "that strongly support real dissection" (p. 2). He further states that:

Have the biologists passed a final verdict against computer dissection, or are they simply postponing a virtual inevitability? Programs such as the Virtual Frog Dissection Kit, for all their shortcomings, illustrate the remarkable promise of education on the Internet. For now, students and teachers may demand their dead organisms. But rising animal-rights sentiment and declining frog populations should widen the niche for electronic frogs. (Sweitzer, p. 4, 1996)

Due to the rising concerns over conventional or actual dissections, virtual On-line dissections need to be studied and compared to actual (frog) dissection in the secondary classroom laboratory setting.

This study is important because it will provide information that will be useful to administrators and teachers. It will illuminate and clarify differences and similarities between the perceptions of teachers regarding actual and virtual On-line dissection. It will provide insight into whether or not a virtual dissection is a significantly viable alternative for any, or any particular ability level, grouping of high school students.

Statement of the Research Questions

1. How does basic achievement on a pre and posttest of basic frog anatomy compare between the students performing a virtual On-line frog dissection vs. an actual laboratory frog dissection?

2. What are the perceptions of the teachers regarding the actual and virtual lab dissection experiences of the three levels of high school Biology classes.
Research Subsidiary Questions

1. Is there a difference in achievement among the Honors, General Ability, and Foundations level Biology classes?

2. Does a student’s gender influence their achievement on the dissection experience?

3. Is a virtual On-line dissection an educationally appropriate alternative for any student who objects to an actual dissection for moral or ethical reasons?

4. Is the virtual dissection experience more or less suitable for a particular level of Biology class?

5. Do a student’s career aspirations affect the teacher’s perceptions of the virtual dissection experience?

Statement of the Null Hypotheses

1. There is no significant difference in achievement between students performing an actual frog dissection and a virtual On-line dissection as determined by a pre and posttest of basic frog anatomy.

2. There is no significant difference among student achievement for each of the three levels of Biology classes: Honors, General Ability, and Foundations levels performing an actual frog dissection and a virtual On-line dissection as determined by a pre and posttest of basic frog anatomy.

$H_0$: Honors achievement $=\text{General Ability achievement} = \text{Foundations achievement}$.

3. There is no significant difference between gender and achievement of students performing an actual frog dissection and a virtual On-line dissection as determined by a pre and posttest of basic frog anatomy.
Definition of Terms

CAI: An acronym for computer-aided (or computer assisted) instruction. An educational program designed to serve as a teaching tool. CAI programs typically use tutorials, drills, and question-and-answer sessions to present a topic and to test the student’s comprehension (Fryer et al., 1997, p.72).

Dissect: To separate into pieces: expose the several parts of (as an animal) for scientific examination (Woolf et al. [Ed.]. 1975, p. 331).

Foundations Level Biology: Students who are primarily in the 10th grade, but may occasionally be 11th or 12th grade, who have shown lower achievement and often low motivation. They are likely to have failed their 9th grade Physical Science course or previous Biology class.

General Ability Biology: Students who are primarily in the 10th grade and were not selected for the Honors Biology classes nor recommended for the (lower level) Foundations classes.

Honors Biology: Students who are in the 9th Grade and have been selected via 8th grade achievement and teacher recommendation to be in this advanced class.

Internet: The world-wide connection of networks and gateways that use the TCP/IP suite of protocols to communicate with one another. At the heart of the Internet is a backbone of high-speed data communication lines between major nodes or host computers, consisting of thousands of commercial, government, educational and other computer systems that route data and messages (Fryer et al., 1997, p. 258).
On-line: In reference to a computing device or a program, activated and ready for operation: capable of communicating with or being controlled by a computer (Fryer et al., 1997, p. 340).

Virtual: Of or pertaining to a device, service, or sensory input that is perceived to be what it is not in actuality, usually as more "real" or concrete than it actually is (Fryer et al., 1997, p. 497).

World Wide Web: The total set of interlinked hypertext documents residing on document servers all around the world. Documents on the World Wide Web, called pages or Web Pages, are written in HTML (Hyperlink Markup Language), identified by URLs (Uniform Resource Locators) that specify the particular machine and pathname by which a file can be accessed, and transmitted from node to node to the end user HTTP (Hypertext Transfer Protocol) (Fryer et al., 1997, p. 511).

Limitations of the Study

This study pertains only to 218 students in the three levels of Biology classes offered in a Northeastern New Jersey high school with a socioeconomic District Factor Grouping (DFG) = 4, or DE.

This study compares a gain in basic knowledge of frog anatomy, as measured by a pencil and paper test, from pre to posttest, along with a qualitative analysis of the perceptions of three teachers, regarding its use for the three different ability levels, of biology classes taught in the high school.

This study is limited only to a comparison of a specific virtual frog dissection to an actual dissection of a preserved frog specimen.
This study compares only the perceptions of the three high school teachers, each of whom teach one, or two, of the three different ability groups of biology classes available in the high school.

This study only pertains to the On-line web site actually utilized during the study.

The On-line dissections were performed in a computer lab in the high school. It was not performed in the respective biology laboratories due to fact that only one On-line computer was available there. The computer laboratory has a sufficient number of computers so that the pairs of students can simulate a collaborative experience, as do the students performing the actual dissection.

The assessment instrument was a modification of material from two tests marketed by Boreal Laboratories Ltd. and may have influenced any results.

Although the teachers participating in the study indicated that their students were reasonably proficient in the use of computers and the Internet, the “novelty effect” may have influenced any results (Krathwohl, 1998, p. 520).

Organization of the Study

This chapter provided the background to problem. It included a statement of the research questions and the subsidiary questions. A statement of the null hypotheses was followed by definitions of key terms, the limitations of the study and its organization.

Chapter 2 reviews the related literature. It starts with the uses of educational technology and uses of computer-assisted instruction. From there secondary uses of computer instruction are explored. Further review is given to uses of computer-assisted instruction in biology, and computer assisted instruction in laboratory frog dissections followed by a chapter summary.
Chapter 3 tells the research design, variables, and information regarding the subjects, the instrumentation, procedures, data collection and recording. Data processing and analysis, the methodological assumptions and a summary complete the chapter.

Chapter 4 relates the quantitative and qualitative findings of the study.

Chapter 5 provides a summary of the purpose of this research, a statement of the research questions, subsidiary questions, and null hypotheses. This chapter also provides conclusions with recommendations for educational practice and for further research.
CHAPTER II

Review of Related Literature

Uses of Educational Technology

O'Riordan and Griffith (1999) indicate that there has been an increase in the use of computers and the World Wide Web (WWW) in education. They indicate that:

In contrast to traditional lectures, a web-based education system may encourage more active participation as more control and responsibility is given to students (e.g., order of topics, pace). The WWW offers many advantages such as worldwide delivery, access to a huge amount of information, an attractive media for representing course material, support for a non-linear approach to learning, and no time constraints. In addition, over time, links can be tailored to suit individual students. (pp. 264-265)

Lynda Ginsburg (1999) suggests, “The Internet has expanded the quantity of and access to relevant information, data, and electronic discourse about virtually any educational content; and there is reason to expect this trend to continue (p. 13).

Jones and Paolucci (1999), posit that substantial sums of money are being spent on educational technology. They cite a Katz, Tate, & Weimer study that reports in 1994, $2.4 billion was spent on computer-based technology in Kindergarten through Grade 12 (p. 17). Jones and Paolucci (1999) argue that the cost-effectiveness of technology must be weighed against the value added to learning outcomes. Jones and Paolucci’s (1999)
study that found that "less than 5% of published research was sufficiently empirical, quantitative, and valid to support conclusions with respect to the effectiveness of technology in educational learning outcomes" (p. 17).

Educational technology is already being used to train medical students. Virtual dissections, autopsies, and pathology assist medical students to better visualize the disease process and increase knowledge of anatomy (Couzin, 1998). Virtual technology has recently been applied to the practice of medicine.

In September of 2001, two New York doctors located in a Manhattan office building performed 'telesurgery' on a patient in Strasbourg, France. This patient had her gall bladder removed. The operation, done with the arms of the Zeus Telesurgical Robotic System, received signals from the doctors' hands that were carried through a high-speed fiber-optic cable located under the Atlantic Ocean. This surgical event brings the promise of remote surgery being performed in battlefields to third-world countries where expert doctors may not be on hand (Osborne, 2001). Many surgeons believe that most future heart surgeries will be robotic-assisted (Kolata, 2000).

Computer interfaces are beginning to incorporate a sense of touch. Incorporating the sense of touch into a computer interface, called haptics, will help future surgeons 'feel' traditional surgery even though this may be performed continents apart (Herez, 2000). Recent technology is also being developed to incorporate a sense of smell into computer interfaces (Eisenberg, 2000), (Grimes, 2000). These new developments may bring two more bodily senses, touch and smell, into use along with those of sight and sound currently incorporated into many computer uses and programs.
Uses of Computer Assisted Instruction

Suzik (1998) reports the answers given by three different computer gurus to the question: “Is computer based training or human instruction the way to go” (p. 56)? One of the respondents, the executive vice president of a communications corporation felt that the issue was so complex that a definitive answer would oversimplify it. The second guru, a director of instructional telecommunications for a university indicated that he had done comparative studies over a ten-year period and found the two methods to be equal. The third guru, the president and chief executive officer of a multimedia learning systems corporation, and the director of a university’s Institute for Learning Sciences, also feels the issue is complex. He indicated some concerns about human inadequacy as well as admitting that computers may be able to teach better than humans, although that may not always be practical. He said: “What learning is all about is practice. What computers bring to the table is to allow you to practice without practicing on the real thing. So if you’re talking about an air flight simulator, for example, and you crack it up and no one dies, it’s a pretty good thing” (Suzik, 1998, p. 57).

Press (1997) posits that (IT) Information Technology, though not usually the primary force compared to social and political forces, can facilitate change. In an article relating his hopes for the implications of Information Technology over the next 50 years, he suggests that if IT helps us process biological information, understand and model biology, dramatic breakthroughs in therapies can be expected (Press, 1997).

A recently published study in the Journal of Physical Therapy Education found that “The use of CAI as a primary or adjunctive tool for teaching in health care professions education has steadily increased over the past two decades” (Boucher, Henry, and
Hunter, 1999 p. 48). The authors cite various published studies on respiration therapy and occupational therapy (Boucher, et al. p. 48). They indicate evolving CAI use in medicine, dentistry, nursing, pharmacology, and radiation therapy. Their research involved physical therapist education. In their particular study, Boucher, et al. compared the use of traditional lecture supported by a graphics-enhanced CAI program to traditional lecture instruction without the CAI program. This comparison involved the teaching of anatomy, biomechanics and pathomechanics of the temporomandibular joint to first and second year physical therapist students (Boucher, et al., 1999). Their CAI program utilized graphics that “provided the capability of peeling away skin and tissue to allow the student to view the architecture of the deeper underlying structures” (Boucher, et al. p. 48). Their research found no significant difference between the two study groups. Each student was given a 25 question multiple pretest and posttest. The posttest was identical to the pretest except for a random reordering of the posttest questions. They found, based on pre and post test scores that the second year students were better prepared to understand the information being taught (Boucher, et al. p.47).

Another study that was done in the area of physical therapy education reports that traditionally, the dissection of cadavers to study gross anatomy is an integral part of physical therapy curriculum. However, due to rising costs, concerns regarding health risks from extended exposure to formalinized wet specimens, and decreased human cadaver availability; many institutions have had to make changes to their anatomy programs. One method being explored is anatomy intensive computer programs (Berube, Murray, and Schultze, 1999).
The authors noted in their concluding remarks that "another research study of significance would be to compare the retention of anatomy of students taught using cadavers versus students who have used computers solely to gain their knowledge" (Berube et al., 1999, p. 46). These authors cited a survey done by Mattingly and Barnes which noted, "there was no significant difference in student performance regardless of the anatomy teaching methods. Dissection of cadavers was still the preferred method, but schools were beginning to experiment with alternative to save time and money" (Berube, et al., 1999, p. 41). The authors' survey revealed that many respondents felt that computers could not give the students the "full tactile experience (when) using computers alone" (Berube, et al., 1999, p. 45). They recommended that: "future anatomy computer programs should consider adding a component that would include variations and pathology in the computer-generated models" (Berube et al., 1999, p.45). These authors went on to cite a study done by Rajendron, Tan, and Voon, which found that, "Methods that incorporate three-dimensional visualization appear to have the most significant impact on the teaching and learning of gross anatomy" (Berube et al., 1999, p. 42).

Gordon, Issenberg, Mayer, and Felner, (1999) report in "Medical Teacher," "advanced simulation technology and multimedia computers will provide a significant component of medical education and skills assessment in the 21st century" (p. 32). They do not see simulations replacing real patients, but will help solve current problems of limited teacher and patient availability. A Cardiology Patient Simulator (CPS) named 'Harvey' is a proven teaching tool that simulates 27 common and rare heart conditions. Various stages of cardiac disease can be simulated. Gordon et al. (1999) states, "The
most important requirement for curriculum innovation is leadership and a willingness to change. An equally important requirement is testing outcomes” (p. 35).

Baillie and Percoco (2000) did a study in which they surveyed 106 lecturers from 16 different departments in a technical college regarding the use of Computer assisted learning (CAL). The main finding of this study was that many of the respondents believed that the technical subjects, such as engineering and science, benefited greatly from real-life computer simulations. The survey results further indicated a belief by the respondents that these simulations increased motivation and understanding, as the students worked at their own pace.

Secondary Uses of Computer Assisted Instruction

Lehman (1994) sent out a 20-question survey to 179 secondary science department chairpersons. He found that even though the frequency of microcomputer use in the secondary science classrooms was found to be still relatively low, it had increased considerably from data reported from the mid 1980’s. He found that the reasons given most often why science teachers did not use computers during instruction were lack of enough available computers and software. The most often reason cited for using computers was for laboratory work (Lehman, 1994).

Skinner (1997) discusses the debate about whether using computers and the Internet in the classroom environment really help students learn better. Skinner suggests that how computers are used by educators in the classroom and the quality of computer programs and products, produced by the computer industry, is vital. He compares and contrasts uses of computers in authentic science lessons that involve real-world experiments and data analysis to uses that contribute to dumbing down science
curriculum. He believes that the burden of proof, regarding computers being indispensable in the classroom, rests with the computer industry.

Shusterman, and Shusterman, (1997) developed a new methodology for teaching electron density concepts. This involves computer generated three-dimensional models that simulate electron density distributions. They find that these models better prepare students to learn orbital concepts than traditional methods.

Burke, Greenbowe, and Windschitl (1998) suggest that most chemistry instructors do not use commercial computer animations because of flawed quality. They posit guidelines for faculty to use in developing their own instructional animations. Listed among the suggested guidelines are that navigation should be linear, and the simulations be tested in the classroom by both students and faculty.

An anonymous article (2000) in the January issue of “State Legislatures,” it is reported that the states of Kentucky and Florida now offer, certain students, Math, English, and science courses On-line. Both of these states offer advanced courses using the Internet.

Kelleher (2000) did a survey of the literature regarding recent developments in using Information Communication Technologies (ICT) in science classrooms. Kelleher concludes that (ICT) cannot replace student to teacher relationships, classroom interaction, and teaching. He posits that ICT can, however, be used to provide “new, authentic, interesting, motivating and successful educational activities” (p. 37). Kelleher cites Rodrigues (1997b) regarding the science classroom use of ICT in the simulation category “Simulations allow students to perform experiments that would be impossible to
perform normally due to constraints relating to time, money, safety, magnitude or ethics” (Kelleher, 2000, p.34).

Uses of Computer Assisted Instruction in Biology

Matray, and Proulx, (1995) report their experiences, occurring over several years, with integrating multimedia/computer programs into their high school biology classes. These programs included software on circulatory and respiratory systems, genetics, cellular respiration and genetics. They concluded that technology, although not a replacement for the teacher significantly complemented their biology curriculum. They indicated that computer programs should not be a replacement for laboratory experiences. They felt that software programs provided lab experiences that could not otherwise be possible because of time or expense.

Jensen (1998) reports that during the first few years that computers were introduced into biology labs in a university, much time was spent helping students learn how to use them. Now, several years later, relatively little time is expended teaching computer basics. Jensen indicates success with a computer program teaching Mendelian genetics via simulation of various fruit fly crosses. Jensen argues the “place” of computers in biology labs. He suggests two trends that are of concern. As the price of computer simulations drop and also improve in quality will this result in the continued replacement of simulations over ‘real’ laboratory science? The other concern being the total replacement of laboratory science experiments by simulations. Jensen (1998) argues, “No matter how realistic computer simulations become, they can never replace that smell, that touch, that psycho-motor coordination, that risk of failure, that ‘experience’ of biology” (p.249).
Huppert, Yaakobi, and Lazarowitz (1998) studied tenth-grade students use of computer assisted learning (CAL) simulation in a microbiology classroom. This study involved manipulating three independent variables and determining their impact on the growth curve of actual and simulated yeast cells. A pre and posttest was utilized to assess achievement. A two-way ANOVA was performed on the mean post scores by method and for gender. No significant difference was found between the posttest scores of the males in the control or the experimental group. A significant difference was found, in favor of the experimental group, for the females. No significant differences were found between genders for any of the study groups.

Morrell (1992) did a study of CAI vs. traditional classroom lecture/discussion in the biology classroom. Only one teacher was used. The sample size was relatively small. She compared the posttest means, utilizing a two-sample t-test, for a total of 56 students receiving instruction on photosynthesis and introductory genetics. The level of significance was set at $p=.05$ level. Overall, Morrell found no significant difference between the posttest means of the students receiving the two treatments. She concluded that CAI tutorials and traditional lecture/discussion were not more effective, or less effective in contributing to student achievement (Morrell).

Computer Assisted Instruction/Simulations in Laboratory Frog Dissection

As stated earlier, at least nine states, plus the state of New Jersey, have legal proceedings or statewide policies requiring that alternatives to actual dissection of laboratory animal specimens be permitted in their school districts. The controversy became newsworthy during 1987 when a fifteen-year old female California high school biology student objected, on ethical grounds to dissect a frog. Her lawsuit became the
first of its kind in the United States. Since then, other States have enacted similar legislation (Johnson, 1997).

Jonathan Balcombe, an associate director for the Humane Society for the United States, reports, "About six million animals are killed each year for academic inquiry," "Frogs are used most commonly" (Johnson, p. A16, 1997).

Barbara Orleans has been widely cited in the literature regarding how many high school students dissect frogs. She reports that approximately 75 to 80% of United States high school students dissect frogs (Orleans, 1988a). In "Compute," Steven Anzovin reports that a handbook, "Beyond Dissection," published by the Anti-Vivisection Society in Boston, Massachusetts lists a cost of $1,069 for three biology classes using bullfrogs over three years. This "Compute" article further states other advantages to a simulated dissection, namely reduced exposure to chemical preservatives such as formaldehyde, and the non-use of sharp objects such as scalpels (Anzovin, 1993).

In the "Science Teacher," Barbara Orleans, Ph.D., is listed as holding degrees in anatomy and physiology. She is further listed as being on staff at the Kennedy Institute of Ethics, in Georgetown University. She states:

The growth of dissection is getting out of hand. When dissection was first introduced in the 1920's (at a time when books were poorly illustrated and before the development of visual aids and films) one dissection in an upper grade level was the norm. By now multiple dissections are the norm despite the availability of an alternative. (Orleans, 1991, p. 14)

She further reports that in 1990, the National Association of Biology Teachers official policy on the classroom use of animals advises that, "Teachers (should) carefully
consider alternative ways to achieve the objectives of teaching’ without resorting to ‘the more traditional practices’ of dissection” (Orlans, p.14, 1991).

Steven Anzovin feels that computer simulations are not duplicating the “details of living organisms or that they can give students a feel for the inside of a body. Serious students of biology and medicine still work with real specimens. But do the millions of school children who perform vivisections and dissections every year need the real thing” (Anzovin, p. 90, 1993)?

Ruth Russo, with the chemistry department at Whitman College in Washington, relates, “Computers are powerful tools in science education and have great potential for sparing the lives of animals in teaching laboratories” (Russo, 1997, p. 577). However, she feels that in pharmacological experiments, virtual labs are “not as rich a learning experience” (Russo, 1997, p. 577). Additionally she states that: “the revulsion that students experience in sacrificing lab animals is itself a valuable experience” (Russo, 1997, p. 577). Russo questions whether improvement in instruction reported by the use of computer simulations as compared to lectures and textbooks can be applied to laboratories involving live animals. She indicates that further research in this area is needed. Russo suggests that live animal labs, as compared to computer simulations, bring important ethical and emotional considerations into the context of teaching biological science.

In 1990, “Alternative to Dissection, Second Edition” was published. This work was made available from the Human Society of the United States. It contained an overview of various alternatives to actual dissection, which included activity sheets, resources, and an appendix that contained information regarding Interactive Video Disks and computer
software. Among the activities listed were such things as clay model building, and observation of live animals, field trips, etc. (DeRosa & Winiarsky, 1990). Since then, various virtual simulations of frog dissection have evolved. Mable B. Kinzie, of the Department of Educational Studies/Curry School of Education, at the University of Virginia, and Richard Strauss of the Norfolk, Virginia Public Schools have done a series of key studies in the field of virtual frog dissection.

In 1993, Mable B. Kinzie, along with M. Jean Foss and Susan M. Powers published a study on the “Use of Dissection-Related Courseware by Low-Ability High School Students: A Qualitative Inquiry.” This study involved one high school teacher and two researchers (as observers). Data was collected from two high school “Level 1” Biology classes. These two classes are described as having “lesser ability,” or “have been poor performers” (Kinzie, Foss, & Powers, 1993). Each class in the study had 12 students in it. The students worked in groups of three. Each student took a 10-item pretest. Each student then performed three dissection activities. Two of these activities were computer-based programs with a videodisc assist. One of these programs used an IBM platform, input via a “touch screen,” and a linear “tutorial” format. The other used a Macintosh platform with a linear database. The latter giving the students a degree of control over the program using a “mouse.” This study utilized “all three” dissection activities for “all three” groups of students. The study found a “modest” increase in pre and posttest results for each of the two classes. The posttest consisted of the same 10 items on the pretest, plus and additional 9 organ identification items, randomly selected from the simulation materials (Kinzie et al., 1993). This study did not compare achievement between simulated and actual dissection. It did, however gain insight into
the use of dissection simulations. These findings suggest that a linear format did help structure the delivery of content. The data based format provided the students with a degree of control over the delivery of the content. The authors further suggest that the teacher can gain flexibility and provide structure in a data based format by interacting with the students, posing questions, and requiring that certain items in the data base be utilized (Kinzie et al., 1993).

Strauss (1993) did a study comparing achievement and attitudes of 192 tenth-grade biology students towards frog dissection by utilizing an interactive disk simulation and preserved frog specimens. The students were grouped into three ability levels. He found a significant gain in knowledge of frog anatomy by both groups, as measured from pre to posttests. In addition to this Strauss found no significant difference between the posttest scores of the Interactive Video Disc (IVD) group as compared, utilizing ANOVA, to the traditional frog dissection group. Strauss further found, in this study, no significant difference between the scores of females and males. Additional findings in this study include no significant difference between the method of instruction and the ability level of the students. Strauss (1993) found that the students in the middle achievement level of the simulation group had the highest posttest mean scores and the students in the lowest achievement level had the lowest mean posttest scores. In the traditional dissection group, the students with the highest achievement levels had the highest posttest scores. The medium achievement level group scored the next highest posttest scores. The lowest achievement level group obtained the lowest posttest mean scores.

In 1994, Strauss and Kinzie published a study on “Student Achievement & Attitudes in a Pilot Study Comparing an Interactive Videodisc Simulation to
Conventional Dissection.” This study, a pilot to Strauss’ (1993) study, used an IVD as the medium for the simulated dissection. This study involved two high school biology classes. The total number of students included in the study was 17. Their findings revealed no significant difference between the pre and posttests of the simulated and conventional dissection groups. They further found that no significant difference in scores was due to gender. However, a significant interaction was found between the time of the dissection, either simulated or actual, and the time of the questionnaire administration. It was found that “those using the simulation became less positive over time about the value of animal dissection, while those who dissected a frog became more positive” (Strauss & Kinzie, 1994, p. 401). As noted in their article, “The lack of significance for the treatment, gender and interaction factors may well be due to the small sample size used for this preliminary study. Future research will re-examine these possible differences with larger groups” (Strauss & Kinzie, 1994, p. 401). These authors conclude their article with a recommendation for further research “to better determine the effectiveness of simulations such as the Interactive Frog Dissection in comparison to traditional dissection” (Strauss & Kinzie, 1994, p. 402). This Interactive Frog Dissection, also called Net Frog, was the web site accessed for this research study.

In 1993, Kinzie, Strauss, and Powers published an article on “The Effects of an Interactive Dissection Simulation on the Performance and Achievement of High School Biology Students.” In this paper (which was a follow up to the study mentioned above, but not actually published until 1994), they investigated the use of IVD or Interactive Video Disks that contained a simulated frog dissection. Their study compared simulated versus the actual laboratory dissection, both as alternative to, and a preparation for actual
laboratory dissection. This study involved 61 high school students. These students were in three General Ability classes. The same teacher taught all of these classes. 77% of these students participated in a previous dissection. Their findings suggest, "The IVD simulation was at least as effective as actual dissection in promoting student learning of frog anatomy and dissection procedures" (Kinzie, Strauss, & Foss, 1993, p. 889). They further found that students who used the IVD prior to an actual dissection learned more about dissecting procedures and frog anatomy than students not using the IVD prior to actual dissection (Kinzie et al., 1993, p. 889).

Harper (1995) did a study comparing a level III video disk/hypermedia with a traditional frog dissection. This involved 141 high school students. The pretests showed no significant difference in learning. The posttest consisted of two subparts: 55 multiple-choice questions on knowledge and fifteen questions on organ identification. No significant difference was found between the posttest scores of the conventional dissection and the Interactive video disc/hypermedia group in the multiple choice subsection. In the organ identification subsection, the students' had to identify the name of 15 organs from an image on a projected slide. Harper (1995) found a significant difference between the posttest scores of the control and treatment group. Harper suggests that this difference may have resulted from several factors. The lab manual used by the conventional dissection group had the students consciously identify organs in context to the surrounding organs and the videodisc (group) did not. Although the videodisc utilized color images, the hypermedia computer software utilized black and white images. Some students commented that the computer diagrams and computer study sheets were not realistic. Harper (1995) mentions in his epilogue that the
University of Virginia developed an Online frog dissection tutorial while his study was conducted. This Interactive Frog Dissection is the one mentioned by Strauss & Kinzie, (1994) in their recommendations for further research.

As time progressed, CD ROMs were developed. During 1996, The "American Biology Teacher" carried a review of "The Digital Frog." In this review, a CD ROM containing a simulated dissection is described. This CD also contains information about the anatomy and ecology of a frog. The author notes, "The Digital Frog CD and workbook do a superb job of supplementing the normal frog or supplanting it in some cases" (Harris, 1996, p. 187). The author goes on to describe the enthusiasm of the teachers and students who previewed this software package.

Interactive three-dimensional graphics have been utilized to develop a "Virtual Frog Dissection Kit." This kit consists of a digital frog that can be rotated in any direction, taken apart and put back together using clicks of a computer mouse button. The frog can be seen with skin on or off. "The frog’s skeleton and organs, with the exception of muscle tissue, can be accessed simultaneously by multiple users due to techniques developed for the Whole Frog Project" (Robertson, Johnston, & Nip, 1995, p. 158).

A three dimensional interactive frog dissection may have certain advantages over traditional dissection in that:

Using a virtual dissection approach provides a realistic representation of the internal 3D structure of animals in a way that physical dissection can only imply: organs and structure may be examined in their undisturbed relationships to each other. One can look at the stomach by themselves, with their original relationship
to each other, and then add the small intestine to see where it fits in (see Figure 1).

These operations would be difficult if not impossible in an actual dissection.

(Robertson et al., 1995, p. 156)

In 1996 the Stanford University Medical Media and Information Technology group (SUMMIT) applied for and received a US National Science Foundation (NSF) grant to create a three-dimensional (3D) virtual frog dissection. One of the benefits related that, “Dissections done on a virtual creature are instantly renewable, without the offending odours” (Dev & Walker, 1999, p. 637). The design team envisioned a virtual library of dissectible creatures. As the development of this Virtual Creatures Project progressed, the focus was revised to a more holistic view of the frog. The final result was called Frog Island. Here students can learn not only about the internal anatomy and physiology of a frog, but also about its relationship to the environment (Dev & Walker, 1999).

In 1996, Kinzie, Larsen, Burch, and Boker, published an article on “Frog Dissection Via the World Wide Web: Implications for Widespread Delivery of Instruction.” In this study, the importance of the World Wide Web, or WWW, as a medium for the distribution and use of educational materials was investigated. The authors describe their creation, called “The Interactive Frog Dissection,” or “Net Frog.” Net Frog can be accessed free over the Internet at http://teach.virginia.edu/go/frog. It was developed using HyperText Markup Language (HTML). This HTML language enabled Net Frog to be accessed by various computer platforms such as PC-compatible and Macintosh. This eliminates the need for multiple videodisc players and software. Their research showed an average of 2,285 separate visits each week, for the first 17 months, since the program went On-line in August 1994. They further found that 81% of the
visits were from computers in the United States, with 26.6% being from United States educational institutions (Kinzie, Larsen, Burch, & Boker, 1996). The authors of the study make a note in the Limitations and Future Research section of their 1996 study. They are currently looking into doing further analysis on the "event histories" of the various Online users. They wish to investigate how Online users navigated Net Frog, and how much time was spent in the various portions of the program.

Christine Marszalek (1998) did a study comparing seventh grade students' achievement and anxiety among conventional frog dissection, an interactive C-D (Rom) tutorial, and a combination of desktop computer materials termed Microworld. This Microworld was comprised of a C-D Rom and digitized movies, pictures and sound downloaded from variety of Internet sites including "Net Frog." Marszalek found no significant difference by treatment on pre and posttest achievement scores using an ANOVA. She did however, find a significant difference in the students' mean gain scores from the pretest to the immediate posttest and from pretest to delayed posttest among the treatments. The Conventional dissection group showed a statistically significant difference in mean gain scores as compared to the Microworld dissection group from pretest to immediate posttest. The group using the C-D Tutorial did not show a statistically significant difference in mean gain scores when compared, using an ANOVA, to the conventional dissection group or to the Microworld group from pretest to immediate posttest. The Conventional treatment group also showed a statistically significant difference as compared to the other two treatment groups from pretest to delayed posttest. Three months after the posttest, a delayed posttest was given to the subjects. There was no statistically significant difference among the delayed posttest
gain scores of the three treatments. The Conventional treatment group had the highest
delayed posttest scores, followed by the Microworld group and then the C-D Tutorial
group. It appears that the Microworld group retained more over the three months than the
C-D Tutorial group. An ANOVA done on the gain scores from immediate posttest to
delayed posttest showed no statistically significant differences in long-term retention by
treatment.

Akpan (1998) reviewed approximately fifty studies done on computer simulations
in the area of science education. He concluded, “simulations can turn a tedious task into
one done more easily, quickly, or cheaply for both learners and teachers” (p. 62). He
argues that even though computer simulations can facilitate efficient learning and
productivity, they are not a panacea for science teachers’ problems. He asserts “The
effectiveness of simulations as educational tool depends very much on the purpose for
which they are used” (p. 62). Akpan’s (1998) study was done in a Mid-Western middle
school. His purpose was to see if (1) a computer simulation on frog dissection improved
the students’ subsequent, traditional dissection performance, knowledge of frog anatomy
and morphology. (2) Did the sequence in which the simulation was presented with
regard to the traditional dissection determine effectiveness? (3) He investigated the role
of gender as an influence on learning from the simulated to the traditional dissection.
The subjects, n=127 seventh grade students, comprised three treatment groups: Those
who utilized a frog simulation experience before the frog dissection. A second group
who dissected the frog first, then used the frog computer simulation. A third group
consisted of students who did the traditional dissection of the frog only. Akpan found no
significant difference among the three groups’ pretest scores using a one-way ANOVA.
The posttest data indicated that the students who utilized the simulation before the traditional dissection achieved higher scores and performed better on the traditional dissection. These findings were statistically significant. The group that utilized the computer simulation after the traditional dissection and the group that only did the traditional dissection did not have significantly different scores. Akpan (1998) further found that the role of gender was not significant.

**Summary**

The research history suggests a developmental evolution of educational technology. Computer Assisted Instruction (CAI) has become increasingly more integrated into learning environments. It is being used in the medical field for instructional purposes. Now CAI is available to simulate frog dissection. The various studies cited began with non-computer-based alternatives to dissection, through some computer-based usage in conjunction with interactive videodiscs to virtual dissections available on-line over the World Wide Web. Different studies cited, in this chapter explored the application(s) and implications of virtual frog dissection for classroom use by students in different level Biology courses. Their data serves as a current reference to this study for possible alternatives and supplements to frog dissection in the various levels of Biology classes in a Northeastern New Jersey public high school.
CHAPTER III

Methodology

Research Design

This study was a qualitative study with an experimental achievement component. A pre and posttest measured student achievement. The achievement component measured achievement in basic knowledge of frog anatomy. The study included data on ability level, and gender, of the students involved in the study. The study was conducted during the regular time and sequence that dissections normally occur in the curriculum. As per the science department policy, participation in dissections is optional. Every attempt was made by the teachers to control the variables within the classes they instructed with the exception of the treatment. The regular classroom laboratories were not used for the virtual dissections due to the fact that only one On-line computer was currently available in each one. Students reported to a computer lab during their regularly scheduled class periods for the virtual dissections. Teachers proceeded to conduct both types of dissections, actual and treatment, in a manner as close to their usual teaching style as possible. After the results of the posttests were tabulated, a voluntary anonymous survey questionnaire was administered to solicit the perceptions of these three teachers regarding any differences and/or similarities between the two instructional methods. The complete set of survey questions and answers are included, verbatim, in the Appendix section A.
Variables

The method used to deliver the instruction on frog dissection was the independent variable or treatment. The dependent variables were the pre and posttest achievement scores of the students and the survey questionnaires returned by teachers.

Subjects

The subjects were biology students in a North-eastern New Jersey public high school. The high school has an enrollment of approximately 1014 students. The ethnic composition of the high school is approximately 452 White, 284 Asian, 208 Hispanic and 70 Black students. The 218 students involved in the study can be considered, for the most part, comprising the entire complement of students in the biology classes of the high school.

The Honors Biology classes consisted of students who were 9th graders. They were selected to be in this level class after the 3rd marking period of their 8th grade experience. Students having a B+ average in science and algebra, along with a teacher recommendation are scheduled into this ability level. Students who do not qualify in this manner may elect to take a special science process skills test offered during May of their 8th grade school year. Those achieving above a predetermined cut off may also enter the program. Generally only one to three students who take the test qualify for the Honors Biology program in this alternative manner. These students are highly regarded to be college bound.

General Ability classes consist of students who do not qualify, or on rare occasion, do not elect to go into the Honors Biology Classes. They are primarily 10th graders.
They may occasionally be in the 9th, 11th or 12th grade; but this is the exception, not the norm. They may be college bound or not.

The Foundations level classes consist primarily of 10th graders. They may also be in the 11th or 12th grade. They are most likely to have scored below the grade of C in their previous (Physical Science) course. They may not necessarily be college bound.

Instrumentation

The pre and post-tests consisted of the same 34 questions. The test had 22 of these questions identifying a basic part of the internal anatomy of the frog. 13 questions were knowledge based multiple-choice (4 possible answers for each question). One question was inadvertently repeated on the multiple-choice test. Consequently, question number 9 in this section was discounted. Questions from two tests marketed by Boreal Laboratories Ltd. were utilized as resource material and adapted with permission from the author. The multiple choice questions were selected from the “Boreal’s Teacher’s Guide” (Boreal Laboratories Ltd., 1997c). The organ identification questions were selected from “Boreal’s Frog Anatomy Test” (Boreal Laboratories Ltd., 1997a). These Boreal tests are marketed as posttests for actual, or traditional, frog dissection. For this reason, they were selected as the basis for the quantitative instrument. The three teachers comprising the biology department reviewed the Boreal test materials. Cumulatively, these teachers have over 25 years of experience teaching biology. They collaborated to identify and select the questions that served as the measure of knowledge gained regarding basic frog anatomy. After discussion, 34 questions were selected. The resulting instrument, adapted by the researcher (see Appendix B), included 22 matching
questions involving organ identification and 12 multiple-choice questions on internal and external anatomy.

Student data was collected anonymously using historical data. The pre and posttest scores were reported via a random student number. Only a student’s classroom teacher knew the name of the student associated with that number. Dissection is a regular part of the curriculum. Participation in any conventional dissection is optional. If a student declines to participate in a conventional dissection, they have in the past been directed to construct a written report on the anatomy of an animal of the same species as the one currently being dissected by their classmates. More recently, they have been directed to view commercially produced videotape on the dissection of an animal of the same species as the one actually being dissected in the laboratory. During the dissections reviewed by this study, one student declined to participate in the actual dissection. This student willingly worked, individually, on the virtual On-line dissection in lieu of the actual laboratory dissection. After two class periods this student decided to go back and work with their actual dissection group. This student’s achievement data was not included in the results of this study. A regular lab activity grade was given for each student’s posttest. Dissection is considered a part of their ongoing Biology coursework. Provisions are made, as noted above, for any student who objects to performing conventional dissections.

Questions regarding student data: pre and posttest scores, grade level, gender, and any career aspirations, were gathered from anonymously from preexisting data.

Perceptions were gathered from the classroom teachers via anonymous surveys. The surveys were distributed to the teachers, mailboxes by a teachers’ association (union)
representative in order to reinforce the voluntary nature of participation in the survey. The instructions given to the teachers by this representative consisted of a request to place their surveys, completed or not, in a sealed drop-box located in the Biology Workroom's outer office area. The drop-box was located in such a manner that any survey could be placed in the box without being observed by any other individual. The drop box was taken, sealed and unopened, to an independent third party, who unsealed the drop-box and transcribed the surveys, verbatim, to typewritten text. This independent third party was a secretary in a school business office. The transcripts were then handed over to the researcher. The third party who transcribed these surveys then destroyed the original surveys to avoid any possible handwriting recognition. Only the typewritten transcripts of the teachers' responses were provided to the researcher.

Participation in this study was voluntary for the teachers. Each pair (set) of Honors, General Ability, and Foundations level classes were randomly assigned, with one exception due to a logistical consideration, to either a virtual or actual dissection. For example: one Honors class will perform a virtual dissection; the other Honors class an actual dissection, etc. The students will work in pairs of two, except if there is an odd-number of students in the class. In this case the "extra" student will be given the opportunity to work independently or be assigned to a group of two which the teacher thinks would be the most productive group for that particular individual to join.

The students in each class, at the individual teachers discretion, were either randomly assigned to a group of two for the dissection experience or kept in their pre-existing lab partner groups. The students are assigned to their particular class, within their ability level, by a computer program. This can be considered random with the
exception of minor adjustments made by the guidance department. The same lab partner groups were used for both the virtual and actual dissection experiences.

The approximate number of students participating, in each class of the three levels was approximately 15 to 22 (n = 15 to n = 22). The total number of students participating in the dissection experiences that took both the pretest and the posttest was n=218.

The virtual frog dissection utilized for this study was Net Frog. This web site can be accessed over the Internet at http://teach.virginia.edu/po/frog. The Quick Time movies were downloaded to the hard drives of the computers used for the study. The computers contained sound cards. The Quick Time Movie Player is an application program from Apple Computer-Inc. It is available for download over the Internet. It is available at www.apple.com/quicktime/download/. The Internet was accessed via T1 (type) transmission line.

The actual frog dissection specimens were medium size preserved frogs of the species “Rana Pipiens” purchased from Carolina Biological Supply Company of Burlington, North Carolina.

Procedures

Each class was given the same basic introduction to the dissection. Every effort was made by the teachers to control all classroom variables within their ability group with the exception of the method of instruction. Each virtual group used the same set of computers. Each student group, whether actual or virtual, had a copy of the Boreal Laboratories, LtD. (1997b) “Frog Dissection Laboratory Student Study Guide” to use as a reference. The teachers each had the “High School Frog Dissection Laboratory Teacher’s Guide” (Boreal Laboratories LtD., 1997c) to use as a reference. Each actual
dissection group used the same type of dissection tools: pans, pins, scissors, scalpels, probes and forceps. The method used was either the virtual (treatment) or actual/conventional dissection. Each teacher had their students use the same preliminary text readings, and any prior assignments, for their particular ability level. The pretest was given two days before the virtual or actual dissection occurred. The day just before the dissection was reserved for any student who may have been absent to take the pretest. The posttest was given the day after the laboratory dissection had taken place. The day following this reserved for any student, who may have been absent, to take the posttest. Any student who did not take both the pre and posttest was not included in the data analysis (n=218). The Surveys were distributed to the teachers via the local teacher’s association (union) representative three days after the posttest. This three-day period allowed the teachers to review and score the posttests prior to being exposed to the survey on their perceptions of this overall experience.

The class periods consist of 42 minutes each. The Honors Biology Class has one double-lab period once every six schools days in addition to one period each day. The General Ability and Foundations levels of biology have one class period each day with no double-lab period. Approximately one-half of all class sections started with the virtual dissection. The other approximate half started with the actual frog dissection. Twelve class sections, in all, participated in the dissections. Overall, seven of these sections started with the virtual dissection, the other five started with the actual dissection. There were two more virtual dissection class groups than the number of sections that did the actual dissection first. This was due to the logistics of the established departmental class
schedule and the availability of the computer laboratory. The three teachers were randomly assigned letters A, B, C for purposes of anonymity.

Teacher A had three class sections starting the virtual dissection first, and two class sections starting with the actual dissection. One of these virtual class sections was a Foundations level. All of this teacher's other class sections were General Ability level.

Teacher B had three class sections starting with the virtual dissection and two class sections starting with the actual dissection. One of these virtual class sections was Foundations level; the other General Ability level. Two of this teacher's General Ability sections started with the virtual dissection; the other General Ability level section started with the actual dissection.

Teacher C had one class section starting with the virtual dissection and one starting with the actual dissection. Both of these class sections were Honors level.

After each class section finished with the dissection method they started with, they were given the posttest. After the posttest each class section performed a second dissection using the other methodology. Teacher A and B and C utilized four class periods for the initial virtual and actual dissection experience. Students in the virtual groups that were finished ahead of the others were permitted to look back over the previous parts of the virtual dissection. Students that were finished ahead of the others in the actual dissection groups were permitted to explore/remove any remaining portions of the preserved frog. The posttest was given to all groups on the fifth class period/day. The groups that did the virtual dissection first subsequently switched, after the posttest, to the actual dissection method.
Teacher A utilized two class periods for the second virtual dissection. This teacher reported that there was low interest by the end of the period on the second day. Teacher B utilized one day for the second virtual dissection. This teacher reported that there was low interest by the end of the first class period. Teacher C utilized the one regularly scheduled double-lab period for the second virtual dissection. This teacher reported that this was all that was necessary for the dissection. Teachers A, B, and C reported lower, to much lower interest by these groups, relative to their groups that initially performed the virtual dissection prior to doing the actual dissection. Teachers A, B, and C reported increased interest and a degree of increased proficiency by the actual dissection groups that did the virtual dissection first.

Data Collection and Recording

The respective biology teachers scored and recorded the data from their classes. This data was entered into their grade books. Data from these historical grade records was tabulated and transcribed anonymously by the biology teachers, to a form developed by the researcher for this purpose. These data were listed using random numbers to represent each student. Next to each random number the teachers indicated the number of correct answers for the matching and multiple-choice sections of the pre and posttests. The overall total test scores were raw scores, based on the total number of correct responses.

Data concerning ability level, gender and any career aspirations was noted on these anonymous forms.

Perceptions of the teachers regarding the dissection experiences were collected via anonymous survey, transported in a sealed container and delivered to an independent
third party. This independent third party transcribed the original surveys, verbatim, to
text. This was done, on account of the small sample size, to eliminate the possibility of
any handwriting recognition. The three teacher surveys were randomly assigned numbers
1-3. These numbers were chosen to avoid any direct connection to the previously
mentioned designations of teacher A, B, C. This was done for purposes of anonymity due
to the small sample size.

All data was collected anonymously and kept strictly confidential.

After analysis, all anonymous data was destroyed.

Data Processing and Analysis

This study employed a pretest and posttest. Achievement data was analyzed using
a matched-paired dependent samples t-test, a squared Curvilinear Correlation ($\eta^2$ or \textit{eta}),
and an Analysis of Variance (ANOVA). The level of significance was set at $p = .05$. All
statistical analysis was completed using Statistical Product and Service Solutions [SPSS]
PC version 10.0 (199).

Methodological Assumptions

The researcher assumed the role of the observer. The researcher observed
conditions in the study groups, but did not take part in the instructional method. The
survey questionnaire regarding the teachers' perceptions of the dissection experience was
voluntary and anonymous. The researcher constructed the survey questions and enlisted
the services of an independent third party to help administer the survey. This third party
was a representative of the local teachers' association who was not a member of the
science department. This person distributed the surveys to the teachers involved with the
dissection experience. The completed surveys were not viewed directly by the
researcher. They were placed by the participating teachers into the slot of a sealed box that was opened by a different independent third party. This person was a secretary in a school business office. This person transcribed the surveys to type written text, verbatim. This third party then destroyed the original transcripts to preclude any possible handwriting recognition. Only the anonymous transcripts were presented to the researcher.

1. Questions posed to the teachers were consistent for all three
2. A virtual frog dissection was accessible and available On-line for teacher and student use.
3. The virtual On-line frog dissection is a different format/method than and actual frog dissection.
4. Teachers were familiar with actual frog dissections and the web site utilized.
5. Teachers and students were reasonably proficient in basic computer skills and Internet use.
6. Students were present and able to take both a pre and posttest on basic achievement in basic frog anatomy.
7. Teachers were willing and able to be anonymously surveyed regarding their perceptions of virtual vs. the actual dissection experiences.
8. The virtual On-line dissection material selected for the study was the same for all selected students.
9. The actual frogs being dissected were similar for all the actual dissections.
10. There were three teachers: one for the pair of Honors level classes, two taught both General Ability level classes and Foundations level classes. Each teacher taught their own classes utilizing the virtual and actual dissection methodologies.

11. Each student in a particular class level was assumed to have the same basic classroom exposure to biology consistent with the ability level that they were currently enrolled in.

Summary

This study compared a virtual, On-line, frog dissection to an actual laboratory dissection. It compared basic achievement between virtual frog dissections to actual/conventional frog dissections. It compares and contrasts the perceptions that the three teachers, involved with the study, have regarding the two methodologies. It attempts to delineate and clarify any differences about the two methodologies as perceived by the teachers of three different levels of high school Biology classes. It can serve as a future reference for administrators and teachers to use regarding alternative or supplemental dissection methodology.
CHAPTER IV

Results and Findings

Introduction

This Chapter contains the quantitative data from the study. Student achievement was measured via pre and posttests. This study controlled for method, ability level and gender. Data are listed in table format. Each of the eighteen tables contained in this chapter are explained and analyzed. Relevant findings are noted.

Quantitative Data Analysis

Table 1

Gender

<table>
<thead>
<tr>
<th>Gender</th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
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<td>46.8</td>
<td>47.2</td>
<td>47.2</td>
</tr>
<tr>
<td>Valid Female</td>
<td>114</td>
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<td>52.8</td>
<td>100.0</td>
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<td>216</td>
<td>99.1</td>
<td>100.0</td>
<td></td>
</tr>
<tr>
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<td>.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>218</td>
<td>100.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

There were 102 males and 114 females validated as participating in the study. Males comprised 46.8% of the study population; females comprised 52.3% of the study population. The gender of two individuals was not indicated in the anonymous data and
subsequently was not included in the gender analysis. The number of individuals of each gender was approximately the same (see Table 1).

Table 2

Level

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Honors</td>
<td>32</td>
<td>14.7</td>
<td>14.7</td>
<td>14.7</td>
</tr>
<tr>
<td>General</td>
<td>142</td>
<td>65.1</td>
<td>65.1</td>
<td>79.8</td>
</tr>
<tr>
<td>Foundations</td>
<td>44</td>
<td>20.2</td>
<td>20.2</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>218</td>
<td>100.0</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

This study controlled for course levels. Out of 218 total participants, 32 were Honors level. 142 were General Ability level. 44 were Foundations level students. The Honors level students comprised 14.7% of the participants. The General Ability level comprised 65.1% of the participants. The Foundations level comprised 20.2% of the participants in the study (see Table 2).

Table 3

Method

<table>
<thead>
<tr>
<th>METHOD</th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual</td>
<td>94</td>
<td>43.1</td>
<td>43.1</td>
<td>43.1</td>
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<tr>
<td>Virtual</td>
<td>124</td>
<td>56.9</td>
<td>56.9</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>218</td>
<td>100.0</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>
Out of the 218 total participants, 94 students, or 43.1% of the study population, dissected the frog using the actual methodology first. 124 students, or 56.9% of the study population utilized the virtual methodology first. The group size for each method was approximately equal (Table 3).

Table 4

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
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<tr>
<td>1</td>
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<td>.9</td>
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<td>3.7</td>
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<td>.9</td>
</tr>
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</tr>
<tr>
<td>Total</td>
<td>218</td>
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<td>100.0</td>
</tr>
</tbody>
</table>

The range for the total pretest raw scores was from 1-23. The mean raw score was 8.78. 28 students, or 12.8% had a raw score of 9, n= 218 (see Table 4).
### Table 5

**Frequency Table Total Posttest**

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
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<tr>
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<td>1.00%</td>
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<tr>
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<td>1.00%</td>
<td>1.00%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>218</strong></td>
<td><strong>100.0</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>
The range for the total posttest raw scores was from 2-34. The mean raw score was 15.08. 14 students, or 6.4% had a raw score of 15, n=218 (see Table 5).

Table 6

**t-Test: Paired Sample Statistics (Pre & Post for Both Actual & Virtual Combined)**

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>N</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair 1 total-pre</td>
<td>8.78</td>
<td>218</td>
<td>3.17</td>
<td>.22</td>
</tr>
<tr>
<td>1 total-post</td>
<td>15.08</td>
<td>218</td>
<td>6.63</td>
<td>.45</td>
</tr>
</tbody>
</table>

The total posttest mean was 15.08 with a standard deviation of 6.63 and a standard error of .45, n=218. The mean difference is 6.30 with the total post-test having the higher mean score (see Table 6).

Table 7

**Paired Samples Test (Pre & Post for Both Actual & Virtual Combined)**

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
<th>95% Confidence Interval of the Difference</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair 1 total-pre - total-post</td>
<td>-6.30</td>
<td>6.70</td>
<td>.45</td>
<td>-7.20, -5.41</td>
<td>-13.897</td>
<td>217</td>
<td>.000</td>
</tr>
</tbody>
</table>

A paired samples t-Test was done for the total pre and posttests. t=-13.897 with df=217. This was statistically significant at the .000 level of significance. The total pretest mean was 8.78 with a standard deviation of 3.17 and a standard error of .22, n=218. This shows a significant difference in achievement scores from pre-test to post-test for both the actual and virtual methodologies (see Table 7).
Table 8

t-Test: (Pre & Post for Actual)

Paired Samples Statistics

<table>
<thead>
<tr>
<th>Pair</th>
<th>Mean</th>
<th>N</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>total-pre</td>
<td>8.17</td>
<td>94</td>
<td>3.48</td>
<td>.36</td>
</tr>
<tr>
<td>total-post</td>
<td>15.07</td>
<td>94</td>
<td>6.96</td>
<td>.72</td>
</tr>
</tbody>
</table>

The total pretest mean was 8.17 with a standard deviation of 3.48 and a standard error of .36, n=94. The total posttest mean was 15.07 with a standard deviation of 6.96 and a standard error of .72, n=94. The mean difference is 6.90 with the total posttest having the higher mean score (see Table 8).

Table 9

Paired Samples Test (Pre & Post for Actual)

<table>
<thead>
<tr>
<th>Paired Differences</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
<th>95% Confidence Interval of the Difference</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>total-pre - total-post</td>
<td>-6.90</td>
<td>7.22</td>
<td>.74</td>
<td>-8.38 to -5.43</td>
<td>-9.273</td>
<td>93</td>
<td>.000</td>
</tr>
</tbody>
</table>

A paired samples t-Test was done for the total pre and posttests of the actual method of dissection. t=-9.273 with df=93. This was statistically significant at the .000 level of significance. This indicates a significant difference in achievement from pretest to posttest for the actual methodology (see Table 9).
Table 10

**t-Test (Pre & Post for Virtual)**

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>N</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>total-pre</td>
<td>9.24</td>
<td>124</td>
<td>2.85</td>
<td>.26</td>
</tr>
<tr>
<td>total-post</td>
<td>15.09</td>
<td>124</td>
<td>6.40</td>
<td>.57</td>
</tr>
</tbody>
</table>

The total pre test mean was 9.24 with a standard deviation of 2.85 and a standard error of .26, n=124. The total post-test mean was 15.09 with a standard deviation of 6.40 and a standard error of .57, n=124. The mean difference is 5.85 with the total post-test having the higher mean score (see Table 10).

Table 11

**Paired Samples Test (Pre & Post for Virtual)**

<table>
<thead>
<tr>
<th>Paired Differences</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
<th>95% Confidence Interval of the Difference</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair 1 total-pre - total-post</td>
<td>-5.85</td>
<td>6.26</td>
<td>.56</td>
<td>-6.96 -4.73</td>
<td>-10.396</td>
<td>123</td>
<td>.000</td>
</tr>
</tbody>
</table>

A paired samples t-Test was done for the total pre and posttests of the virtual method of dissection. t=-10.396 with df=123. This was statistically significant at the .000 level of significance. This shows a significant difference in the achievement scores from pre-test to post-test for the virtual methodology (see Table 11).
Analysis of Variance (ANOVA)

A one-way ANOVA was performed on the total pre test and total posttest scores for the three ability levels: Honors, General Ability and Foundations.

Table 12

ANOVA - Level

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>74.342</td>
<td>2</td>
<td>37.171</td>
<td>3.782</td>
<td>.024</td>
</tr>
<tr>
<td>Within Groups</td>
<td>2113.089</td>
<td>215</td>
<td>9.828</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2187.431</td>
<td>217</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between Groups</td>
<td>1735.996</td>
<td>2</td>
<td>867.998</td>
<td>23.899</td>
<td>.000</td>
</tr>
<tr>
<td>Within Groups</td>
<td>7808.518</td>
<td>215</td>
<td>36.319</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>9544.514</td>
<td>217</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The ANOVA shows that there is a significant difference between the total pretest scores of the Honors, General Ability and Foundations level groups with an F value of 3.782 at the .024 level of significance with 2 degrees of freedom (see Table 12).

Likewise, the ANOVA shows that there is a significant difference between the total posttest scores of the Honors, General Ability and Foundations level groups with an F value of 23.899 at the .000 level of significance with 2 degrees of freedom (see Table 12).
Table 13

Descriptive Statistics – Combined Level

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>Honors</th>
<th>General</th>
<th>Foundations</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>total-pre</td>
<td>Mean</td>
<td>Std. Deviation</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>Honors</td>
<td>10.06</td>
<td>3.93</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>General</td>
<td>8.70</td>
<td>2.93</td>
<td>142</td>
<td></td>
</tr>
<tr>
<td>Foundations</td>
<td>8.09</td>
<td>3.13</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>8.78</td>
<td>3.17</td>
<td>218</td>
<td></td>
</tr>
<tr>
<td>total-post</td>
<td>Mean</td>
<td>Std. Deviation</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>Honors</td>
<td>21.25</td>
<td>5.34</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>General</td>
<td>14.74</td>
<td>6.48</td>
<td>142</td>
<td></td>
</tr>
<tr>
<td>Foundations</td>
<td>11.70</td>
<td>4.83</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>15.08</td>
<td>6.63</td>
<td>218</td>
<td></td>
</tr>
</tbody>
</table>

The mean score for the Honors ability level pretest was 10.06. The mean for the General ability level pretest score was 8.70. The mean for the Foundations ability level was 8.09 (see Table 13).

The mean posttest score for the Honors ability level was 21.25. The mean posttest score for the General ability level was 14.74. The mean posttest score for the Foundations ability level was 11.70 (see Table 13).
Tukey HSD

Table 14

Tukey HSD for Total Combined Pre and Total Combined Posttest

<table>
<thead>
<tr>
<th></th>
<th>Level (I)</th>
<th>Level (J)</th>
<th>Mean Difference (I-J)</th>
<th>Sig. (p)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total-Pre</strong></td>
<td>Honors</td>
<td>Honors</td>
<td>1.36</td>
<td>.069</td>
</tr>
<tr>
<td></td>
<td>General</td>
<td>General</td>
<td>1.97*</td>
<td>.019</td>
</tr>
<tr>
<td></td>
<td>General</td>
<td>Honors</td>
<td>-1.36</td>
<td>.069</td>
</tr>
<tr>
<td></td>
<td>General</td>
<td>General</td>
<td>.61</td>
<td>.493</td>
</tr>
<tr>
<td></td>
<td>Foundations</td>
<td>Honors</td>
<td>-1.97*</td>
<td>.019</td>
</tr>
<tr>
<td></td>
<td>General</td>
<td>General</td>
<td>-.61</td>
<td>.493</td>
</tr>
<tr>
<td></td>
<td>Honors</td>
<td>General</td>
<td>6.51*</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>General</td>
<td>General</td>
<td>9.55*</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>Foundations</td>
<td>Honors</td>
<td>-6.51*</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>General</td>
<td>General</td>
<td>3.03*</td>
<td>.010</td>
</tr>
<tr>
<td></td>
<td>Honors</td>
<td>General</td>
<td>-9.55*</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>General</td>
<td>General</td>
<td>-3.03*</td>
<td>.010</td>
</tr>
</tbody>
</table>

A Tukey HSD was performed on the total combined pre and total combined posttest scores to see where the statistically significant differences among the means occurred (see Table 14).

The mean difference between the Honors ability level pretest scores and the Foundations ability level pretest scores was 1.97. This was statistically significant at the .019 level of significance.

The mean difference between the Honors ability level posttest scores and the General ability level posttest scores was 6.51. This was statistically significant at the .000 level of significance. The mean difference between the Honors ability level posttest
scores and the Foundations ability level posttest scores was 9.55. This was statistically
significant at the .000 level of significance (see Table 14).

The mean difference between the Honors ability level posttest scores and the
Foundations ability level was 3.03. This was statistically significant at the .010 level of
significance. Therefore the hypothesis of no significant difference among student
achievement for each of the three levels of Biology classes: Honors, General Ability, and
Foundations level performing an actual frog dissection and a virtual On-line dissection as
determined by a pre and posttest of basic frog anatomy is rejected. H₀: Honors
achievement = General Ability achievement = Foundations achievement is rejected.

**Squared Curvilinear Correlation (eta squared)**

A squared Curvilinear Correlation, η² or eta squared, was performed to determine
what proportion of the variance in total pre and posttest scores that is predictable from the
student’s being in one of the particular ability levels. Utilizing Cohen’s rule of thumb,
the estimated differences among the population means is small if η² ≈.01, medium if η²
≈.06 and large if η² ≈.14 or larger (Cohen, 1988, pp. 285-87). The η² for the total pretest
scores was calculated. η²=.03. This value approximates the η² for the small effect.
Therefore the ability levels of Honors, General, and Foundations biology are a predictor
of student achievement on the pretests.

The η² for the total posttest scores was calculated. η²=.18. This value
approximates the η² for the large effect. Therefore the ability levels of Honors, General,
and Foundations biology are a good predictor of student achievement on the posttests.
Table 15

ANOVA - Method

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>total-pre</td>
<td>61.413</td>
<td>1</td>
<td>61.413</td>
<td>6.239</td>
<td>.013</td>
</tr>
<tr>
<td>Within Groups</td>
<td>2126.019</td>
<td>216</td>
<td>9.843</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2187.431</td>
<td>217</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between Groups</td>
<td>1.1E-02</td>
<td>1</td>
<td>1.084E-02</td>
<td>.000</td>
<td>.988</td>
</tr>
<tr>
<td>total-post</td>
<td>9544.503</td>
<td>216</td>
<td>44.188</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within Groups</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>9544.514</td>
<td>217</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A one-way ANOVA shows that there was a statistically significant difference between the total pretest scores of the actual and virtual method groups. The $F$ value was 6.239 with a significance level of .013 with 1 degree of freedom (see Table 15).

A squared Curvilinear Correlation, $\eta^2$ or $\text{eta}$ squared, was done to determine what proportion of the variance in total pre and posttest scores that is predictable from the students utilizing either the actual or virtual method. Utilizing Cohen’s rule of thumb, the estimated differences among the population means is small if $\eta^2 \approx .01$, medium if $\eta^2 \approx .06$ and large if $\eta^2 \approx .14$ or larger (Cohen, 1988, pp. 285-87). The $\eta^2$ for the total pretest scores of the two methodologies was calculated. $\eta^2 = .02$. This value approximates the $\eta^2$ for the small effect that can be partly explained by the previous analysis.

The one-way ANOVA also shows that there is no significant difference between the posttest scores of the actual and virtual method groups. The $F$ value was .000 with a significance level of .988 with 1 degree of freedom.
The $\eta^2$ for the total posttest scores of the two methodologies was calculated. $\eta^2$ was calculated at less than the small effect of .01.

The previous paired samples t-Tests indicated a statistically significant difference between the mean achievement scores, from pre to posttest, for both the actual and virtual methodologies. The ANOVA performed on the total posttest scores indicated no statistically significant difference between the mean achievement scores for the actual dissection method and the virtual dissection method. The virtual method group had thirty more students in it due to the scheduling process. The virtual method group had scored higher on the pretest and posttest compared to the actual group. This may indicate that the students in the virtual group had more prior knowledge of frog anatomy. Analysis of the posttest scores, however, indicated no statistically significant differences between the two methodologies used for frog dissection. Therefore the hypothesis of no significant difference in student achievement between students performing an actual frog dissection and a virtual On-line dissection as determined by a pre and posttest of basic frog anatomy cannot be rejected.
Table 16

Descriptive Statistics - Method

<table>
<thead>
<tr>
<th>Method</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual</td>
<td>8.17</td>
<td>3.48</td>
<td>94</td>
</tr>
<tr>
<td>total-pre</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Virtual</td>
<td>9.24</td>
<td>2.85</td>
<td>124</td>
</tr>
<tr>
<td>Total</td>
<td>8.78</td>
<td>3.17</td>
<td>218</td>
</tr>
<tr>
<td>total-post</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Virtual</td>
<td>15.07</td>
<td>6.96</td>
<td>94</td>
</tr>
<tr>
<td>Actual</td>
<td>15.09</td>
<td>6.40</td>
<td>124</td>
</tr>
<tr>
<td>Total</td>
<td>15.08</td>
<td>6.63</td>
<td>218</td>
</tr>
</tbody>
</table>

The total pretest mean of the Actual method group was 8.17 with a standard deviation of 3.48, n=94 (see Table 16).

The total pretest mean of the Virtual method group was 9.24 with a standard deviation of 2.85, n=124 (see Table 16).

The total posttest mean of the Actual method group was 15.07 with a standard deviation of 6.96, n=94 (see Table 16).

The total posttest mean of the Virtual method group was 15.09 with a standard deviation of 6.40, n=124 (see Table 16).
Table 17

ANOVA - Gender

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups total-pre Within Groups</td>
<td>2148.311</td>
<td>214</td>
<td>10.039</td>
<td>.164</td>
<td>.686</td>
</tr>
<tr>
<td>Total</td>
<td>2149.958</td>
<td>215</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between Groups total-post Within Groups</td>
<td>9271.715</td>
<td>214</td>
<td>43.326</td>
<td>1.711</td>
<td>.192</td>
</tr>
<tr>
<td>Total</td>
<td>9345.833</td>
<td>215</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A one-way ANOVA for gender shows that there was no significant difference between the pretest scores of males and females with an F value of .164 at the .686 significance level with 1 degree of freedom (see Table 17).

Likewise, the one-way ANOVA for gender shows that there was no significant difference between the posttest scores of males and females with an F value of 1.711 at the .192 significance level with 1 degree of freedom. Therefore the hypothesis of no significance difference between gender and achievement of students performing an actual frog dissection and a virtual On-line dissection as determined by a pre and posttest of basic frog anatomy cannot be rejected (see Table 18).
Table 18

Descriptive Statistics - Gender

<table>
<thead>
<tr>
<th>total</th>
<th>gender</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>total-pre</td>
<td>Male</td>
<td>8.91</td>
<td>3.52</td>
<td>102</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>8.74</td>
<td>2.82</td>
<td>114</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>8.82</td>
<td>3.16</td>
<td>216</td>
</tr>
<tr>
<td>total-post</td>
<td>Male</td>
<td>15.65</td>
<td>7.77</td>
<td>102</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>14.47</td>
<td>5.31</td>
<td>114</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>15.03</td>
<td>6.59</td>
<td>216</td>
</tr>
</tbody>
</table>


Qualitative Data Analysis

The following section contains the qualitative portion of this research. An analysis of the comments of three teachers involved in the study is provided. These comments, as indicated by the returned surveys, provide insight as to their perceptions regarding the dissection experience.

Teachers’ Responses

A complete copy of the survey questions and the corresponding responses to these questions by the three teachers are located in Appendix A. These questionnaires have been randomly assigned numbers 1-3 for purposes of anonymity.
The three teachers who utilized the actual and virtual dissection methods were surveyed as to their perceptions of these laboratory experiences. None of these three teachers had ever done a virtual dissection with any of their classes before.

Teacher number one indicated that Computer Assisted Instruction (CAI) can become a very useful and appropriate use of technology in the biology classroom. Teacher number two felt that CAI is beneficial under certain circumstances such as preview, review, long-term illness situations; to learn general concepts and to observe living organs in a pithed frog. Teacher three indicated that CAI serves best by supplementing the actual frog dissection experience.

As for a comparison of the two dissection methodologies: teacher number one felt that a virtual dissection can be used as an alternative to actual frog dissection. This teacher felt that the narrative that accompanied this particular virtual dissection was important to the experience. Teacher number two felt that the virtual dissection was not as messy or smelly as the actual experience. There was no clean up problem. This teacher found the segments on the beating heart and expanding lungs very educational. This teacher felt that the sense of touch was extremely important for understanding technique. This teacher also felt that students learn more by using senses other that the sense of sight. Teacher number three felt that the students become more interested and involved using hands-on when they are doing the actual dissection.

When asked what if any advantage(s) do you feel that one dissection methodology has over the other, teacher number one felt that the virtual dissection has several advantages over the actual: It was easier for the instructor to keep the students focused on one particular aspect of the dissection if all of the students are viewing one particular
web page that focuses on the identity of a particular organ or body part. This teacher felt that with the actual methodology that they could not be certain that the entire class is looking at the correct body part and not getting it mixed up with another part. This teacher further indicated that there is less preparation with the virtual methodology and possibly less cost. Teacher two felt that the actual method of dissection was better because the students can see and feel what they are doing. The students have the ability (in the actual dissection) to make significant and irreversible mistakes and therefore they learn better by making these mistakes. However, this teacher felt that, in the case of long-term illness, you can’t beat a virtual dissection. Teacher three felt that the students would learn better by using hands-on in the actual dissection methodology. This teacher felt that the students were looking forward to the actual since the beginning of the school year and that their attention span is greatly increased during this (hands-on) time.

In comparing disadvantage(s) of the actual and virtual methodologies: teacher number one felt that some students have difficulty working with the real organism. Teacher two indicates that the main disadvantage of the virtual is that one can only be as accurate as the computer monitor. This teacher feels that a student can only learn what the computer allows you to, so there is no room for accelerated learning. Teacher three found that most of the students did not want to just ‘click’ on certain areas of the computer screen. They wanted to do actual cuttings, pinning, and remove organs, etc.

Teacher number one felt the virtual dissection experience was very suitable for the regular ability and the foundations level students. The teacher felt that the information was not difficult to understand and that none of the students had any trouble using the computer. All of their students seemed to be very computer literate. Teacher
number two also felt that the virtual dissection experience was suitable for their students. However, this teacher indicated that they preferred as much hands-on experiences as possible. They further indicated that they would use the virtual methodology as a preview or review. Teacher number three felt that the use of the virtual methodology should be based on personal feelings about dissecting and not grade level.

In regards to perceptions on whether or not the virtual methodology is more appropriate for students with certain career aspirations: teacher number one did not feel that the virtual frog experience is more appropriate for students with certain career aspirations. Teacher number two felt that if a student (in their career aspiration) did not need any knowledge of anatomy and physiology that they supposed this (virtual) methodology was suitable. This teacher further indicated that if a student was dangerous with dissecting equipment that the virtual methodology may be suitable. Teacher number three strongly felt that everyone should try the actual dissection. This teacher felt that the actual dissection could be the one event that could influence a student into choosing a science career.

When asked if the virtual dissection is less, equally, or more suitable for a student interested in pursuing a career in science, Teacher number one felt that the virtual dissection experience was equally suitable for student who are interested in pursuing a career in science. This teacher felt that the actual and virtual experience were educationally equivalent. Teacher number two felt that the virtual methodology was less suitable. This teacher felt that hands-on experience, and using more senses, was a far better way to learn. Teacher three also felt that the virtual methodology was less suitable for a student interested in pursuing a career in science. This teacher felt that the students
interested in pursuing science careers looked forward to the actual dissection. This teacher felt that these students became more involved in their work.

Regarding the suitability of the virtual dissection methodology for Honors, General Ability, or Foundations level students, teacher number one felt that any virtual dissection could be designed for any particular ability level. This teacher felt that it is up to the instructor to find the appropriate virtual dissection experience. Teacher number two again, felt that the virtual methodology was less suitable, that hands-on experience, and using more senses, was a far better way to learn. Teacher number three felt that the virtual dissection methodology would work best with the foundations level students. This teacher felt that this would best be used an introduction to the actual dissection which would be done at a later time.

Teacher number one felt that it appeared that the students had less difficulty dissecting the actual frog after dissecting the virtual frog. This teacher felt that the students had gained a great deal of knowledge by dissecting the virtual frog before they dissected the actual frog. Teacher number two felt that a virtual dissection enables the students to learn what to expect. This teacher felt that viewing the Quick Time movie segments of a pithed frog (in the virtual method) was very interesting because they do not pith (live) frogs anymore. Teacher number three felt that their students looked forward to the actual dissection and that they could not wait for the virtual dissection to be over.

Teacher number one felt that the virtual dissection is educationally equivalent to an actual dissection experience for any student who objects to an actual dissection for moral or ethical reasons. Teacher number two also feels that under these circumstances that the virtual dissection is absolutely an educationally appropriate alternative. This
teacher indicates that it is not necessary to compel a student to do an actual dissection for any reason. However, this teacher feels that the experience of viewing a dissection is very important to understand anatomy. Teacher number three also feels that the virtual dissection is an educationally appropriate experience for those who object to an actual dissection for moral or ethical reasons. However, this teacher feels that everyone should try to participate in the actual dissection. If any student feels very strongly about not doing an actual dissection, then they should be able to work on the virtual dissection.
CHAPTER IV

Summary, Conclusions and Recommendations

Introduction

In this chapter, a summary of the purpose of this study is presented. Next is a statement of the research questions, the null hypotheses and the subsidiary questions. A summary and discussion regarding the findings of this study is provided. The conclusions, recommendations for educational practice and recommendations for further research complete this chapter.

Summary of the Purpose of this Research

For a variety of reasons, alternatives to dissections have become necessary. Religious reasons (J.G.M., on behalf of his minor child, M.M., Petitioner, v. Board of Education of the Woodstown-Pilesgrove Regional School District ET. AL., Respondents, 1989) and concerns regarding the ethical treatment of animals (Jackson, 1991) have been cited as reasons when individuals refuse to participate in dissection activities. Other concerns include the use of sharp instruments by some students (Anzovin, 1993) and exposure to vapors from chemicals used to fix or preserve specimens (Oosthuizen, 1998), (Anzovin, 1993) used for dissection. Some students have received penalties for refusing to dissect animals in the classroom laboratory (Wells, 1989; J.G.M., on behalf of his minor child, M.M., Petitioner, v. Board of Education of the Woodstown-Pilesgrove Regional School District ET. AL., Respondents, 1989). As previously mentioned, seven
states are reported to have laws, policies or resolutions regarding alternatives to animal dissection. In particular, New Jersey, the state in which this study was done, has case law to support a supervised alternative to dissection (J.G.M., on behalf of his minor child, M.M., Petitioner, v. Board of Education of the Woodstown-Pilesgrove Regional School District ET. AL., Respondents, 1989).

Amphibian species, including frogs, are in decline worldwide (Cone, 2000; Murphy, and Fortner, 2001). Millions of frogs are dissected each year in classroom laboratories. The species of North American frog “Rana Pipens” was subjected to over collection and depletion of the population in the 1960’s (Orlans, 1988a). The National Association of Biology Teachers does not feel that any alternative can substitute for an actual dissection experience, but does encourage teachers to be ‘sensitive’ to student objections regarding dissection and consider providing ‘appropriate lessons’ when necessary (NABT, 1995).

The main purpose of this study was to evaluate the effectiveness of an On-line virtual frog dissection as a alternative for three different ability levels of biology classes in a Northeastern New Jersey high school. This study also provides insight as to the perceptions of the teachers of these three different ability levels regarding the virtual experience as compared to the actual dissection experience. Gender was also considered during the achievement component of this study.

**Statement of Research Question #1**

How does basic achievement on a Pre and Posttest of basic frog anatomy compare between the students performing a virtual On-line frog dissection vs. an actual laboratory frog dissection?
Research question corresponds to research null hypothesis # 1 denoted below.

**Research Null Hypothesis # 1**

There is no significant difference in achievement between students performing an actual frog dissection and a virtual On-line dissection as determined by a pre and posttest of basic frog anatomy.

This study found that the gain in knowledge, as shown by a comparison of the posttest scores among the students in the three ability levels, showed no statistically significant difference between the treatment and conventional frog dissection groups. The ANOVA showed that there was no significant difference between the posttest scores of the actual and virtual method groups ($F = .000$ with a significance level of $.988$ for $p > .05$ df = 1). This suggests that no matter what method was utilized, the students showed statistically similar results in achievement regarding basic frog anatomy as determined by the posttest. The virtual method group had scored higher on the pretest and posttest compared to the actual group. This may indicate that the students in the virtual group had more prior knowledge of frog anatomy. Analysis of the posttest scores, however, indicated no statistically significant differences between the two methodologicals used for frog dissection. Therefore the null hypothesis of no significant difference between pretest to posttest student achievement in basic frog anatomy cannot be rejected.

Marszalek (1998) found that there was a significant difference favoring a conventional dissection over a desktop Microworld treatment in an immediate posttest. A delayed posttest comparison however, showed that a desktop Microworld and a CD-tutorial were statistically similar to the conventional treatment and were "viable
alternatives to physical frog dissection in retaining knowledge gained over the long-term (p.220).

Harper (1995) compared interactive video level III instruction to conventional frog dissection and found no significant difference between achievements in the multiple choice knowledge portion of the posttest. Harper's (1995) study which involved only A level biology students did find a significant difference between the conventional dissection and the interactive video level III treatment on the organ identification portion of the posttest. In this portion of the posttest the students had to view colored slides and identify the names of selected organs. Harper (1995) cites possible factors such as: the video segments in the treatment may not have identified individual organs with respect to surrounding organs and their identification; computer generated diagrams may have lacked realism, and students may have had trouble identifying organs on black and white computer-generated diagrams. Strauss (1993) found no significant difference between achievement for students using an Interactive Frog Dissection and an actual frog dissection. This lack of significance in achievement found between virtual and conventional instructional methods also agrees with non-dissection research studies that compared computer assisted instruction to traditional/conventional forms of instruction and found no significant difference by treatment (Boucher et al., 1999; Huppert, Yaakobi, and Lazarowitz 1998; Morrell 1992; & Mattingly and Barnes as cited in Berube et al., 1999).
Statement of Research Question # 2

What are the perceptions of the teachers regarding the actual and virtual lab dissection experiences of the three levels of high school Biology classes?

The three teachers involved in the study had a number of different perceptions regarding a comparison of the virtual and actual frog dissection experience. The responses of these three teachers were assigned random numbers one through three for purposes of anonymity. None of these three teachers had ever done a virtual dissection before. All three teachers firmly agreed that a virtual frog dissection was an educationally appropriate alternative for any student, regardless of ability level, who objects to doing an actual or conventional frog dissection. This was the main topic of agreement among the three biology teachers. In other areas, the three teachers’ perceptions of the virtual experience as compared to the actual dissection experienced varied.

Teacher number one indicated that the virtual dissection was not more appropriate for one ability level than another. This same teacher further indicated that the virtual dissection was not more appropriate for students with certain career aspirations. This teacher indicated it was equally appropriate for students interested in pursuing a career in science. Teacher number one also indicated that doing the virtual dissection first appeared to lessen the difficulty for the students that dissected the actual frog subsequent to the virtual dissection. The teacher felt that the students had a great deal of prior knowledge (from the virtual frog dissection experience). Advantages of the virtual method over the actual method indicated by this teacher were the ease in which to keep
student focused on particular aspects of the dissection, less preparation for the virtual
dissection and possibly less cost.

Teacher number two indicated that the virtual dissection was less appropriate than
an actual dissection for all three of the ability levels. This same teacher supposed that the
virtual dissection was more appropriate only for students with career aspirations that had
no need for knowledge regarding anatomy and physiology. Teacher number one also
indicated that doing the virtual dissection first enables students to learn what to expect
(regarding an actual dissection). This teacher felt that viewing the Quick Time Movie
segments on a pithed frog were very interesting because they no longer pith any frogs.
Teacher number two felt that the actual dissection is better than the virtual dissection
because the students get to see and feel what they are doing. This teacher felt that it was
an advantage for the students to make “terrible and irreversible mistakes and therefore
they learn better by their mistakes” (Appendix A). The advantage of the virtual method
over the actual method indicated by this teacher was its use in the case of long-term
(student) illness.

Teacher number three indicated that the virtual dissection was not more appropriate
than an actual dissection for any of the three of the ability levels. Teacher number three
felt strongly that all students should try an actual dissection; that whether or not a virtual
dissection was suitable for the ability level you currently teach should be based on
personal feelings about dissection rather than grade levels. This same teacher felt that a
virtual dissection was less suitable for students interested in pursuing a career in science.
Teacher number three felt that doing a virtual dissection would work best with the
Foundations level students; furthermore it should be used first as and introduction to the
subsequent actual dissection. Teacher number three, as did teacher number two, felt that the actual dissection is better than the virtual dissection. Teacher number three indicated that the hands-on in actual dissection enabled the students to learn better, attention span is greatly increased during actual dissections, and that their students have been looking forward to actual dissections. This teacher felt that the advantage of the actual method over the virtual method was that most students would rather do actual dissection procedures than 'click' the mouse on certain sections of a computer screen.

The three teachers agreed in their perceptions of the virtual frog dissection being an educationally appropriate alternative for any student who objects to an actual dissection. However, two of the teachers favored the actual dissection over the virtual dissection. Teacher one felt that the virtual dissection was equally suitable for the students in the ability levels they taught, as well as for students pursuing a science career. Teachers two and three did not. Teacher two felt that the virtual dissection was less suitable for all ability level students because more senses are being used in the actual hands on dissection experience. This teacher felt that the Computer Assisted Instruction was best suited to circumstances of preview, review, long-term illness and observing living organs in a pithed frog. Teacher three felt that the virtual dissection was best suited as a preparation for the Foundations level students. Even though all three teachers indicated that the virtual dissection experience was an educationally appropriate alternative for students who object to an actual frog dissection; teachers two and three favored the actual dissection overall, while teacher number one found the virtual and actual dissection experience equally suitable.
**Subsidiary Question # 1**

Is there a difference in achievement among the Honors, General Ability, and Foundations level Biology classes?

The discussion of subsidiary question # 1 corresponds to the research null hypothesis # 2 denoted below.

**Research Null Hypothesis #2**

There is no significant difference among student achievement for each of the three levels of Biology classes: Honors, General Ability, and Foundations levels performing an actual frog dissection and a virtual On-line dissection as determined by a pre and posttest of basic frog anatomy.

\[ H_0: \text{Honors achievement} = \text{General Ability achievement} = \text{Foundations achievement}. \]

This study controlled for course levels. Out of the 218 total participants, 32 were Honors level. 142 were General Ability level. 44 were Foundations level students. The Honors level students comprised 14.7% of the participants. The General Ability level comprised 65.1% of the participants. The Foundations level comprised 20.2% of the participants in the study.

A one-way ANOVA indicated that there was a significant difference between the total pretest scores of the Honors, General Ability and Foundations level groups (F = 3.782 with a significance level of .024 for p < .05 df = 2).

The mean score for the Honors ability level pretest was 10.06. The mean score for the General ability level pretest was 8.70. The mean score for the Foundations ability level pretest was 8.09.
Likewise, the ANOVA shows that there was significant difference between the total posttest scores of the Honors, General Ability and Foundations level groups ($F = 23.899$ with a significance level of .000 for $p < .05$ $df = 2$).

The mean posttest score for the Honors ability level was 21.25. The mean posttest score for the General ability level was 14.74. The mean posttest score for the Foundations ability level was 11.70.

The Tukey HSD performed on the total combined pre and total combined posttest scores indicated where the statistically significant differences among the means occurred. The mean difference between the Honors ability level pretest scores and the Foundations ability level pretest scores was 1.97. This was statistically significant at the .019 level of significance (for $p < .05$).

The mean difference between the Honors ability level posttest scores and the General ability level posttest scores was 6.51. This was statistically significant at the .000 level of significance (for $p < .05$). The mean difference between the Honors ability level posttest scores and the Foundations ability level posttest scores was 9.55. This was statistically significant at the .000 level of significance (for $p < .05$).

The mean difference between the Honors ability level posttest scores and the Foundations ability level was 3.03. This was statistically significant at the .010 level of significance (for $p < .05$). Therefore the hypothesis of no significant difference among student achievement for each of the three levels of Biology classes: Honors, General Ability, and Foundations levels performing an actual frog dissection and a virtual On-line dissection as determined by a pre and posttest of basic frog anatomy ($H_0$: Honors achievement = General Ability achievement = Foundations achievement) was rejected.
Strauss' (1993) study comparing an interactive disk simulation to preserved frog specimens also grouped students into three ability levels. His study found that the students in the middle achievement level of the simulation group had the highest posttest mean scores and the students in the lowest achievement level had the lowest mean posttest scores. In the traditional dissection group, the students with the highest achievement levels had the highest posttest scores. The medium achievement level group scored the next highest posttest scores. The lowest achievement level group obtained the lowest posttest mean scores. With the exception of the middle level achievement mean scores in the simulation group, similar results were found in this study. Posttest achievement mean scores in both simulation and conventional groups corresponded to ability level. The highest ability level groups achieving the highest mean scores and the lowest ability level achieving the lowest mean scores.

A squared Curvilinear Correlation, $\eta^2$ or eta squared, was performed to determine what proportion of the variance in total pre and posttest scores that is predictable from the student's being in one of the particular ability levels. The $\eta^2$ for the total posttest scores was calculated. $\eta^2 = .18$. This value approximates the $\eta^2$ for the large effect (Cohen, 1988, pp. 285-87). Therefore the ability levels of Honors, General, and Foundations biology are a good predictor of student achievement on the posttests.

Subsidiary Question # 2

Does a student's gender influence their achievement on the dissection experience?

The discussion of subsidiary question corresponds to null hypothesis # 3 denoted below.
Research Null Hypothesis #3

There is no significant difference between gender and achievement of students performing an actual frog dissection and a virtual On-line dissection as determined by a pre and posttest of basic frog anatomy.

Controlling for gender, the ANOVA performed on achievement scores in this study, shows that there was no significant difference between the posttest scores of males and females ($F = 1.711$ and is not significant at $p > .05$, df = 1).

Strauss (1993), Strauss and Kinzie (1994) found no significant difference in achievement based on gender. Akpan’s (1998) study using computer simulation software of a frog dissection utilized in a treatment before an actual dissection as compared to using the simulation software being used in a treatment after an actual dissection, and in a control group, found no significant difference in posttest achievement due to gender.

Subsidiary Question #3

Is a virtual On-line dissection is an educationally appropriate alternative for any student who objects to an actual dissection for moral or ethical reasons?

The ANOVA performed on the achievement scores in this study indicated that there was no significant difference between the posttest scores of the actual and virtual method groups ($F = .000$ with a significance level of $.988$ for $p > .05$ df = 1). This finding agrees with the no significant difference achievement between treatments in frog dissection found by Strauss (1993), the multiple-choice test of knowledge in Harper (1995), and in long-term retention by Marszalek (1998). Other studies that compared computer assisted instruction to traditional/conventional forms of instruction and found

In this study the perceptions of the three teachers involved all indicated that the virtual frog dissection was an educationally appropriate alternative for any student who objects to an actual dissection. Two of the three teachers involved indicated a preference for actual dissections over virtual dissections, yet all three teachers agreed that the virtual frog dissection experience was an educationally appropriate alternative for any student who objects to an actual dissection for moral or ethical reasons. These perceptions agree with overall conclusions of Marszalek (1998), and Strauss (1993) regarding frog dissection simulations. It is therefore concluded from this study that a virtual On-line dissection is an educationally appropriate alternative for any student who objects to an actual dissection for moral or ethical reasons.

**Subsidiary Question # 4**

Is the virtual dissection experience more or less suitable for a particular level of Biology class?

A paired samples t-Test performed on the total pre and posttest scores of the virtual method of dissection group indicated a significant difference in achievement from pre-test to post-test for the virtual methodology (t= -10.396 statistically significant at .000 for p < .05, df=123). The total pre test mean was 9.24 with a standard deviation of 2.85 and a standard error of .26, n=124. The total post-test mean was 15.09 with a standard deviation of 6.40 and a standard error of .57, n=124. The mean difference is 5.85 with the total post-test having the higher mean score. This evidence suggests that there was a
statistically significant gain in knowledge from pre to post tests among the three ability levels utilizing the virtual method.

A paired samples t-Test performed on the total pre and posttest scores of the actual method of dissection groups indicated a significant difference in achievement from pre-test to post-test for the actual methodology \( (t=9.273 \text{ statistically significant at } .000 \text{ for } p < .05, \text{ df}=93) \). The total pre test mean was 8.17 with a standard deviation of 3.48 and a standard error of .36, \( n=94 \). The total post-test mean was 15.07 with a standard deviation of 6.96 and a standard error of .72, \( n=94 \). The mean difference is 6.90 with the total post-test having the higher mean score. This evidence suggests that there was a statistically significant gain in knowledge from pre to post tests among the three ability levels utilizing the actual method.

The Mean posttest achievement scores for the Honors ability level were 21.25, 14.74 for the General ability level, and 11.70 for the Foundations ability level.

The ANOVA performed on the posttest achievement scores showed that there was no significant difference between the posttest scores of the actual and virtual method groups \( (F =.000 \text{ not significant at } .988, \text{ for } p > .05, \text{ df} = 1) \).

The statistical results mentioned above suggests that achievement results on a basic test of frog anatomy are statistically similar among the three levels utilizing the treatment method as compared to the conventional frog dissection method.

The \( 
eta^2 \) for the total posttest scores was calculated at \( 
eta^2=.18 \). This value approximates the \( 
eta^2 \) for the large effect (Cohen, 1988, pp. 285-87). Therefore the ability levels of Honors, General, and Foundations biology are a good predictor of student
achievement on the posttests. This suggests that ability level is a good predictor of student achievement between the three ability levels.

The cumulative statistical data suggests that the treatment groups gain knowledge statistically similar to that of the conventional dissection groups to a degree that is proportional to their ability grouping.

The perceptions of the three teachers who utilized both the treatment and conventional methods are now discussed. Two of the three teachers taught two different ability levels: General Ability level and Foundations level. One teacher taught the Honors Biology level. On the basis of the surveys, teacher number one indicated that the virtual dissection was not more appropriate for one ability level than another. This teacher felt that it was up to teacher to find an appropriate virtual dissection. This teacher indicated that the virtual dissection was very suitable for the ability levels they taught. Teacher number two indicated that the virtual dissection was suitable for the ability level they taught and would prefer to use it for preview and review purposes because they preferred hands on dissections and found the virtual dissection less appropriate than an actual dissection for all three ability levels for this reason. Teacher number three indicated that the virtual dissection was not more appropriate than an actual dissection for any of the three of the ability levels. Teacher number three felt that doing a virtual dissection would work best with the Foundations level students; used first as and introduction to the subsequent actual dissection. Teacher number three, as did teacher number two, preferred the actual dissection to the virtual dissection. Teacher number three indicated that the hands-on in actual dissection enabled the students to learn better, attention span is greatly increased during actual dissections, and that their students have
been looking forward to doing actual dissections. Each of the three teachers did find the virtual dissection suitable for the ability level(s) they taught. Two of the teachers preferred the actual dissection to the virtual dissection for their students. These same two teachers would prefer to use the virtual dissection as a preview, and review. One of these two teachers would include to this list circumstances of long-term illness, learning general concepts and viewing living (moving) organs in a pithed frog. All three teachers agreed that the virtual frog dissection would be suitable for students who objected to an actual frog dissection.

**Subsidiary Question # 5**

Do a student’s career aspirations affect the teacher’s perceptions of the virtual dissection experience?

Teacher number one indicated that a virtual frog dissection was not more suitable for students with certain career aspirations. This teacher felt that the virtual dissection was equally suitable for students who were interested in pursuing a career in science.

Teacher number two supposed that the virtual dissection would (only) be suitable for a student who had a career aspiration that did not require any knowledge of anatomy and physiology. This teacher also felt that the virtual dissection was less suitable for a student interested in pursuing a career in science because more senses were being used in the actual dissection and the hands on approach (of the actual dissection) was a far better way to learn.

Teacher number three felt that everyone should try actual dissection. This teacher felt that the actual dissection might be the one thing that could influence a student towards a science career. Teacher number three further indicated that virtual dissections
are less suitable for students interested in pursuing a career in science. This teacher indicates that students interested in pursuing science careers look forward to doing actual dissections and become more involved in their work.

In conclusion, the students' career aspirations do affect the perceptions of the virtual dissection experience. While teacher number one indicated that the virtual dissection experience was equally suitable for all students regardless of career aspirations, Teacher number two supposed that the virtual experience was suitable for students absolutely not needing any knowledge of anatomy and physiology in their aspired career. Teacher number three felt the virtual dissections were less suitable for all students regardless of career aspiration. Teacher number three felt that all students should try actual dissections and that students with science career aspirations looked forward to doing actual dissections.

The perceptions of the three teachers in this study comprise a relatively small sample of biology teachers. This sample is important, however, because these three teachers make up the entire population of the teachers teaching biology in this high school. Cumulatively, they have over 25 years of experience teaching biology. These are the perceptions of the teachers whose instruction impacts the 218 or so students that take biology each year in this high school. It is their perceptions that provide us with insight as to the context in which they view the overall virtual frog dissection experience as compared to the actual/traditional frog dissections. Their perceptions may or may not be comparable to other biology teachers in other high schools. For a New Jersey high school with a student population of approximately 1100 students, three biology teachers instructing biology classes may be somewhat typical to other high schools the
approximate size and DFG of the one involved with this study. In New Jersey the
assigned DFG is an indicator of the socioeconomic status of the citizens in the district.
DE is the DFG of the high school involved with this study. According to a publication of
the New Jersey Department of Education (2001) there are 100 New Jersey School
Districts with the District Factor Group (DFG) of DE.

Recommendations for Educational Practice

Ethical or moral objections to animal dissections have been raised (Balcombe,
1994; Jackson, 1991; J.G.M., on behalf of his minor child, M.M., Petitioner, v. Board of
Education of the Woodstown-Pilesgrove Regional School District ET. AL., Respondents,
1989). The virtual On-line dissection is recommended as an alternative for students who
have moral and or ethical objections to conventional frog dissection. The application of
this virtual On-line dissection may supersede the current practice by some teachers of
 ‘doing a report’ on frog anatomy, or viewing a videotape of frog dissection in lieu of
actual frog dissections for students who object to doing actual dissections. Virtual On-
line dissections may also be a viable alternative in certain applications where the use of
sharp objects such as scalpels and exposure to chemicals is a concern (Anzovin, 1993).
Logically, these concerns may be even more pronounced for middle school children than
for older students. Marszalek (1998) reports in her Epilogue that, subsequent to the
results of her study, the seventh-grade life science teachers shifted their classroom
practice towards a desktop Microworld approach to frog dissections. The teachers
involved with the study elected to do only one actual frog dissection per class period as a
demonstration presented before the students participate in the desktop Microworld
dissection experience.
Virtual On-line frog dissections may also have value as preparation activity prior to conventional frog dissection. Akpan (1998) found that a virtual frog simulation done prior to doing an actual frog dissection increased the level of learning as compared to a control group. Certain types of dissections may be able to be performed in earlier grade level courses using a virtual method; thus preparing students for future, more advanced dissection experiences, whether they are virtual or actual in nature.

Conventional frog dissections may not be the method of choice for every student. According to the National Association of Humane and Environmental Education only 4% of fifth graders will obtain a college degree in science, “and not all of those will be in a medical field” (Jackson, 1991, p. 18). This is not mentioned in order to suggest that only students pursuing a science or medical career should perform actual dissections. It does however; provide some context as to how many students pursue higher learning in these fields. Anzovin (1993) questions whether or not millions of students performing dissections each year need use real frogs. The National Association of Biology Teachers (NABT) feels that no alternative can substitute for the actual experience of dissecting an animal. Teachers are cautioned by the NABT to be aware of the limitations of alternatives to dissection. The NABT further indicates that when the best way to meet instructional objectives do not require dissection, alternatives, including forms of multimedia should be found. Teachers are encouraged by the NABT to be sensitive to ‘substantive’ objections of students regarding dissection and provide alternatives when necessary (NABT, 1995). Reports suggest that frogs are disappearing from the wild (Murphy & Fortner, 2001; Cone, 2000). In light of this information, and research on the efficacy of dissection simulations, Marszalek (1998), Strauss (1993), Harper (1995), even
more consideration may be advisable as to when an actual frog dissection is appropriate and when and to what degree available virtual frog dissections can supplement or provide educationally viable alternatives to actual frog dissections. Orlans (1991) suggests that the few people who say they were influenced towards the biological sciences by dissection will also say they may just as well have been influenced by studying unharmed living organisms.

The three teachers involved in this current study made informal comments to the effect that their students had very little, if any, trouble using the computers. Their students seemed to be generally familiar with the operations of the computer and the Internet. This informal consensus agrees with Jensen (1998) who reported that during the first few years that computers were introduced into biology labs in a university, a great deal of time was spent helping students learn how to use them. Several years later, relatively little time was spent on teaching computer basics to students. It is reasonable to suggest that as time has progressed students, in general, have become more familiar with computers and the Internet. Therefore, accessing a virtual dissection that is On-line may be a readily usable method of instruction for traditional students as well as for those who cannot or do not attend traditional school classes. These circumstances may apply to students who are out ill, receiving home instruction, involved in distance learning, or are home schooled. The virtual dissection does not require laboratory dissection equipment. Virtual dissections, whether On-line or not, involve no actual specimens, chemicals, or odors. Virtual animal dissections may be accessed On-line as freeware or shareware. This may assist in providing access to a frog dissection alternative when cost, environmental, ethical, and/or safety issues are a consideration.
Recommendations for Further Research

The application of a virtual On-line method of instructing students in dissection needs to be evaluated in future research with students receiving home instruction, involved in distance learning, or are for those who are home schooled.

This study was done one time with 218 students in the three levels of Biology classes offered in a Northeastern New Jersey high school with a socioeconomic District Factor Grouping (DFG) = 4, or DE. Future research is needed to explore whether these results are repeatable with other schools with the same DFG and to schools with different DFG’s in other geographic areas.

The application of a virtual On-line method of instructing students in dissection of other animal species such as (fetal) pigs and cats needs to be evaluated in future research.

In the future, even more sophisticated interactive virtual dissection materials may evolve. If so, these will need to be evaluated for use in the field of education. These new materials may incorporate individual variations into the specimens being virtually dissected. Teachers who teach gross anatomy to physical therapy education students responded in a survey regarding their use of cadavers and computers that “students cannot gain the full tactile experience with computers alone” (Berube, et al. 1999, p.45). New technology leading towards a full tactile sense of the dissection experience may add an increased sense of realism to the audio and visual dimensions of virtual dissections.

An Associated Press article in the “Bergen Record” (2002) reports that a 70-year-old man, recently in a New York hospital, was the subject of the United States’ first robotically assisted coronary bypass operation. With this new technology, the subject did not require the traditional 10-inch chest incision or the longer hospital stay associated
with the traditional bypass surgery. This operation utilized the Da Vinci robotic system. This system provides a 3-D view inside the body, and has surgical instruments that have a range of motion similar to that of a human wrist. Here is a case in which a doctor is using a monitor and robotically controlled arms instead of traditional surgical instruments to perform surgery. There was no actual intrusion of the doctor’s hands into the patient’s chest. The doctor’s hands did not directly apply the surgical instruments to the patient during the surgery. Three pencil-sized holes made between the patient’s ribs allowed the entry of the tiny camera and two robotic arms. This surgical event provides a new context in which to place future discussions on virtual laboratory simulations not being ‘real’ and whether or not they are less suitable for those individuals pursuing careers in science or medicine.
References


http://e4rs.org/dissection/dissection.html


http://www.nabt.org/sub/position_statements/animals.asp

Net Frog. Retrieved May 2, 2001, from the World Wide Web:

http://teach.virginia.edu/go/frog


Appendices
Appendix A

Teachers' Responses
1. Have you ever done a virtual dissection with any of your classes before this current dissection experience?

No

a). If so what animal was simulated?

N/A

b). What was the nature (format) of the dissection experience?

N/A

2. How do you feel about using Computer Assisted Instruction in Biology classroom learning situations?

I feel this can become very beneficial to teaching biology. It is also an appropriate use of technology in the classroom.

3. How do you feel the virtual frog dissection experience compares with the actual frog dissection experience?

I feel that a virtual dissection can be used as an alternative to an actual frog dissection. This particular dissection provided an important narrative with each step to the dissection.
4. What, if any advantage(s) do you feel one dissection methodology has over the other?

I feel the virtual dissection has an advantage of the actual dissection for several reasons. It is easier for the instructor to keep the students focused on one particular aspect of the dissection if all the students are looking at one particular web page that clearly identifies a particular organ or other body part. With actual dissections one can't be certain that the entire class is looking at the correct body part and not getting it mixed up with another. There is less preparation in the lab with a virtual dissection, and there is possibly less cost involved with a virtual dissection.

5. What, if any disadvantage(s) do you feel one dissection methodology has over the other?

Some students have difficulty working with an actual organism.

6. How suitable, or not, is the virtual dissection experience for the students in the ability level you currently teach? Why?

The virtual dissection was very suitable for foundations and regular biology. The explanations were not difficult to understand and none of the students had difficulty with the computer. All students seem to be very computer literate.

7. Do you feel that the virtual dissection experience is more appropriate for students with certain career aspirations? If so which career aspirations? Why?

No, I do not feel that the virtual frog dissection is more appropriate for students with certain career aspirations.
8. Do you feel that the virtual dissection experience is: less, equally, or more suitable for students who are interested in pursuing a career in science? Why?

I feel that virtual frog dissection is equally suitable for students who are interested in pursuing a career in science. This activity is educationally equivalent to an actual dissection.

9. Do you feel a virtual dissection less, equally, or more suitable for Honors, General Ability, or Foundations level students? Why?

Any virtual dissection can be designed for a particular ability level. It is up to the instructor to find an appropriate virtual dissection. All of these students have computer skills.

10. Which of the choices below do you feel would have the most instructional value for your students? (Circle one)

a). Actual dissection then virtual dissection
b). Virtual dissection then actual dissection
c). Actual only
e). Virtual only
f). No dissections

Why?

Virtual then actual, it appeared less difficult for the students to dissect an actual frog after dissecting a virtual frog. They had a great deal of prior knowledge (from the virtual frog) before they dissected the actual frog.
11. Do you feel that a virtual On-line dissection is an educationally appropriate alternative for any student who objects to an actual dissection for moral or ethical reasons? Why?

Yes, the virtual dissection is educationally equivalent to an actual dissection.
Teacher Number 2

1. Have you ever done a virtual dissection with any of your classes before this current dissection experience?

No

a). If so what animal was simulated?

b). What was the nature (format) of the dissection experience?

2. How do you feel about using Computer Assisted Instruction in Biology classroom learning situations?

   It is beneficial under certain circumstances:
   preview
   review
   long term illness
   general concepts
   observing living organs in a pithed frog.

3. How do you feel the virtual frog dissection experience compares with the actual frog dissection experience?
It is not as messy or smelly and clean up is no problem. Also, viewing a beating heart and expanding lungs is very educational. However, students learn more by using senses other than sight. I believe the sense of touch is extremely important for understanding technique.

4. What, if any advantage(s) do you feel one dissection methodology has over the other?

The actual dissection is better because students can see and feel what they are doing. They have the ability to make terrible, irreversible mistakes and therefore they learn better because they make mistakes. However in the case of long term illness, you can’t beat a virtual dissection.

5. What, if any disadvantage(s) do you feel one dissection methodology has over the other?

The main disadvantage of the virtual is, one can only be as accurate as the “monitor.” One can only learn what the computer allows so there is no room for accelerated learning.

6. How suitable, or not, is the virtual dissection experience for the students in the ability level you currently teach? Why?

It is suitable, however I would use a virtual dissection as a preview or review to an actual dissection because I like my students to get as much hands on experience as possible.

7. Do you feel that the virtual dissection experience is more appropriate for students with certain career aspirations? If so which career aspirations? Why?

If a student has absolutely no need for knowledge regarding anatomy and physiology I suppose this type of dissection is suitable or if the student is dangerous with dissecting equipment it may be suitable. But I do not know which could be appropriate.
8. Do you feel that the virtual dissection experience is: less, equally, or more suitable for students who are interested in pursuing a career in science? Why?

Less, because hands on experience is a far better way to learn, more senses are being used.

9. Do you feel a virtual dissection less, equally, or more suitable for Honors, General Ability, or Foundations level students. Why?

Less, for the same reason as # 8.

10. Which of the choices below do you feel would have the most instructional value for your students? (Circle one)

a). Actual dissection then virtual dissection
(b). Virtual dissection then actual dissection
(c). Actual only
(e). Virtual only
f). No dissections

Why?

A virtual dissection allows students to learn what to expect. Also, viewing a pithed frog is very interesting because we do not pith frogs anymore.

11. Do you feel that a virtual On-line dissection is an educationally appropriate alternative for any student who objects to an actual dissection for moral or ethical reasons?
Why?
Absolutely, I do not feel it is necessary to force a student to dissect for any reason.

However, the experience of viewing dissection is very important for an understanding of anatomy.
1. Have you ever done a virtual dissection with any of your classes before this current dissection experience?

None

a). If so what animal was simulated?

b). What was the nature (format) of the dissection experience?

2. How do you feel about using Computer Assisted Instruction in Biology classroom learning situations?

It serves best as a supplement to the actual frog dissection.

3. How do you feel the virtual frog dissection experience compares with the actual frog dissection experience?

I believe that the students become more interested and involved with hands-on when they do the actual frog dissection.
4. What, if any advantage(s) do you feel one dissection methodology has over the other?

I think students will learn better by using hands-on in dissection. Their attention span is greatly increased during this time plus it’s something they’ve been looking forward to since the beginning of the school year.

5. What, if any disadvantage(s) do you feel one dissection methodology has over the other?

I found that most students didn’t just want to “click on” certain areas on a computer screen. The wanted to do actual cuttings, pinnings, removal of organs, etc.

6. How suitable, or not, is the virtual dissection experience for the students in the ability level you currently teach? Why?

I don’t think it can be based on grade level but rather on personal feelings about dissecting.

7. Do you feel that the virtual dissection experience is more appropriate for students with certain career aspirations? If so which career aspirations? Why?

No, I strongly feel that everyone should try the actual dissection. It may be the one thing that can influence a person into a career in science.

8. Do you feel that the virtual dissection experience is: less, equally, or more suitable for students who are interested in pursuing a career in science? Why?
I think it is less suitable. I have that those students pursuing a career in science look forward to actual dissections. They become more involved in their work.

9. Do you feel a virtual dissection less, equally, or more suitable for Honors, General Ability, or Foundations level students. Why?

I think that the virtual dissection would work best with foundations level students. This would be used before the actual dissection as an introduction to what they’ll be doing in the future.

10. Which of the choices below do you feel would have the most instructional value for your students? (Circle one)

a). Actual dissection then virtual dissection
b). Virtual dissection then actual dissection
c). Actual only
d). Virtual only
e). No dissections
f). No dissections

Why?

I have found that students look forward to doing actual dissections. Those students that started with the virtual couldn’t wait for it to be over.

11. Do you feel that a virtual On-line dissection is an educationally appropriate alternative for any student who objects to an actual dissection for moral or ethical reasons? Why?
Yes, I still believe that everyone should try to do the actual dissection. But if a student feels very strong about not doing it, then they should be able to work on the virtual dissection.
Appendix B

Institutional Review Board (IRB) Approval Letter
May 24, 2001

<School name>
<Street address>
<Town, NJ>

Dear Mr. Kopek:

The Institutional Review Board For Human Subject Research at Seton Hall University reviewed your proposal entitled "Virtual, On-Line Frog Dissection vs. Conventional Laboratory Dissection: A Comparison of Student Achievement and Teacher Perceptions Among Honors, General Ability, and Foundations Level High School Biology Classes". Your project has been approved as amended by the revisions submitted to the Chair of the IRB. Enclosed please find the signed Request for Approval form for your records.

The Institutional Review Board approval of the project is valid for a one year period from the date of the original approval letter. Any changes to the research protocol must be reviewed and approved by the committee prior to implementation. Thank you for your cooperation and best wishes for the success of your research.

Sincerely,

Robert C. Hallissey, Ph.D.
Acting Chair
Institutional Review Board

c: Juan Cobarrubias, Ph.D.
Appendix C

Frog Anatomy Test
Multiple Choice - circle the letter of the correct answer.

1. The following tubes all open into the back of the mouth except:
   a) eustachian  b) esophagus  c) bile duct  d) trachea

2. The membrane from the lower eyelid to cover the eye is the:
   a) pleura  b) nictitating  c) peritoneum  d) meninges

3. The opening at the tail end of the frog is the:
   a) cloaca  b) pyloric  c) gottis  d) internal nares

4. The short appendage for support is the:
   a) eustachian tube  b) hindlimb  c) forelimb  d) laryngotrachea

5. Males can be distinguished from females during the mating season by the presence of:
   a) an eyefold  b) vomerine teeth  c) cloacal opening  d) enlarged finger pad

6. The eardrum is called the:
   a) eustachian tube  b) glottis  c) nares  d) tympanum

7. The frog lacks ________ on its head:
   a) external ears  b) nostrils  c) eyes  d) upper eyelids

8. The chambered muscular organ in the center of the chest is the:
   a) kidney  b) liver  c) lung  d) heart

9. The chambered muscular organ in the center of the chest is the:
   a) kidney  b) liver  c) lung  d) heart

10. The small round sack attached the liver is the:
    a) spleen  b) gall bladder  c) pancreas  d) cloaca

11. The pyloric sphincter is found at the lower end of the:
    a) large intestine  b) spleen  c) stomach  d) esophagus

12. The short tube with a large diameter that opens into the cloaca is the:
    a) colon  b) esophagus  c) spleen  d) pancreas

13. The thin white coiled tubes along the sides of a female frog are called:
    a) ovaries  b) oviducts  c) testes  d) kidneys

Note: Adapted and used with permission from Boreal Laboratories Ltd., Tonawanda, NY.
Appendix D

Boreal Laboratories Ltd. Approval Letter
January 3, 2001

<School name>
Attn: Ronald Kopec
<Address>
<Town, NJ>

Dear Ronald:

I am writing you in response to your request to use both our test sheet on Frog Anatomy and our Post Test contained in the Teacher's Guide on High School Frog Dissection in your Doctoral research. The changes that you spoke to me about including deleting questions and making other specific modifications that you outlined to me are within the guidelines of Science Kit. We are completely satisfied with you accreditation of our property and wish you luck in the defense of your thesis.

Sincerely,

Matt Witzky
National Sales and Marketing Manager