12-20-2002

Virtual Fetal Pig Dissection As An Agent Of Knowledge Acquisition And Attitudinal Change In Female High School Biology Students

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VIRTUAL FETAL PIG DISSECTION AS AN AGENT OF KNOWLEDGE ACQUISITION AND ATTITUDINAL CHANGE IN FEMALE HIGH SCHOOL BIOLOGY STUDENTS

A Dissertation

Submitted to the Graduate Faculty of the
University of New Orleans
in partial fulfillment of the
requirements for the degree of

Doctor of Philosophy
in
The Department of Curriculum and Instruction

by

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December 2002

ACKNOWLEDGEMENTS

This study was made possible through the loving support of my family, my friends and colleagues. I express sincere thanks to Dr. Richard Speaker, my major professor, for his guidance and support through every step of this process. He was there for me when I needed the push to complete my journey. He was always available when I needed him, and for that I am truly grateful.

I sincerely thank Dr. April Whatley for her encouragement and support. She was there for me when I needed to vent and cry, and always offered words of caring and wisdom. In addition to her support, I learned how to teach in a truly humanistic manner. If I can be half as dedicated as she is to her students I will feel that I have succeeded.

I am indebted to Dr. Cory Buxton for his intellectual support. Cory was always pushing me to produce at a more scholarly level. I may not have appreciated it at the time, but I know that this dissertation is better because of his suggestions.

Dr. Hae-Song Park taught me how to be a researcher. He taught me all that I know about statistics, which unfortunately isn't as much as he meant for me to learn. I will always be in his debt for guiding my research and helping me to focus my study.

I will always remember Dr. Frank Hall each time I sit down to a plate of waffles. His unique way of questioning my knowledge will remain in my memory forever. I thank you, Dr. Hall, for surprising me, and for your support when I needed it.

This dissertation would never have been possible without the support of two wonderful people, Mr. David Shroyer and Ms. Ellen Levitov. These two extraordinary

people believed in me and gave me a chance when I was an undergraduate student that changed my life. I will always be indebted to both of you for your love, support and guidance. Ellen was the first person to ever say to me that she could envision me receiving my doctorate one day, and I will always be in her debt for giving me the hope that this could be possible.

My colleagues at Archbishop Chapelle made this dissertation possible by allowing me to work with their students. I am especially indebted to Mrs. Fay Lewis who has been my rock throughout the years. I am who I am because of her support and guidance.

My family is the reason that I succeed. To my mom, my sister, and my brothers, I owe you so much for always supporting me, I can never repay you enough. To my wonderful husband Steve, my daughter Melissa, and my son Stephen, thank you for supporting me in this journey that often took me away from you. You three are the reason I live, and I thank you from the bottom of my heart.

Finally, I dedicate this dissertation to my dad. Dad, you taught me that education was important through your lifelong quest for knowledge. You inspired me to read and think and continue learning. You supported me in this quest, and although you won’t be there when I graduate this time, I will look up, raise my diploma to you, and smile in thanks.

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ABSTRACT

One way to determine if all students can learn through the use of computers is to introduce a lesson taught completely via computers and compare the results with those gained when the same lesson is taught in a traditional manner. This study attempted to determine if a virtual fetal pig dissection can be used as a viable alternative for an actual dissection for females enrolled in high school biology classes by comparing the knowledge acquisition and attitudinal change between the experimental (virtual dissection) and control (actual dissection) groups. Two hundred and twenty four students enrolled in biology classes in a suburban all-girl parochial high school participated in this study. Female students in an all-girl high school were chosen because research shows differences in science competency and computer usage between the genders that may mask the performance of females on computer-based tasks in a science laboratory exercise.

Students who completed the virtual dissection scored significantly higher on practical test and objective tests that were used to measure knowledge acquisition. Attitudinal change was measured by examining the students' attitudes toward dissections, computer usage in the classroom, and toward biology both before and after the dissections using pre and post surveys. Significant results in positive gain scores were found in the virtual dissection group's attitude toward dissections, and their negative gain score toward virtual dissections. Attitudinal changes toward computers and biology were not significant. A purposefully selected sample of the students were interviewed, in addition

to gathering a sample of the students' daily dissection journals, as data highlighting their thoughts and feelings about their dissection experience. Further research is suggested to determine if a virtual laboratory experience can be a substitute for actual dissections, or may serve as an enhancement to an actual dissection.

CHAPTER I

Introduction

Educational technology has been introduced to many schools across the world, mainly through the addition of computers into classrooms. At the heart of these acquisitions is one large question: Can all students learn through the use of these computers? One way to determine this is to introduce a lesson taught completely via computers and compare the results with those gained when the same lesson is taught in a traditional manner. For this study, I chose to introduce a virtual fetal pig dissection into a high school biology classroom and compared its results to those obtained from a traditional, or actual, fetal pig dissection. More specifically, this study attempted to determine if a virtual fetal pig dissection could be used as a viable alternative for an actual dissection by comparing the knowledge acquisition and attitudinal change between the experimental (virtual dissection) and control (actual dissection) groups.

Knowledge acquisition was measured through objective and practical tests administered after the completion of the actual or virtual dissections. Attitudinal change was measured by examining the students' attitudes toward dissections, computer usage in the classroom, and toward biology both before and after the dissections using pre and post surveys. A purposefully selected sample of the students’ daily dissection journals was gathered as data highlighting their thoughts and feelings about their dissection experience. Interviews with a purposefully selected group of students from each group yielded additional data concerning the students' feelings toward their dissection experience.

The population chosen for this study was girls enrolled in high school biology courses. I chose to study girls because research shows that fewer women choose to enter the science and technology fields and often encounter difficulties in those fields (Barley & Philips, 1998; Hanson, 2000; National Science Foundation, 2000; Scholar, 1998). One way to attract more women into these fields may be to enhance their science and technology instruction while they are still in high school as studies have shown that girls do not perform as well as their male counterparts in science and computer classes (Bain, Hess, Jones & Berelowitz, 1999; Crombie, Ararbanel & Anderson, 2000). Research also tells us that differences exist between males and females with respect to computer usage (Barrett & Lally, 1999; Charlton, 1999; Kadijevich, 2000; Kafai & Sutton, 1999; Whitelock & Scanlon, 1998). Since these differences in science competency and computer usage may mask the performance of females on computer-based tasks in a science laboratory exercise, I chose to study girls in a single-sex classroom in a single-sex school to study, more accurately, the effect of technology on girls in a science class. This setting eliminated the confounding variables of male-female instruction in the classroom and the treatment effects of the teacher who may interact differently with males and females (Crombie et al., 2000; Sadker, 1999).

Archbishop Stephens High School, a pseudonym, a southern all-girls parochial high school, has traditionally required the dissection of fetal pigs by their biology students. Due to the rising costs of the specimens and the objections to actual dissection on moral and ethical grounds by the students, finding a viable alternative to dissection is imperative. At Archbishop Stephens, students who objected to dissecting were assigned a lengthy report about fetal pigs that, according to the teachers, was not a viable alternative in that it did not meet the objectives of the dissection. I met with the biology teachers at the school to determine the actual objectives of fetal pig dissections. After these meetings, I was able to compile the objectives of these traditional fetal pig dissection activities. These objectives were then reviewed by the teachers for their approval, and altered according to their suggestions. One surprising finding was that dissection skills were not part of the teachers' objectives, and since the acquisition of these specific skills was not an objective, a virtual dissection could be studied for use as an alternative to an actual dissection.

From these discussions, I developed a virtual fetal pig dissection using an existing laboratory exercise on the Internet. To enhance and more accurately align this online dissection with the traditional dissections performed at the school, I incorporated pictures taken by student members of the yearbook staff of an actual dissection performed by one of the school's biology teachers. Because a questionnaire measuring attitudes toward dissections, computer usage and biology could not be found, I consulted with the biology teachers to develop a pre and post survey for this type of study. These surveys were tested during a pilot study at the school and modified versions based on the results of the pilot study were used in this current study.

The data collection began with a pre survey that was administered to the students to determine the students' attitudes toward dissections, computer usage, and biology. A post survey was used at the completion of the virtual and actual pig dissections to determine the changes in the attitudes of the students. Objective and practical tests were administered at the completion of the dissections to determine knowledge acquisition. The students also completed daily journals which contained a description of what they learned that day, information describing how they worked with their partner, and how they felt about their dissection experience. A purposeful sample of these journals was added to the data collected. This sample of journals was purposefully selected by the teachers as good examples of the students' work and as rich sources of data. Semi-structured interviews with a purposeful sample of the students who completed dissections enhanced the data collected. The teachers purposefully selected the students to be interviewed for their verbal and communication skills. This synthesis of quantitative and qualitative data constitutes a study containing a triangulation of research.

Thesis Statement

A well-designed virtual fetal pig dissection can be used as a viable alternative to an actual fetal pig dissection by enhancing female students' knowledge of anatomy and positively affecting attitudinal change toward dissections, computer usage, and biology.

Purpose of the Study

The purpose of this study was to determine if a virtual fetal pig dissection could be used as an alternative to an actual dissection for girls enrolled in a high school biology class. The variables used to determine if the virtual dissection was viable were knowledge acquisition, and attitudinal change toward dissections, computer usage, and biology.

Research shows that males out-perform females in science and computer classes. Due to this fact, I chose to concentrate on the performance of females in a single-sex class on a computer-based virtual dissection laboratory. The performance of males and/or females in a mixed-gender class is beyond the scope of this study.

Theoretical Framework

The theoretical framework underlying Computer Assisted Learning (CAL) is very difficult to define because CAL exists in so many forms. Kemmis, Atkin and Wright (1977) may have devised the clearest system of classification for this type of learning. The authors set up a classification system for computer programs consisting of four paradigms: instructional, revelatory, conjectural, and emancipatory.

The instructional paradigm is based on a behaviorist perspective. Computer software that is developed from this paradigm uses programmed learning techniques. This type of software breaks concepts down into smaller units, and directs the learner through the steps of the program. Drill and practice programs would serve as a good example of this type of software.

The revelatory paradigm is based on discovery or experiential learning. Software developed within this paradigm would encourage a student to explore a model or simulation. As the students explore this type of software, they are able to see and explore but are unable to build models or simulations. This paradigm would be based on the discovery learning ideas of Bruner (1960).

The conjectural paradigm is based on constructivist ideas of learning. Basically, the software allows the students to have control over their learning as they test hypotheses and ideas. Different computer programs that allow the students to build, model, or manipulate ideas and concepts would be considered in this paradigm. Knowledge in this paradigm is actively constructed using the computer as a tool.

The emancipatory paradigm contains aspects of the other paradigms. This student-centered paradigm is based on the idea that computer software can be a labor saving device. Computer programs that allow the student to create text documents or graphs would be in this category. Smeets and Mooij (1999) would classify a fetal pig dissection in this paradigm. They stated, "Examples are the use of a word processor, the use of the computer for calculations, and the use of multimedia for performing "virtual experiments" (p.489).

The virtual fetal pig dissection used in this study exists in two paradigms: emancipatory and revelatory. This virtual experience would definitely be considered emancipatory because it is a labor saving program. The students can use this program to very quickly see the structures in the virtual fetal pig, while their counterparts must take their time cutting and separating the specimen to uncover the structures. This time-saving idea means that the students would have more time to focus on the material to be mastered.

The second category in which this virtual dissection laboratory exercise fits would be revelatory. According to Smeets and Mooij (1999), "A learning environment is created which stimulates students to find connections in the available information" (p.489). Simulations fall into this category because they allow students to make these connections of information.

This virtual fetal pig dissection would also be considered revelatory because the students have the limited opportunity to discover the various structures within the virtual specimen. Limited discovery means that the students are guided through the simulation as the structures are revealed.

According to Bruner (1960), education should have an aspect of discovery. This idea was adopted as "discovery learning" and applied to science education. Unfortunately, many science laboratory exercises follow a cookbook design of a list of instructions that the students must follow to complete the assignment. Dissection laboratory activities follow this structure, with very little discovery taking place. In addition, the 1996 National Science Education Standards (NSES) created by the National Research Council (NRC) indicate that scientific inquiry should be a major emphasis of science instruction. Unfortunately, a dissection laboratory is not based on inquiry in that the students are conducting hands-on activities without "posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence…" (NRC, p.23). As a dissection activity is not constructed along the lines of true discovery and inquiry learning, neither is the virtual fetal pig dissection used in this study. However, this virtual dissection was constructed to closely mimic the actual dissection to ensure that the main difference between the experimental and control groups was the physical dissection of the actual specimen.

In addition to the four paradigms of CAL, the conceptual framework of this study was constructed from different learning theories as they pertain to students' learning science through the use of technology. These theories will be discussed in the literature review in Chapter 2.

There were a few basic premises that I used in the construction of this virtual dissection. These premises comprise what I think student learning must be.

Successful learning must be:

- student-centered
- cooperative learning with mutual tutoring
- facilitated by a teacher who is comfortable with the flexibility necessary to teach with Internet technology
- composed of a spiral design in which the non-linearity of hypermedia allows students to return again and again to content which enhances mastery

Statement of the Problem

Many students who are assigned to dissect an animal in biology laboratories disagree with the assignment for ethical or religious reasons. Until the advent of the Internet and its multimedia design, a viable alternative had not been present. This study attempted to determine if a virtual fetal pig dissection could be used in place of an actual dissection by examining the students' academic and attitudinal change. This use of technology in a science laboratory served to illustrate one way that computer usage is enhancing learning. In addition, this study adds to the body of knowledge pertaining to the science and computer achievement of girls.

Research Questions

Specifically, this research attempted to answer the following questions:

1. Does a virtual fetal pig dissection, as compared to an actual fetal pig dissection, significantly affect female students’ knowledge of anatomy?

2. Does a virtual fetal dissection, as compared to an actual fetal pig dissection, significantly affect female students' attitudes toward dissections, toward the use of computers, or toward biology?

Objectives for Fetal Pig Dissections

The objectives for the fetal pig dissections were developed with the input of the biology teachers at Archbishop Stephens High School. By meeting with these teachers, and discussing their goals and objectives of fetal pig dissections, I was able to compile the following 6 objectives.

At the completion of this virtual pig dissection, the students will be able to:

1. Name the major organs found in a typical mammal.
2. Locate the various organs found in a typical mammal.
3. Relate the position of various organs relative to one another in the fetal pig.
4. List the components of different body systems.
5. Differentiate between the organs of a fetal pig and those of a human.
6. Compare and contrast fetal pig and human anatomy.

These objectives were compiled from discussions with four biology teachers who have been teaching actual fetal pig dissections at the school and since their years of experience stretch from ten to thirty years at the school, I considered them an expert panel. While composing this list, these teachers discussed, rejected, and refined various objectives until a consensus was reached. Although I would like to see the dissection laboratory rewritten to contain aspects of discovery learning and inquiry, I chose to adopt these objectives for this study at Archbishop Stephens.

Method of Investigation

The majority of the students enrolled in the academic and core level biology classes at Archbishop Stephens High School took part in this study. These students were enrolled in 11 classes and were taught on the core and academic levels. Core level students at Archbishop Stephens are characterized as students who score low on standardized tests, and learn at a slower pace than the students taught on the academic level. Both of these levels are considered college preparatory at the high school.

In this study, 88 students performed an actual fetal pig dissection, and 136 performed a virtual fetal pig dissection. All of the students received the same written materials, quizzes and objective and practical tests, and completed daily journals of their experiences.

The students were also given a pre survey to determine their attitudes toward dissections, computers, and biology. At the completion of the dissections, the students were given a post survey to determine any attitudinal change in these areas. To determine if the students had acquired knowledge of anatomy during the dissection experience, they were given practical and objective tests after completing the exercise. Results of these tests were compared across the groups to determine if the students experiencing the treatment gained as much knowledge of anatomy as those who performed an actual dissection. A purposeful sample of the students’ daily journals, and the data collected by semi-structured interviews, gave insight to the students' experiences.

Need for the Study

Few studies have been performed which examine the use of virtual laboratories in science classrooms. Most of these studies have focused on virtual frog dissections

(Apkan & Andre, 2000; Kinsie, Strauss & Foss, 1993; Sweitzer, 1996), and one with mixed-gender college students (Matthews, 1998) on fetal pig dissections. Of these studies, none have focused exclusively on the performance of females on virtual dissection in a single-sex classroom setting. The results of this study could serve as a baseline measure for future studies of females in mixed-gender classrooms.

Significance of the Study

This was the first study of virtual fetal pig dissections with a population of girls in a single-sex setting. Another unique feature of this study is that it examined knowledge acquisition and attitudinal change toward dissections, computer usage and biology. This combination has been previously unnoticed by researchers.

Another unique feature is the combination of quantitative and qualitative data that was gathered. The purposeful sample of the students' daily journals and semi-structured interviews also from a purposeful sample of the participants, generated a rich source of data that added depth to the results of this study.

Definition of Terms

Actual dissection – For the purpose of this study, an actual dissection refers to students using a scalpel and accessory tools to dissect a preserved fetal pig.

Fetal pig – Fetal pigs are preserved specimens of unborn pig fetuses that are purchased from biological companies for the express purpose of dissection. These specimens were not killed for this purpose, but were extracted from their mothers during the butchering process. According to a pamphlet distributed by Nebraska Scientific, "Sows are not bred for the purpose of producing fetal pigs for dissection. Fetal pigs are a by-product of the food industry."

Virtual dissection - For the purpose of this study, a virtual dissection refers to the students' use of computers to view a fetal pig dissection without physically performing any of the dissection activities.

Limitations and Delimitations

The subjects in this study were females enrolled in an all-girls school. Without the presence of males in the class, it is not possible to determine if the results can be generalized to girls in a mixed-gender classroom. I am not concerned with the reaction of males to a virtual fetal pig dissection, or to using computers in the biology laboratory. I am also not concerned with the reaction of females in a mixed-gender classroom. These ideas are beyond the scope of this study.

Another limitation of this study is that the students were enrolled in a parochial school. The results from this setting may not generalize to those obtained from a public school setting. Additionally, the subjects in this study were enrolled in two different levels of biology: core, and academic. Although differences may be found between the two levels of students, these samples are too small to generalize to all levels of biology. More research is definitely needed to determine if a virtual pig dissection works as a viable alternative to all levels of biology classes.

The author of the original virtual fetal pig dissection, Dr. Earl Fleck, used this computer laboratory in studies with his students enrolled in college biology courses. This program has only been used with high school biology students in the pilot study performed by this researcher. Due to this fact, further use of this program with high school students is recommended before broad generalizations of the results are made.

This study attempted to determine the change in the female students' attitudes toward biology, not their overall feelings to science in general. Research indicates (National Science Foundation, 2000) that in 1997, more females (36.2%) were employed in the life sciences than those (21.9%) who are employed in the physical sciences, although overall women account for 23% of the science and engineering work force (p.52). This study examined female high school students' attitudes toward a dissection experience that is a laboratory exercise specific to the life sciences. Overall attitudes toward science in general were beyond the scope of this study.

The National Science Foundation (2000) also reports an unequal percentage of minority women in the science and engineering labor force. The report states that 83% are White, non-Hispanic, 10% are Asian/Pacific Islander, 3% are Black, non-Hispanic, 3% are Hispanic, and .3% are American Indian/Alaskan (p.52). As Archbishop Stephens is predominately composed of White, non-Hispanic students, the results of this study cannot generalize across racial boundaries. Future study is needed to determine if a virtual dissection experience appeals equally to various racial and ethnic groups.

Summary and Overview of the Study

This research study attempted to determine if a virtual fetal pig dissection could be used as a viable alternative for female high school biology students. To determine if the virtual dissection was viable, knowledge acquisition and attitudinal change toward dissections, computers, and biology were examined. The data gathered from this study is both quantitative and qualitative, and was analyzed accordingly. Literature was reviewed from the areas of dissections, science education, educational technology and gender studies.

CHAPTER II

Literature Review

The literature reviewed for this study encompasses four broad areas: dissections, science education, educational technology, and gender issues in science and technology. This review gives an overview of each of these topics as they pertain to this study. In addition, a brief explanation of the learning theories that comprise the basic framework of the virtual dissection used in this study is included in this literature review.

Learning Theories

The learning theories supported by the use of technology in this study are constructivism, anchored instruction, and collaborative learning. The use of these theories in the instructional design of a virtual laboratory is imperative. A well-designed virtual laboratory experience should enhance a student's learning while incorporating tasks that enable the student to meet the science standards set by the NRC. The NSES created by the NRC state that "As a result of their activities in grades 5-8, all students should develop understanding of structure and function in living systems…" (1996, p.155). In addition the NSES state that "As a result of their activities in grades 9-12, all students should develop understanding of the cell, molecular basis of heredity, biological evolution, interdependence of organisms, matter, energy and organization in living systems, and behavior of organisms" (p. 181). To meet these standards, students should be able to differentiate the structure and function of body systems, and this dissection laboratory meets the objective by exposing students to body structures. The development of these standards serves as an impetus to creating exceptional scientific laboratory experiences.

Constructivism

Theories of constructivism are eclectic and complex, and difficult to connect with all aspects of educational technology. Bruner (1996) thought that students would construct meaning based on their culture and previous knowledge using the tools given them by their teachers. His idea of a “spiral curriculum” was one that would revisit ideas repeatedly until “the student has grasped the full formal apparatus that goes with them” (Bruner, 1960, p.13). Piaget, and to a greater extent, Vygotsky, thought that meaning was socially constructed in that students could work together with their teachers to construct meaning.

A virtual fetal pig dissection, by nature, is student-centered. The students interacted with the computers in groups of two. These groups worked cooperatively by exploring the computer laboratory together, and helped each other complete their daily journal entries. The teacher’s role in this type of dissection was that of a guide or coach to facilitate the students’ interaction with the computer. Each teacher had models and dissected fetal pigs to share with the students, but their role was to give instructions, make sure that the students did not encounter difficulties while accessing and using the virtual laboratory, and keep the students on task. The students were free to explore the computer site during the entire class period and had the freedom to return to any of the body system sites to review the material.

Roblyer, Edwards and Havriluk (1997) have outlined their characteristics of constructivist approaches as they apply to technology:

- Problem-oriented activities.
- Visual formats and mental models.
- "Rich" environments.
- Cooperative or collaborative (group) learning.
- Learning through exploration.
- Authentic assessment methods (p. 72).

With the exception of a problem-oriented activity, the virtual fetal pig dissection fits the characteristics listed above. Multimedia is a visually rich environment in which the students work in groups to explore the various anatomical features of the fetal pig. The journal created by the students as they proceed through the dissection laboratory served as an authentic assessment of the experience.

Anchored Instruction

The Cognition and Technology Group at Vanderbilt (CTGV) bases their instructional design on the theory of anchored instruction. This theory is attributed to John Bransford who is a founding member of the group. According to the CTGV (1992), anchored instruction is described "whereby instruction is situated in engaging, problem-rich environments that allow sustained exploration by students and teachers" (p.65). Although the virtual fetal pig dissection is not based on problem solving, it does create an anchor around which learning takes place. The non-linearity of this hypermedia laboratory also allows sustained exploration by the students. The students have the freedom to move back and forth between the body systems on the web site. This enables the students to spend more time on the areas in which they need more work, and less time on the areas that they have mastered. The students can also revisit areas on the website that may serve to clarify or review their current area of study. This revisiting of body systems is not available to the students who actually dissect a fetal pig because they remove each system as it is studied and once removed, the systems are discarded.

Collaborative Learning

Gokhale (1995) defines collaborative learning as "the grouping and pairing of students for the purpose of achieving an academic goal" (p.22). Proponents of collaborative learning have found that this type of learning may promote critical thinking. Gokdale (1995) stated that "the development and enhancement of critical-thinking skills through collaborative learning is one of the primary goals of technology education" (p.22). In this study, the students completed their dissection experience in a group of two members. Each group was assigned one fetal pig, or one computer on which to work. The group members worked together to complete the tasks listed in their instruction packet. They also worked together to respond to the questions and complete the drawings assigned to them. In addition, the students reflected on their group cooperation in their daily journal entries.

In summary, the virtual dissection used in this study was constructive in nature in that the students used the computer as a tool to construct their knowledge of fetal pig anatomy. The students worked cooperatively in groups of two along with their teachers who acted as facilitators to construct this knowledge. The virtual dissection uses the hypermedia of the web site as an anchor for instruction, and allows the students to revisit areas as often as they need for clarification and review.

Dissections

Dissections have been traditionally required of both high school and college biology students. For many years, students' objections to dissections were disregarded. If a student had a strong enough reason, they were excused from the dissection and had to instead produce a report on the experience. The problem with the report is that it did not enable the students to meet the objectives of a dissection, which were mainly locating and visually recognizing organs and structures in the specimen being dissected. So, researchers began to study different alternatives to dissection. The earliest of these studies was conducted in 1968 when Fowler and Brosius studied the use of film as an alternative to dissection. This was followed years later with studies of computer dissections (Strauss & Kinzie, 1991; Duhrkopf, 1998). However, these studies are scarce. Much more research is needed to address this contentious issue.

High School Dissections

Jennifer Graham was a 15-year old high school student when she refused to dissect a frog. She was told that she would fail the course if she did not comply, but eventually received a "C" for the course. Unwilling to accept this grade, she filed suit. Although this case was dismissed on August 1, 1988, it resulted in an enactment of a state law. According to Orlans (1988), "This 1987 law upholds the right of a student under the age of 18 to conscientious objection to dissection - specifically to educational projects 'involving the harmful or destructive use of animals'" (p.37).

Dissection is a way of life in most biology classrooms. Many teachers require students to perform dissections and fail to offer alternatives to students who may object to the laboratory activities. Teachers have made many cases over the years of why dissection is important that include the inability to replicate the actual experience of seeing the inside of an actual animal, the fact that medical research has advanced through the use of dissection, and that anatomy can be learned through this process. Orlans (1988) states" another argument made in its favor is that teachers, through dissection, can teach responsible attitudes toward animals" (p.38). But Balcome has a different point of view as to why teachers are reluctant to giving up teaching dissection. According to Balcombe (1997), "Perhaps the most common basis of reluctance among biology teachers to offer dissection alternatives is a perception that such alternatives are inferior to dissection" (p. 23). In 1995, the National Association of Biology Teachers (NABT) issued a statement of policy on the use of animals in biology education. This policy stated that the "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" (NABT, 1995).

One problem could be in the development of a good computerized alternative to dissection. Greenhalgh (2001) states:

> The development of computer based teaching and learning materials requires expertise in content, in pedagogy, and in technical aspects of design and delivery. Staff with most to offer in the way of technical design may overlook important educational principles, and those who focus on content may make incorrect assumptions about the ability of the technology to deliver their imaginative ideas. (p.51)

Hopefully, the virtual dissection used in this study acts as a viable alternative. It was developed by science educators with a sound knowledge of pedagogy and technology. Although the issue of continuing to dissect in high school classrooms is debatable, and the laboratory exercise itself isn't discovery or inquiry based, I agree with Offner (1993) as she stated,

> Students who have been through a good biology course, who have studied both animals and their relationship with the world in a broad sense, will leave the course with an enduring respect and reverence for life. Dissection is an essential part of such an education. (p.148)

Alternatives to Dissection

The earliest study of alternatives to dissection in a high school biology class was performed in 1968. Fowler and Brosius (1968) studied the use of dissection films in a high school biology class. They found a greater acquisition of knowledge among the students who viewed the films as opposed to those students who actually performed a dissection. They found the use of dissection films was as effective as the actual dissection when comparing problem solving, the students' understanding of the methods and aims of science, the students' attitudes toward science, and the students' skill in manipulating laboratory dissection implements. The authors recommended that, "more investigative-type laboratories be substituted for the so-called time-honored dissection exercises"(p.57).

Although there are few studies concerning alternatives to dissections, most of these studies were performed by Strauss and Kinzie. In a 1991 report they stated that alternatives to dissections exist as "relatively straightforward lecture presentations, to the use of videotapes and anatomical models, to the employment of more sophisticated computer-based simulations and interactive videodisc-based simulations" (p. 155). The virtual fetal pig dissection used in this study is not considered a simulation in the truest sense of the word. A computer simulation allows the user to build or create something by manipulating the program in unique ways. The virtual dissection in this study allows the student to click on the area to be dissected, which then reveals the structures underneath the surface. The student cannot deviate from the computer-generated image to create something unique.

In a 1994 study, Strauss and Kinsie compared an interactive videodisc of a frog dissection to actual frog dissections in a high school biology class. They found that there was no significant difference in the achievement between the male and female students in either immediate or delayed post-tests. Due to the small number of subjects in the experimental group (n=8) and the control group (n=9), these results may not be as reliable as from those of other studies.

Leonard (1992) completed a study that examined students' performance after using an interactive videodisc that taught the concept of respiration. According to his study, there was no statistically significant difference in the students' grades on laboratory quizzes, reports or on the final exam. One unique finding of this study was that the students completed the videodisc laboratory in one-half the classroom time as the control group that completed the traditional laboratory exercise.

Predavec (2001) found that computer-based alternatives to dissection have advantages to actual dissections in that he found that students were able to clearly see the structures, the structures that could be seen were from a range of animals of all sexes and stages of development, the students could work and review at their own pace, and were better at naming structures and associating their functions. In his study using a computer based rat dissection with first-year undergraduate biology students, Predevac (2001) found that the students who completed the virtual dissection did better than those who actually dissected, and "not only were E-Rat students better able to identify structures in pictures and relate their functions, there were also better able to identify structures in real dissected rats" (p.78). He found that one reason the students who virtually dissected did better was that "by observing students completing the conventional dissection, it was clear that for a number of them the smell and the blood was a major inhibitor, keeping them from fully investigating the dissection" (2001, p.79). One aspect of his study that should be noted is that 85% of the 391 freshman undergraduates that participated in the virtual dissection had actually dissected a rat in high school.

This study is based on the fact that researchers found that students could achieve at the same level (Leonard, 1992; Strauss & Kinsie, 1994), or even achieve a greater acquisition of knowledge (Fowler & Brosius, 1968), than those students who actually dissected in these studies. This study attempts to duplicate these results, and compile additional data on the students' attitudinal change as a result of a virtual dissection.

Opponents to Virtual Dissection

A carefully constructed virtual dissection, uploaded to the Internet, may be a viable alternative to dissection in the biology class. However, there are some opponents to virtual dissection. For example, Offner (1993) argued that the type of learning that occurs in a traditional hands-on dissection is qualitatively very different from the learning that occurs from any form of instructional media presentation. Offner stated that, "Models, videos, diagrams and movies do not provide the same kind of learning that students experience in hands-on dissection" (p. 147).

According to Offner (1994), "No model, no video, no diagram and no movie can duplicate the fascination, the sense of discovery, wonder and even awe that students feel when they find real structures in their own specimens" (p.147). She goes on to say that "The alternative to dissection is ignorance, and let us never forget that ignorance comes at a terrible price" (p. 148). The goal of this study is to illustrate that this ignorance is unnecessary, that a viable alternative does exist in the use of a virtual dissection environment.

Another opponent to virtual dissection, James Sweitzer (1996) states, "Computer programs are poor substitutes for living beings, even ones as 'simple' as frogs. They may teach kids the names and locations of a few organs, but not the complex anatomical systems and functions that link them together" (p. 43). These valid points must be taken into consideration when designing and implementing a virtual laboratory experience.

Duhrkopf (1998) conducted a study with his college biology students using the software *MacPig*. He found that the computer simulation was not as effective as the actual dissection, and that "the computer-trained students could not transfer their knowledge to the real animal" (p.229). He concluded that the computer dissection "cannot replace the learning that occurs while performing a real dissection"(p.229). Duhrkopf found that his students couldn't learn from a computer monitor and were missing out on the hands-on learning of an actual dissection experience. An interesting conclusion to his study is that Duhrkopf felt that the computer monitor illustrated a two-dimensional image that "alters reality and the cognitive experience. I wonder if our brain can recognize the difference when we are learning something new in an altered dimensional state?" (p.229). This final criticism appears to be geared more to the use of educational technology rather than the use of a virtual dissection.

Dissection Summary

Gilmore (1991) states that some biology teachers continue to dissect because "the pressure exerted on them by college-level instructors to send on students who've had some dissecting experience causes them to continue the practice in the high school" (p. 272). Orlans (1998) is adamantly against this continuance. She stated:

> Teachers should seriously reassess the need for dissection in introductory biology courses. Challenges to the 60-year-old inclusion of dissection in the curriculum are being made. The direction is to give up dissection and replace it with other studies that are more relevant to the student's educational needs and that better represent the current state of biological information. (p.40)

However, Offner (1994) offers this warning, "We should not be deluded into thinking that alternatives to dissection are the 'wave of the future.' They are not. They are a step back into a grim and ignorant past" (p.149).

Archbishop Stephens has traditionally required that their biology students dissect fetal pigs. Over the years, students have objected to the dissection for various reasons and have been assigned a report on the dissection rather than participating in the actual dissection. The teachers did not consider this report a viable alternative to the dissection because they felt that it did not meet the objectives of the laboratory experience. In their study using films as an alternative, Fowler and Brosius (1968) found that students who viewed films of dissection acquired more knowledge that those who actually dissected. In addition, Strauss and Kinzie (1994) and Leonard (1992) found no significant difference in achievement in the actual and alternative dissection groups in their studies. The results of these studies led this researcher to develop a virtual fetal pig dissection with the hope that this virtual experience would meet the objectives of a dissection laboratory experience, and be considered a viable alternative to an actual dissection.

Sweitzer (1996) introduced the idea that a computer cannot illustrate the complex connections between structures that are seen in the actual specimen. The virtual dissection used in this study was created to illustrate these connections. Although improvements are always possible, this multimedia virtual dissection is a vast improvement in the alternatives studied by Sweitzer (1996) and Duhrkopf (1998). In addition, this study was designed to allow the students access to models, diagrams, and actual fetal pig specimens. This access allowed the students to see the structures *in situ* and not just in cyberspace.

Science Issues

Science education is coming alive in the 21st century. No longer is it permissible for teachers to preach the subject to a captive audience. Now students and teachers must work together to construct science. So, not only is science changing, but the roles of both teachers and students are changing also. National standards for science have been created and are beginning to be put into practice. These significant changes in science education are examined by reviewing research studies on scientific literacy (National Research Council, 1996; Rutherford & Ahlgren, 1989), science teachers (Bruner, 1996; Longstreet & Shane, 1996; Rakow, 1999), students of science (National Research Council, 1996; Rutherford & Ahlgren, 1989) and science standards (Nelson, 1999).

Scientific Literacy

The nature of science education is in a state of flux. Hurd (1999) states, "Worldwide, science education is in a period of turbulence and transition" (p.49). The concepts and ideas that have been its backbone for decades no longer accomplish the newly emergent goals of science education reform. The National Research Council in its *National Science Education Standards* (NSES) advocates science literacy as the focus for science education, and states as its reason:

> Scientific literacy enables people to use scientific principles and processes in making personal decisions and to participate in discussions of scientific issues that affect society. A sound grounding in science strengthens many of the skills that people use every day, like solving problems creatively, thinking critically, working cooperatively in teams, using technology effectively, and valuing life-long learning. And the economic productivity of our society is tightly linked to the scientific and technological skills of our work force. (1996, p.ix)

If we are to teach scientific literacy as the quote above requires, a different method of teaching science, no, not just a different method, a paradigm shift in science education must occur. To accomplish this task, science teachers need to be educated with a new mindset, one that relinquishes control, and shares the task of learning with their students. In order to teach critical thinking skills and problem solving, science education must practice what it preaches. Unfortunately, as Callahan (1999) states, "The way teachers teach is the way they themselves were taught" (p.4). No longer does the basis of science education exist in a textbook. Rutherford and Ahlgren (1989) state, "Our fundamental premise is that the schools do not need to be asked to teach more and more content, but rather to focus on what is essential to scientific literacy and to teach it more effectively" (p. ix).

This paradigm shift in science education means the very concept of science must forever be altered. As Rutherford and Ahlgren state, "Science is a process for producing knowledge" (1989, p.4). Science is a process, not a stagnant textbook of theories and laws, yet a textbook is the principle tool of science teachers. "The present science textbooks and methods of instruction, far from helping, often actually impede progress toward scientific literacy" (Rutherford & Ahlgren, p.viii). If this statement is true, then new textbooks and methods are mandatory as science educators are being challenged to create in their students "habits of mind" that will enable them fully participate in society (Rutherford & Ahlgren, p.v). This participation includes a facility of thought that must be fostered through a new sense of science. The gauntlet has been thrown, and science educators must step up and take command of the situation. In its NSES, the National Research Council states, " In a world filled with the products of scientific inquiry, scientific literacy has become a necessity for everyone. Everyone needs to use scientific information to make choices that arise every day" (1996, p.1). Science education has been issued the challenge, as Bruner (1996) so aptly asked, "Are we willing enough, united enough, courageous enough to face up to the revolution we are living through?" (p.83).

Science Education

To accomplish reform in science education, its entire structure must be redesigned. Although, according to Rakow (1999) "NSTA has long advocated that teaching less content at greater depth (the principle of 'less is more') enhances student learning" (p. 32). Many science teachers do not adhere to this principle. This fundamental problem exists in all disciplines, not just science, and is a conflict between breadth and depth. How can teachers decide to teach for depth, and still adhere to school, district, or state curricula? Rakow goes on to say, "It is only logical to expect that when students study fewer topics in greater depth, as in other countries, not only will achievement be higher but also students' science and problem-solving skills will be sharper" (1999, p.32). If this statement is really true, why does a science teacher when confronted with the breadth versus depth issue revert to a safe haven of teaching from the textbook? Because, science consists of a large body of facts and theories, and it has been the traditional role of the science teacher to impart these innumerable facts and theories to her students. However, the science teacher runs the risk of her students being inundated by facts, but acquiring little understanding of the concepts. According to Nelson (1999), "Either way, the problem is clear: the curriculum attempts to cover far too many unrelated ideas rather than a connected set of concepts that helps students understand their world and how it works" (p.55). But, as Longstreet and Shane (1993) so clearly state, "Even so, we continue to evaluate students' knowledge of science with standardized tests that emphasize knowledge of terminology and rote applications of laws and formulas" (p.254). If the state of science education is evolving, so too must the manner of science assessment.

So, what is the role of a science educator? An entirely new view of science classrooms is described in the NSES, "In successful science classrooms, teachers and students collaborate in the pursuit of ideas, and students quite often initiate new activities related to an inquiry" (1996, p.33). This new science classroom requires new roles for both teachers and students.

The Role of Science Teachers

In 1960, Bruner published *The Process of Education*, which was actually a report on the culmination of a gathering of educators and scientists to discuss the state of science education in response to the launch of Sputnik and our subsequent embarrassment of failing to be first to launch a satellite. In this book, he initiated his idea of "discovery learning," in which students are encouraged to "discover" knowledge, which would lead to more active science learning. Even as he advocated this process, he was well aware of the difficult task he was asking of science teachers. Bruner (1960) stated:

> There is a vast amount of skilled activity required of a 'teacher' to get a learner to discover on his own – scaffolding the task in such a way that assures that only those parts of the task within the child's reach are left unresolved, and knowing what elements of a solution the child will recognize though he cannot yet perform them. (p.xiv)

Bruner defended this idea in his 1996 work, *The Culture of Education*, he stated, "Acquired knowledge is most useful to a learner, moreover, when it is 'discovered' through the learner's own cognitive efforts, for it is then related to and used in reference to what one has known before" (1996, p.xii).

It is ironic that this same premise of active science learning, advocated by Bruner in 1960, is the basis of the NSES, published in 1996. Discovery learning has been displaced by the idea of scientific inquiry. Inquiry, as defined in the NSES, implies that "students actively develop their understanding of science by combining scientific knowledge with reasoning and thinking skills" (National Research Council, 1996, p.2). According to the NSES, "In successful science classrooms, teachers and students collaborate in the pursuit of ideas, and students quite often initiate new activities related to an inquiry" (National Research Council, 1996, p.21). And, if, as the NSES states, "Learning is something that the students do, not something that is done to them," we have come to crux of the paradigm shift because "Good teachers of science create environments in which they and their students work together as active learners" (1996, p.2-4). The role of science teacher as we know it will cease to exist. According to Longstreet and Shane (1993), "The pedagogy of science teachers will need to be transformed from all-knowing lecturing to questioning and collaboration with students helping them to accomplish projects without dominating the decision making. Teachers will need to know how to both lead and follow"(p.257). Rakow (1999) said it best in the following, "Teachers are no longer dispensers of science facts; students are no longer passive learners. Together they are partners in learning science" (p.30).

The Role of Science Students

It appears that change is no easy task for science teachers, but the same can be said for science students. No longer can students sit and be the recipients of knowledge as delivered by their all-knowing teachers. Unfortunately, in the classrooms of today, students are still being conditioned to this role. All this has to change if we are to truly alter science education. Teachers of the 1990's have incorporated 'hands-on' activities, but NSES says these activities while "essential, are not enough. Students must have 'minds-on' experiences as well" (National Research Council, 1996, p.2).

As Rutherford and Ahlgren (1989) so clearly state, "Students should experience science as a process for extending understanding, not as unalterable truth" (p.191). The key phrase in this quote is "experience science." Science should be an experience, not just stagnant facts that exist in the four walls of a classroom. They go on to say, "By the time they finish school, all students should have had supervised experience with common hand tools, soldering irons, electrical meters, drafting tools, optical and sound equipment, calculators, and computers" (1989, p.192). The use of these tools should serve to engage even the most reluctant student. But, tools alone are not enough; motivation must be present for students to learn. Hopefully, the sharing of learning experiences between students and teachers creates this motivation and revises science education.

Science Standards

The purpose of the Third International Mathematics and Science Study (TIMSS) was to compare mathematics and science achievement, curricula and teaching practices around the world. This study focused on three grades: fourth, eighth, and twelfth. Among the results of this study, which were released in 1996, it was found that American twelfth grade science students scored at the bottom of the pack. According to Hurd (1999), "The greatest effect of the TIMSS findings has been to stimulate public interest in reforming science teaching" (p.49).

Unfortunately for Americans, this study was done before the release of their National Science Education Standards. Nelson (1999) writes, "One of the most important outcomes of the TIMSS may well be its powerful confirmation of the need for benchmarks and standards…" (p.54). The need for science standards has become abundantly clear to the nation. However, as Bruner cautioned in *The Culture of*

Education (1996), "Of course we need standards and resources to make our schools work well in solving the myriad tasks they face. But resources and standards alone will not work. We need a surer sense of what to teach to whom and how to go about teaching it in such a way that it will make those taught more effective, less alienated, and better human beings" (p.117-118). And, although Bruner advocated the use of standards, he wrote, "All the standards in the world will not, like a helping hand, achieve the goal of making our multicultural, or threatened society come alive again, not alive just as a competitor in the world's markets, but as a nation worth living in and living for" (p.118).

Nelson (1999) suggests that there is hope for this current reform in that, "While earlier reform efforts focused on preparing more students for scientific and technical careers, today's efforts grow out of the recognition that science and technology are major influences in the lives of everyone, no matter what their roles in society may be" (p.57). But, as the NSES state, "The real journey of educational reform and the consequent improvement of scientific literacy begins with the implementation of these standards" (National Research Council, 1996, p.243).

Science Summary

The answer for science education may lie in its marriage with educational technology. If teachers can learn to use technology to make science come alive for their students, they will truly be bringing science education into the 21st century. Science is a dynamic subject and must be taught and learned in that manner. National standards are one step toward bringing an excellent science education to students. This study is an effort to find an alternative to a traditional science laboratory activity and update it using technology. However, more research is needed to discover what technology and science have in common, and how they can be used together to improve education.

The virtual dissection used in this study was designed as a tool for students to use as they experience science. The students worked at computers in groups, and the teachers acted as guides and facilitators. This design correlates with the new roles of science teachers and students (Bruner, 1996; Longstreet & Shane, 1996; National Research Council, 1996; Rakow, 1999; Rutherford & Ahlgren, 1989). This researcher realizes that the actual design of a dissection experience is lacking in the areas of inquiry and discovery learning. However, this design issue is an area of future research.

Educational Technology

In order to fully discuss this subject, the term "educational technology" must be defined. Saettler (1990) writes, "If technology is to be completely understood, in either ancient or modern terms, it should be seen as a system of practical knowledge not necessarily reflected in things or hardware" (p. 6). Saettler expanded on this definition by stating that educational technology is "…a particular systematic arrangement of teaching/learning events designed to put our knowledge of learning into practice in a predictable, effective manner to attain specific learning objectives" (p.6).

However, Mellon (1999) states that when educators and those responsible for educational reform are using the term technology, they are "referring to computer-related technology. Technology planning, technology money, and integrating technology into the curriculum have become educational shorthand for planning to buy computers, getting money to buy computers, and using computers in the classroom" (p.7). Regardless of how technology is defined, Mellon goes on to say, "Technology, in its current and emerging manifestations, is here to stay" (p.16). If technology is really here to stay, then educators must learn to use technology, and more importantly, learn how to integrate this technology into their curricula. For the remainder of this literature review, the term technology will be used synonymously with the more formal term educational technology and will always imply the use of computers by teachers for the purpose of lesson preparation or instruction.

Technology in the Classroom

There has been a tremendous outlay of money and physical and human resources by schools to adapt today's classrooms for technology. If implemented correctly, this monetary expenditure may reap large returns, as technology adds a motivational and educational bonus to education. However, teachers, students and parents must buy into the necessity of technology integration and usage. The workforce of tomorrow will be composed of today's students who must have the flexibility of knowledge that comes with educational technology, and the fact that traditional methods of teaching must be modified or even discarded. de Jong, van Joolingen, Swaak, Veermans, Limbach, King, and Gureghian (1998) stated that, "There is now a general conviction that this traditional way of *expository teaching* is not optimum for training employees that the market requires and who need *deep*, *flexible*, and *transferable* knowledge" (p.235). Teachers will have to learn to implement different methods that enable students to obtain this type of knowledge. Perhaps one method could be the use of virtual laboratory experiences in science classes. The use of these labs may have a two-fold benefit: transferring knowledge while enhancing the students' technology skills.

The students will need technological skills, not only for the workforce, but to achieve in our college classrooms. Davis (1999) surveyed undergraduates to determine if computer skills were necessary for their college courses and had the students rate the effectiveness of various methods of learning computer skills. Davis found that most students learn computer skills on their own using a "learn as needed" work style. He stated, "There was unanimous agreement that professors assume students have specific software skills without providing any support or training" (Davis, 1999, p. 70). Davis found that this caused "considerable frustration and stress" for many students (p.70). Ultimately, teachers are responsible for integrating this technology in ways that are educationally beneficial for the students and also allow the students to gain necessary technological skills.

The Role of Teachers and Technology

The thought that one-day technology will replace teachers is never far from the surface. According to Mellon (1999), "There seems to be an implicit assumption that, where technology is concerned, teachers are interchangeable" (p.13). It is almost as if there is a good computer in the classroom, any one at all could teach. She goes on to say that, "I am doubtful that any tool of learning can have the same impact as a good teacher" (1999, p.14). It must be remembered that the computer is a tool, a fancy tool, but a tool nonetheless. Clark, Hosticka and Huddlestun (1999) write:

> It is possible to teach any lesson without the use of the computer. However, the computer can enhance the learning experience in many lessons and can provide the student with more opportunities to investigate the content presented in ways parallel to the way society uses computers. (p.7)

However, Mellon gives a word of caution when she states, "No matter how much technology is available, no matter how well it is integrated into instructional content, it is the learner's willingness or ability to learn that is paramount. In other words, you can lead a child to a computer, but you can't make him or her learn" (1999, p.10).

One innovation brought into the classrooms through the use of computers is the use of multimedia. According to Jonassen, Peck, and Wilson (1999), "Multimedia presentations are engaging because they over-stimulate the senses with a barrage of sounds and images. For today's video generation, they are attention-getting and attention-holding" (p.88). Proponents of these stimulating multimedia programs agree. The authors of *Integrating Educational Technology into Teaching* state:

> They provide vivid visual support which helps students develop better mental models of problems to be solved. Also, they let students work together in cooperative groups to construct products. In short, they meet all of the requirements for fulfilling the constructivist prescription for improving learning environments and refocusing curriculum. (Roblyer, Edwards, & Havriluk, 1997, p.58)

However, teachers must heed the words of Mellon when she states, "For technology-based learning to be effective, teachers must select materials that help meet carefully defined instructional objectives and integrate them into learning experiences that motivate and excite learners" (1999, p.15).

Technology as motivation

Many studies have shown that using computers in the classroom added excitement and increased motivation for learning (Gilliver, Randall, & Pok, 1998;

Hakkarainen, Lipponen, Jarvela, & Niemivirta, 1999). But are motivation and excitement enough to promote learning? In a study of high school students in New Zealand, McKinnon, Nolan, and Sinclair (2000) found that student attitudes towards computers became less positive over time. These researchers concluded that there was a "loss of initial fascination" as the students began to see the computer as just another tool. (McKinnon, Nolan, & Sinclair, 2000, p. 334). They also stated:

> A key message for educators is that even though modern computer technology may be both fascinating and compelling to teachers and students alike, it is the quality of the curriculum program in which the technology is used that makes the real difference to students' attitudes, motivation, and performance. (p. 326)

In one study, different types of software elicited different responses in attitudinal change. Two forms of *Successmaker* were researched by Brush, Armstrong, Barbrow, and Ulintz (1999). One was a *foundations* program designed as an individualized tutorial program to strengthen the students' basic vocabulary and reading comprehension skills; the other was an *explorations* program designed to present students with hundreds of reading activities including skill-building and writing. 73% of the students in this study, who used only the activity oriented "explorations" software, responded that they liked reading in comparison to 61% of the students who used only the individualized "foundations" program. This significant response ($p<.001$) implies that a more flexible software design will improve student attitudes toward the content being studied (Brush et al., 1999). The use of more flexible multimedia and the non-linear design of programs on the World Wide Web may be ways to integrate flexibility into the students' learning experiences. The virtual dissection used in this study allows the students to be completely flexible in that they can observe and review systems as often as needed.

Motivation for students may also be increased through the use of the Internet. The non-linear design of the Internet allows for choice that increases "motivation, commitment, deep involvement and strategic thinking about tasks" (Gilliver et al., 1998, p. 213). This non-linearity allows the students to review and relearn information as needed. More research is needed in this area, as this new way to remediate and review is available to students and teachers.

The Role of Students and Technology

The following quote, from *Learning with Technology: A Constructivist Perspective*, is remarkably similar to those attributed to science education reform:

> Rather, we believe that in order to learn, students should share the role of representing what they know, rather than memorizing what teachers and textbooks know. Technologies provide rich and flexible media for representing what students know and what they are learning. …if we begin to think about technologies as learning tools that students learn with, not from, then the nature of student learning will change. Technologies support learning when they fulfill a learning need - when interactions with technologies are learner-initiated and learner-controlled, and when interactions with the technologies are conceptually and intellectually engaging. Learners and technologies should be intellectual partners in the learning process, where the cognitive responsibility for performing is distributed to the part of the partnership that performs it the best. (Jonassen, Peck, & Wilson, 1999, p.12-13)

The word "science," could be easily and intelligibly inserted in the quote above in place of the word "technologies," as the goals of both science reform and technology mesh. As Gardner (2000) states, "Indeed, computer technology permits us to realize, for the first time, progressive educational ideas of 'personalization' and 'active, hands-on learning' for students all over the world" (p.7).

Technology Standards

Through its National Educational Technology Standards (NETS) Project, the International Society for Technology in Education (ISTE) is "developing standards to guide educational leaders in recognizing and addressing the essential conditions for effective use of technology to support Pre K-12 education" (NETS, 2000). These standards are also perfect illustrations of how technology can be used in the science classroom.

A few examples of these standards are found below:

5. Technology research tools

- Students use technology to locate, evaluate, and collect information from a variety of sources.
- Students use technology tools to process data and report results.
- Students evaluate and select new information resources and technological innovations based on the appropriateness of specific tasks.

6. Technology problem-solving and decision-making tools

- Students use technology resources for solving problems and making informed decisions.

- Students employ technology in the development of strategies for solving problems in the real world. (NETS, 2000)

The six, broad, categories of technology foundation standards have been developed so that teachers can use them "as guidelines for planning technology-based activities in which students achieve success in learning, communication, and life skills" (NETS, 2000). Although the virtual dissection used in this study is not based on problem solving, it is exposing the students to one use of technology as a tool for education and allowing them to locate and collect information. In these respects, this virtual dissection meets the goals of the stated technology standards.

Technology Summary

Educational technology appears to be here to stay. Computer skills are necessary not only for the workplace, but also for the classroom. As college professors expect their students to be proficient, high school teachers must sharpen their skills and introduce more technology into their classrooms. Technology may serve as a motivating factor to students. However, not all students respond the same way to the medium. Differences have been found in the response of males and females to technology. Teachers must be aware of there differences and plan their instruction accordingly. One way to combat these differences may be single-sex classes of computer science.

This study introduced a lesson taught with technology and then compared its results with the same lesson taught in a traditional manner. The virtual dissection used in this study served as an example of how technology can be introduced into curricula to motivate and excite learners while meeting the "carefully defined instructional objectives" suggested by Mellon (1999). This virtual dissection also incorporates the flexibility of multimedia that may, as found by Brush et al. (1999), improve student attitudes toward the content being studies. As this study measures attitudinal change, this introduction of multimedia may play an important role in the students' change in attitude toward dissections, computers, and biology.

Gender Issues

Gender Gaps, a 1999 report released by the American Association of University Women (AAUW), found that although significant strides have been made to ensure that males and females receive an equitable education, gaps still remain. These differences in the social and academic experience of males and females in today's school systems may be attributed to the inherent differences of the genders. However, research has shown that there is more to the gender gaps that exist in classrooms than basic genetic and environmental differences. Some research has found that the gaps between the educational experience of male and female students may have their roots in the actions of the teacher (Jovanovic & Dreves, 1998; Sadker, 1999). Solutions to this problem could be teacher education (Jones, Evans, & Byrd, 2000), instituting academic standards (American Association of University Women, 1999), or offering single-sex classrooms (Crombie, Arbanel, & Anderson, 2000).

Gender and Science Issues

Differences have been found in the attitudes and behaviors in the science classroom (Jovanovic & Dreves, 1998; Sadker, 1999) between boys and girls. Sadker (1999) found that some of these differences may be caused by teachers. These differences in science education may cause an overall difference in students' attitudes toward science. Societal issues may also play an important part in the way that males and females experience and react to science (Hanson, 2000; Scholar, 1998). Although intertwined, science education and societal issues are described separately.

Gender and Science Education

Science teachers may be the cause of differences in the science education of boys and girls. Jovanovic and Dreves (1998) studied the attitudes of girls and boys in the science classroom. They found that science teachers interacted more with boys in the classroom, and it was the boys who dominated laboratory activities and classroom discussions. The actions of the observed teachers seemed to push females further into the shadows, and did nothing to encourage their attitudes toward science.

Sadker (1999) also sees the inequality problem in classrooms as one caused by teachers' actions. Although his article was written with the technology class in mind, the same can be said for all classes. Sadker (1999) found that "Teachers unconsciously make males the center of instruction and give them more frequent and focused attention" (p. 24). He goes on to say, "Increased teacher attention contributes to enhanced student performance. Girls lose out in this equation" (Sadker, p.24).

Weinburgh (1995) conducted a meta-analysis of the literature on gender differences in student attitudes toward science from 1970-1991. She found that "for both boys and girls there is a strong, positive relationship between attitude toward science and achievement in science. The relationship is stronger for girls than for boys" (p.392). These results show that girls need a more positive attitude toward science to achieve higher scores.

Roychoudhury, Tippins and Nichols (1995) found that the following points are the most important of the gender issues in science education:

> Three major recommendations about science teaching, emerging from feminist theories, are of primary concern to us: (a) situating science learning in the lived experiences of students; (b) assigning longer projects to allow a development of personal bonding with learning experiences; and (c) providing a cooperative and supportive environment. (p. 902)

This study examines girls in single sex classes using computers to complete virtual dissections of fetal pigs. These girls worked cooperatively on computers under the supervision of teachers acting as facilitators. Without the distraction of males in the classroom, the achievement of the girls can be more clearly evaluated.

Gender, Science and Societal Influences

According to Hanson (2000), the problems that females face in both the science classroom and in the scientific work force, may begin at home. She states, "The construction of gender in the family domain may create gender identities in young women that work against the choice of science" (p. 169). If this is true then intervention in the home of a young girl may be the correct path to take to correct the problems that are experienced by girls in science.

Scholar (1998) states, "Marriage and a personal life appear to influence women's careers. One of the difficulties cited is that women do not usually have a partner who is a homemaker, or 'wife" (p.70). Hanson (2000) agrees with Scholar's views on the problems of having a family, she states, "Efforts to increase the representation of women in science must work at convincing talented women that they have potential in science regardless of their family plans" (p.183).

In her study, Hanson (2000) found conflicting results as to the family variables working against women. She did find that, "Young people who are less family-oriented, have more progressive sex-role attitudes, and expect to start their families later are more likely to go into science. In addition, young people who have fathers with higher-status occupations and mothers with high educational expectations for their child are more likely to go into science"(p.182). This brings up a new can of worms. Should we be working with the mothers of the school children? This would let them know that a whole new world is opened not only to them, but also to their daughters. Hanson (2000) focuses on changing the role of women in regards to having a family and a career in science. She states, "Efforts to increase the representation of women in science must work at convincing talented women that they have potential in science regardless of their family plans" (p.183).

One question is to whether or not society is at fault in this issue. Hanson goes on to say, "Gender stereotypes and resultant discrimination in the science domain may be another part of the explanation for the shortage of women scientists. Experiences in both of these domains cumulate over the life course of the individual" (p. 169-170). In addition, Hanson states, "Like social class, we can view gender as a social structure that involves power relations and is a basis of inequality" (p.170).

However, the very structure of science has to be examined to determine the root of the problem. Hanson (2000) states:

> The world of science remains a male world that prevents and discourages young women from entry. It is time that we turn attention away from young girls and their abilities and family experiences and turn our attention to the processes,

> procedures, and ideologies in science organizations that continue to work in a way that is gender biased. (p.183)

This focus on the inner-workings of science may be difficult to accept, but may be the key to enabling more females to relate to the field of science. Although this virtual dissection study is unable to address societal issues related to science and women, it is exposing female biology students to technology in an effort to increase their expertise in, and attitude toward, the field of science.

Gender and Technology Issues

One facet of technology implementation is the understanding of the way that males and females react to and work with this relatively new medium. Studies have shown that male and female students interact differently with computers (see, for example, Barrett & Lally, 1999; Charlton, 1999; Kadijevich, 2000; Kafai & Sutton, 1999; Whitelock & Scanlon, 1998). These differences must be understood so that proper instructional techniques can be implemented to fully benefit students of both sexes.

Whitelock and Scanlon (1998) studied female and male undergraduate physics students as they worked in a computer supported collaborative learning environment, and found differences in computer usage at the college level. In this study, students worked in same sex and mixed gender pairs using *PuckLand* software to solve physics problems. It was found that females look at one another more often than males or mixed gender groups do. This was a fundamental difference in how the sexes interact with one another while working on the computer. This study found that females sustain the collaboration with more non-verbal behavior than males. This study concluded that males and females use different problem solving strategies while working with computers (Whitelock & Scanlon, 1998).

Not only were females and males found to be exhibiting differences in computer interactions, a study by Barrett and Lally (1999), found that men and women behave differently in the online learning environment. Postgraduate distance learners, as first year medical students and tutors, used electronic diaries, and on-line discussions. This study found that distance learning provided opportunities to dialog with peers and tutors, and a benefit to the students was that they felt a part of a 'community' of learners. It was found that men had more and larger contributions to online discussions. Men tended to chime in more often and take a leading role in these discussions.

Peled and Rashty (1999) also found gender differences with technology use. In this case study analysis of 3 different models, undergraduate students were given the option of using a web-based learning environment for after class assignments. Gender differences were found in that, "males participated almost three times more than female students in activities that required inputs" (Peled & Rashty, 1999, p.425). This result supported the findings of Barrett and Lally (1999).

Charlton (1999) found males to be more prone to computer overuse than females. In this study, questionnaires were distributed during an undergraduate psychology class (n=134). These students completed the BEM sex-role inventory, and the (CAAS) Apathy and Anxiety scale. In this correlation study, "significant correlations showed that greater masculinity was associated with greater comfort and engagement and that greater femininity was associated with lower over-use" (Charlton, 1999, p.401). Although sex differences were found, this study concluded that a closing of sex differences in computer use was observed as computers are used for more varied purposes. These results are promising in that they indicate that the differences in the sexes as they use technology may be minimizing.

This virtual dissection study is being performed using only females enrolled in high school biology. This single sex sample, in an all-girls high school, was specifically chosen because of the differences between male and female computer use and competencies. Whitelock and Scanlon (1998) found that there were differences in the way that males and females interacted while working on the computer. These differences were found in online communities by Barrett and Lally (1999), and in participation with technology by Peled and Rashty (1999). In addition, Charlton (1999) found males were more comfortable with technology. The results of these studies influenced both the sample and setting of this study.

Solutions to Gender Inequality in the Classroom

Three solutions to the problems associated with gender and science inequality in the classroom are teacher education, the creation of all-female classes, and the introduction of science standards.

Teacher education may go a long way toward eradicating the problem of unequal classroom experiences in science. Jones, Evans and Byrd (2000) studied teachers after they had been exposed to a gender resource manual. After eight weeks of applying the strategies they had learned, the teachers were videotaped interacting with their classes. The videotapes showed that male students tended to call-out in class, interrupt, and misbehave. These behaviors caused the teacher to increase the amount of attention paid to the male students. The teachers reported that they were more aware of their actions, and realized that they needed to focus on "the effects of these behaviors on their female students' self-esteem and achievement" (p.175). However, Sadker (1999) thinks that most of the discrimination toward female students is subtle and not likely to be noticed by teachers. Thus, he states that teacher education is not doing enough to enable teachers to combat this "unintentional, but damaging gender bias that still characterizes classrooms" (p.23).

Barley and Phillips (1998) determined that changing the teaching environment could bring about change. They stated, "a teacher who establishes a noncompetitive learning environment, boosts girls' self-confidence, and who refutes role stereotypes that suggest women do not do math and science, would best influence girls' choices" (p. 250). Crombie, Abarbanel, and Anderson (2000) agree with changing the classroom environment. They found that:

> Apparently, certain classroom environments were more likely than others to facilitate a gender difference in the task value students attached to science. This variation across classrooms suggests that certain teaching styles, or perhaps teacher characteristics, may better facilitate boys' interest in science than girls' interest. (Eccles & Blumenfeld, 1985). It is interesting to note that both classrooms in which a gender difference in task value beliefs was found involved male teachers. (p.245)

Crombie, Arbarbanel and Anderson (2000) advocate the creation of all-female computer science classes. They studied an all-female computer science class that was offered at a high school. This class had been in existence for three years, and during that time the enrollment of girls showed a three-fold increase. As a result of their study, they found that "…the success of the all-female class in computer science was evident in that it not only increased enrollment substantially, but also improved female students' attitudes toward computer science and future intentions to pursue computer-related activities" (p.42). Overall, the researchers found this all-female computer class to be a positive experience and that "Positive academic experiences produce positive attitudes toward computer science, and it is these attitudes that will influence females' future academic and career choices" (p.42). Sadker (1999) disagrees with the idea of creating single-sex classes. He states, "…creating single-gender classes and schools is not a substitute for ensuring equitable public education for all our students" (p.24).

Another solution to the problem of gender inequality, one that should ensure equitable public education in the classroom, could be the implementation of standards. The AAUW (1999) reports that standards consist of great ideas like inquiry learning, the use of cooperative groups, and increasing the amounts of hands-on learning opportunities. Although it seems that these strategies would benefit females, the report states that "…few of these strategies, when transplanted to the standards movement, are directly linked to the needs of girls or historically disadvantaged groups, their impact and usefulness for these groups may be lost or misinterpreted or even become harmful" (p.60). Yet the AAUW states that the goals of the standards movement, and those who propose equity in education are the same. "Equity without excellence would be a terrible waste of talent. Excellence without equity is a contradiction in terms" (p.x).

One solution to the problem of gender equity in science may be to initiate the science standards. Jovanovic and Dreves (1998) found that:

> In terms of equity, the NCTM and NRC standards both call for the same high standards for all students regardless of gender or ethnicity. Small group instruction, hands-on tasks, and opportunity for reflection and discussion are among the new practices that better support girls in science and mathematics (Pollina, 1996; Kepler & Pollina, 1996; Man, 1994). Therefore, the adoption of the new practices could eventually contribute to the closing of the gender gap in higher degrees in science and mathematics. (p. 252)

Gender Recommendations

Tech-Savvy (2000), a report from the AAUW Educational Foundation, has several key recommendations for teachers using technology:

- Compute across the curriculum.
- Redefine computer literacy.
- Respect multiple points of entry.
- Change the public face of computing.
- Prepare tech-savvy teachers.
- Begin a discussion on equity for educational stakeholders.
- Educate students about technology and the future of work.
- Rethink educational software and computer games.
- Support efforts that give girls and women a boost into the pipeline (p. xii).

These recommendations, with very few semantic changes could be used interchangeably for both science and technology in dealing with the issues that affect gender inequality in education. Both science and technology need to be redefined along gender roles. Teachers need to be educated in the new methods and approaches to teaching these subjects. This virtual dissection serves as a scientific technological tool for biology students. The females in this study were introduced to this method of doing science while using technology in a cooperative environment. Hopefully, this experience served to boost their confidence in both science and technology.

Gender Summary

Gaps have been found in the science education of males and females. Some of these differences may be due to the interaction of males and females in the classroom, and in how the teacher interacts with the two sexes. Unfortunately, these differences may have their roots in societal differences in the home and community. These differences in science education affect the attitudes and achievement of girls.

Differences have also been found in how males and females interact with computers. This interaction was visible in cooperative groups, online environments and in the classroom.

As a result of these differences in science education and interaction with computers, this study chose to focus only on girls in single-sex classes. This focus should illustrate the achievement of girls on a virtual dissection without interference from the interaction of males in the classroom.

Conclusion

This literature review highlighted issues in the areas of dissections, science and technology education, and gender as they pertain to this virtual dissection study. Dissections, for better or worse, are present in many classrooms. As long as animals are used for educational purposes, some people will object to their use. Viable alternatives must be created for these students. Although differences exist in their attitudes toward science and technology, both males and females may benefit from virtual dissections. This study utilizes ideas from this literature review to study females in a high school biology class, and serves as a baseline for future studies with females and males in mixed-gender classes of biology.

Specifically, the following ideas from the reviewed literature have impacted this study:

1. Dissections are prevalent in high school biology classes.

2. Some students object to participating in dissections.

3. Some alternatives to dissection have been found to be viable in that the students who participated achieved at the same level or higher on knowledge acquisition tests.

4. Opponents to alternatives to dissection state that it is difficult to replace the actual dissection experience.

5. Science education is changing to encourage more inquiry and flexibility of knowledge, and to expand and refine the roles of teachers and students.

6. The use of computers is becoming more prevalent and necessary in today's schools.

7. Teachers and students need to adapt to the way that technology is being used in the classroom.

8. Differences exist in the science education and computer interaction of girls and boys.

Based on these eight key findings, I have designed a computer laboratory experience in which girls worked cooperatively on computers to complete a virtual fetal pig dissection designed as an alternative to an actual fetal pig dissection. The girls in this study were enrolled in a single-sex class in an all girls school which eliminated male-female interaction. The virtual fetal pig dissection utilized the flexibility of multimedia design to enable the girls to freely review the systems that are presented. This study was an attempt to determine if the girls can learn using technology, and if this technology could be used as a replacement for animal dissection.

CHAPTER III

Introduction

This study is of quasi-experimental pre-test post-test design. Intact classes were used in this study meaning that there was no randomization of subjects. ANCOVA was used in the statistical analysis of the test scores using the students' standardized test scores from the PLAN test as a covariate to minimize any pre-existing differences among the subjects. Gain scores from the pre and post surveys were analyzed using two-group ANOVA tests. A purposeful sample of the students' written daily journals were collected and analyzed using a modified method based on the ethnographic analysis sequence developed by Spradley (1979). Semi-structured interviews were conducted among the control and experimental groups at the end of the dissections with a purposefully selected group of students. The data gathered from the journals and interviews is qualitative in nature and once added to the analysis of the quantitative survey data, created a triangulation of research that strengthened the quality of the inferences drawn by this researcher.

Participants

The participants in this study were 224 girls enrolled in 11 intact classes of a sophomore level biology course. These students attended a suburban all-girl, parochial high school. The biology students at this high school have traditionally performed dissections on fetal pigs, and with the rising costs of these specimens and the growing number of students who voiced objections to dissecting, the biology department at the school was open to finding an alternative to this animal dissection exercise.

Sample

The sample for this study was 224 female students who were enrolled in core or academic level biology classes at Archbishop Stephens High School. Eighty eight girls completed an actual dissection, and 136 completed a virtual dissection. These high school students were in 11 different classes taught by three different teachers. Although all three of the teachers were female, they vary in their years of experience at the school and differences may have occurred in their teaching. To minimize the effects of the different teachers' instructional methods, the students were given the same information and assignments, and followed the same schedule to complete the dissection laboratory exercise.

Another difference between the 11 biology classes is that 4 of the classes were being taught at the core, or basic level, and 7 of the classes were taught at the academic level. Core level students at Archbishop Stephens are characterized as students who score low on standardized tests, and learn at a slower pace than the students taught on the academic level. Both of these levels are considered college preparatory at the high school.

Of these classes, 4 of the academic classes completed the actual dissection, and all of the core classes completed the virtual. This less than ideal situation in the construction of the groups was to maintain the teaching method for each teacher for each of her scheduled laboratory periods. This means that one teacher conducted the actual dissections with her four academic level classes, and the other two teachers conducted the virtual dissections with their classes. Due to space and time considerations, this design was necessary so that in the shared biology laboratory there would either be virtual dissections conducted on computers, or actual dissections with specimens, throughout each day during the same two week period. This also enabled each teacher to conduct all of her classes within one method, virtual or actual, regardless of the level of students.

Population

The population for this study consisted of all high school students who were enrolled in biology classes and who have to perform a dissection as a requirement for the course. I specifically chose girls enrolled in high school biology in a single-sex school from this population to form the subjects for this study.

Selection Criteria

This researcher chose to study girls in a single-sex classroom to reduce the compounding variable of mixed-genders in co-ed classrooms. This choice of participants eliminated the interaction of the two sexes while performing a biology laboratory exercise on computers. More specifically, since studies have shown that girls react differently to science and technology than boys, the true measure of the girls' response to this study could be clearly seen. In addition, all of the biology teachers at the school are female, so this fact eliminated the possible differences of interaction between male instructors and female students in the classroom.

Instrumentation

The objective test used in this study to measure the students' knowledge acquisition was designed by one of the teachers at the school. It consisted of 60 questions that were matching, true and false, and multiple-choice in design. This teacher had used variations of this test for quite a few years and was pleased with its design. After meeting with all three of the teachers, we decided that this test would be an accurate measurement of the students' knowledge acquisition. A copy of this test can be found in Appendix E.

The students' visual recognition of fetal pig anatomical structures was measured with a practical test. A practical test had for many years been conducted in the laboratory setting with the students at the school walking from table to table and identifying structures marked with a pin. Approximately four years before, one of the biology teachers at the school had prepared a PowerPoint presentation composed of slides containing pictures of structures identified with numbers. Since this teacher felt confident that her students were performing as well on this type of presentation as they had on the original laboratory practical, the other biology teachers at the school adopted this type of practical test. I modified the original PowerPoint presentation with pictures taken by the students on the yearbook staff added to those I had taken myself. The practical test used in this study consisted of 27 PowerPoint slides containing 45 structures to be identified by the students. Printed copies of these slides can be found in Appendix F.

Semi-structured interviews were performed with a purposefully selected group of students that constituted approximately 10% of the sample. The teachers identified approximately two students from each class that they felt would be verbal with this researcher about their dissection experience. The interviews were held in the biology lab at the school. Most of the students met with this researcher at the conclusion of their biology class period one or two days after they had completed their objective and practical tests. The rest of the students were given passes to meet with this researcher in the biology lab during their independent study periods that also fell one or two days after they had completed their tests. The questions used in these interviews can be found in Appendix D.

In addition to the interviews, 10% of the students' journals were chosen by the teachers as good examples of the students' work and as rich sources of data. These journals contained all of the instructions for the dissection and worksheets that had been assigned for completion throughout the laboratory experience. In addition to the worksheets on the anatomy and physiology of the fetal pig, the students were instructed to write an entry for each day of the lab that described the information they had learned, their feelings about the daily dissections, and how well they worked with their partner for that day. After the teachers had graded the students' journals, they then turned a sample of these journals over to this researcher for review so that I could focus on the students' feelings about the dissection and their working relationships with their partners. Through careful review of the journals, certain themes began to emerge which lead to the use of an adapted form of domain, taxonomic, and componential analysis as a means to organize the students' descriptions of their experience into a cohesive and meaningful order.

The survey instrument used in this study was designed by this researcher with the input of the biology teachers at Archbishop Stephens. This questionnaire was used as both a pre and post-survey. The original survey instrument consisted of 18 questions that covered knowledge acquisition, attitudes toward dissections, computers, and biology. To create this instrument, an expert panel of biology teachers was assembled at the school chosen for this study. On their suggestion, the questions were compiled and pilot tested.

As a result of the pilot testing, the original survey instrument was refined to contain only 14 questions. The questions involving knowledge of anatomy were among those eliminated. The low alpha score for the items, and the fact that the students' knowledge acquisition would be measured by practical and objective tests determined this choice. The resulting survey was used in this study to determine attitudinal change. An example of this pre and post survey can be found in Appendix C.

Survey Reliability

The survey used in this study consisted of 14 questions that covered the students' attitudes toward dissections, computers, and science and biology. To increase the validity of the survey instrument, the reliability was analyzed. These results are discussed in detail in the next section. To determine the reliability of the questions, a total Cronbach's Alpha test was performed on the data. Factor analysis tests were run to identify the constructs of the instrument, and then individual Cronbach's Alpha tests were performed on each construct.

Reliability of Individual Constructs

The survey instrument was originally designed to measure the students' attitudes toward dissections, computers, and biology. The questions were divided into four categories, or constructs, as identified through factor analysis, with one of the questions not fitting into any of the constructs. Six of the survey questions dealt with the students' attitudes toward dissections. These six questions were divided into two groups of three questions: three questions measuring the students' attitude toward actual dissections, and three questions measuring the students' attitude toward virtual dissections. Five of the remaining questions dealt with the students' attitude toward computers, and two of the remaining questions dealt with the students' attitude toward biology. Each of these four categories was then tested using Cronbach's Alpha, and the results of each category are discussed separately. One of the questions did not fit into any of the categories. However, its results were significant, and are discussed separately from the other groups of questions.

Attitude toward actual dissections

Three of the survey items were used to identify the students' attitude toward actual dissections. Reliability analysis showed a Cronbach's Alpha value of .7121 for the three items measuring attitude toward dissections.

Attitude toward virtual dissections

Three of the survey items measured the students' attitude toward virtual dissections. Reliability analysis showed a Cronbach's Alpha score of .8734 for the three items measuring attitude toward virtual dissections.

Attitude toward computers

Five of the questions on the pre survey dealt with the students' attitude towards computers and their computer usage. Reliability analysis showed a Cronbach's Alpha value of .8141 for these five items.

Attitude toward biology

Two of the questions on the pre survey dealt with the students' attitude toward biology. Reliability analysis showed a Cronbach's Alpha value of .8360 for these two items.

Knowledge of similarity of anatomy

The remaining question on the survey did not fit into any of the other categories. However, because its results may be meaningful to the students' understanding of the relationship between human anatomy and that of a fetal pig, its importance to the study cannot be overlooked.

Procedures

The biology teachers distributed the pre survey to the participants on the first day of their fetal pig dissection activity. The students were instructed by their teacher to answer the questions to the best of their knowledge by circling the selected answer to each question. Once the surveys were completed, instruction packets were distributed to the students that contained instructions for the entire laboratory experience. When all of the paperwork was distributed and completed, the students who actually dissected a fetal pig proceeded to the biology laboratory to begin their dissection, and the students who virtually dissected a fetal pig reported to the library to complete their laboratory exercise. A video of an actual fetal pig dissection was shown to both groups of students before they began their dissections.

The library of Archbishop Stephens High School was chosen as the location for the virtual dissection because of a bank of 15 computers that were connected to the Internet and located on the far side of the library. This location assured the classes of biology students a measure of privacy in an otherwise busy library. In addition, this proved to be the only location in the school where this many computers were connected to the Internet and available for classes to reserve for use. These 15 computers allowed the students to work in groups of two allowing for maximum exposure to the virtual exercise, and little or no wait time for computers. One drawback to this location is that the librarians did not allow the teachers to bring any fetal pig specimens into the library. This meant that the students had to go into the biology laboratory, located in another building, to view actual specimens. To partially solve this problem, the teachers and I set up a day at the end of the two-week period for the students to come into the biology laboratory and view all of the specimens at one time. Although this meant that the students would not have continuous access to the specimens, it was the only solution that was accepted by both the biology teachers and the librarians.

The three biology teachers who participated in this study were each assigned two weeks to complete the dissection. This meant that the dissections in this study, both actual and virtual, should have been performed during a six-week period. However, in order to reserve the library, the students who would virtually dissect had to be scheduled for two weeks later in the semester, almost one and one half months after the students who completed the actual dissection.

Class length at the school is 75 minutes and, with a rotating schedule, the classes met five to six times each within the two-week period. During these class periods, the students completing an actual fetal pig dissection worked in groups of two with one pig assigned to each group. The students completing a virtual dissection also worked in groups of two with one computer assigned to each group. Since it was not allowable to bring fetal pig specimens to the library for the students to view, one additional day of laboratory work was scheduled for the virtual dissection students so that they could go to the biology lab and view displays of the actual specimens. This meant that the students who virtually dissected actually spent one more day on the dissection exercise than the students who actually dissected a fetal pig.

Daily Schedule

The actual dissection group and the virtual dissection group followed the same dissection schedule. The students' lab schedule for dissections can be found in Table 1.

Table 1
Daily Lab Schedule

Day	System to be Dissected
Day 1	External Structure
Day 2	Mouth, Neck and Throat Organs
Day 3	Organs of the Thoracic Cavity – Lungs and Heart
Day 4	Digestive System
Day 5	Urogenital System
Day 6	Nervous System

Each day of the dissection laboratory, the students began by reading their packet and following the instructions. The students in both groups received the same instruction packet, regardless of the type of dissection in which they would participate. To enable both groups of students to use the same packet, the students who virtually dissected were instructed to ignore the dissecting instructions in the packet.

The students were instructed to complete their journal entries which contained the answers to the questions in the packet, drawings of the organs and systems they studied that day, and their thoughts and feelings concerning how they and their partners worked during that period and on the dissection experience itself. In addition, the students were to create a chart of the structures studied that day which included columns for the organs' description, position within the body, other associated organs and the function of the organ or organ system being studied that day. These packets were turned in to their respective teachers at the completion of the laboratory exercises. Daily quizzes were given to determine if the students are keeping up with the dissection assignments. These quizzes were not included in the data for this study as I felt that the daily grades might not accurately depict the students' knowledge acquisition, but would rather illustrate their ability to keep up with the material.

Once the students had completed the dissections, they were given both objective and practical tests to determine knowledge acquisition. The students were given a practical test consisting of PowerPoint slides containing pictures of organs and structures for the students to identify. This PowerPoint test was projected using a large computer monitor placed at the front of the class. The students were then given an objective test that contained questions to measure the students' knowledge of the anatomy and physiology of the fetal pigs.

A post survey was given by their teachers to determine attitudinal change. Once the journals had been graded for content, the teachers turned over a purposefully selected sample to this researcher. The completed surveys were picked up at the same time. The semi-structured interviews were conducted in the biology laboratory by this researcher during the class periods immediately following the test day. I also dropped in periodically throughout the scheduled period for dissections to visually verify teacher compliance with the designed classroom processes.

Data Analysis Procedures

This study is of quasi-experimental, pretest-posttest design. The grades from the objective and practical tests were statistically analyzed using ANCOVA and compared across the experimental and control groups. Statistical analysis of the test scores was ANCOVA so that the students' science scores on the PLAN test, a standardized test given at the high school to freshmen and sophomores, could be used as a covariate in an effort to minimize any existing difference in achievement between the two groups. Gain scores from the pre and post surveys were computed and compared using two-group ANOVA tests. The data collected from the semi-structured interviews was analyzed and sorted by question noting comparisons across the groups. The data collected from the sample daily journals was analyzed to determine any emergent themes from the students' experiences. A modified type of semantic analysis was employed to analyze this data, based on a model of ethnographic analysis. Spradley (1979) developed a system of ethnographic analysis based on domain analysis, taxonomic analysis and componential analysis. This researcher has chosen to modify Spradley's design to refine, compare, and analyze the descriptors used by the students to describe their experience. These descriptors were culled from the students' journals.

Spradley (1979) described a domain as a "symbolic category that contains other categories" (p. 100). The students' experiences were compared across the groups, and once emergent themes were identified, a domain analysis was performed on the data. A taxonomic analysis was constructed of the identified domains so that the students' descriptors can clearly be seen, as they visually surround the various domains that emerged from the journal data. To complete the comparison, a componential analysis was constructed. The results of the componential analysis formed the basis for the comparison of the students' thoughts and feelings about their dissection experience. This qualitative data allowed the researcher to draw more insightful conclusions as to the students' test and survey results.

Research Hypotheses

Hypothesis 1: The mean scores of the practical test taken by the students completing a virtual fetal pig dissection will be greater than the mean scores of those completing an actual dissection.

Hypothesis 2: The mean scores of the objective tests taken by the students completing a virtual fetal pig dissection will be greater than the mean scores of those completing an actual dissection.

Hypothesis 3: A virtual fetal pig dissection as an integral part of a biology laboratory experience will serve to positively affect the students' attitudes towards actual dissections.

Hypothesis 4: A virtual fetal pig dissection as an integral part of a biology laboratory experience will serve to positively affect the students' attitudes towards virtual dissection.

Hypothesis 5: A virtual fetal pig dissection as an integral part of a biology laboratory experience will serve to positively affect the students' attitudes toward computers and their educational usage.

Hypothesis 6: A virtual fetal pig dissection as an integral part of a biology laboratory experience will serve to positively affect the students' attitudes toward biology.

<u>Hypothesis 7</u>: Students interviewed at the completion of the virtual dissection will respond more positively about their dissection experience than those who completed an actual dissection.

<u>Hypothesis 8</u>: Students daily journal entries will show that the students will respond more positively about their virtual dissection experience than those who completed an actual dissection.

<u>Objectives for Fetal Pig Dissections</u>:

The objectives for the fetal pig dissections were developed with the input of the biology teachers at Archbishop Stephens High School. By meeting with these teachers, and discussing their goals and objectives of fetal pig dissections, we were able to compile the following six objectives.

At the completion of this virtual pig dissection, the students will be able to:

1. Name the major organs found in a typical mammal.
2. Locate the various organs found in a typical mammal.
3. Relate the position of various organs relative to one another in the fetal pig.
4. List the components of different body systems.
5. Differentiate between the organs of a fetal pig and those of a human.
6. Compare and contrast fetal pig and human anatomy.

<u>Independent and Dependent Variables</u>

The independent variable in this study is the use of a virtual fetal pig dissection. Two students on the yearbook staff of Archbishop Stephens High School took original photographs with a digital camera during dissections performed by another biology teacher at the school. This original material and additional pictures taken by this researcher, were integrated with an existing virtual pig dissection found on the web to design the virtual experience as close as possible to the structure of the actual dissections. The excellent virtual dissection on the World Wide Web was created by Earl W. Fleck while at Whitman College in Walla Walla, Washington. It can be found at http://www.whitman.edu/biology/vpd/main.html. Dr. Fleck gave permission to this researcher to use his virtual fetal pig dissection through email correspondence.

The web-based program used in this study was designed by the researcher and can be found on the World Wide Web at http://tec.uno.edu/George/Class/2002Fall/EDCI4993603/webSites/BMaloney/pigdissection.htm

The dependent variables in this study are knowledge acquisition and changes in attitude toward dissection, computer use, and biology. The acquisition of knowledge was measured using objective and practical tests administered by the teachers at the end of the laboratory exercise. The results of these tests were statistically analyzed with ANCOVA to determine if any differences between the groups were significant. Attitudinal change was measured with pre and post surveys, and the results from these surveys were analyzed using two group ANOVA tests.

A purposeful sample of daily journals from both the actual and virtual dissection groups was collected. These were examined for the students' thoughts and feelings about the dissection experience, and this data was analyzed to determine if any themes were evident in the students' responses. In addition to the journal entries, interviews were held to allow a purposeful sample of students to elaborate on their dissection experience.

Semi-structured interviews were held with a purposeful sample of students from each dissection experience. The students were asked questions by the researcher during the class that followed their practical and objective tests. The purpose of these questions was to clarify and enrich the data collected from the pre and post-survey questions and the daily journal entries.

Summary

This study compared the dissection experience of two groups of female high school biology students. The experimental group performed a virtual fetal pig dissection, and the control group actually dissected fetal pigs. The population for this study was high school students who dissect in their biology classes. The sample chosen was composed of female biology students who attended a suburban parochial all girls' high school. The data collected from this study was both quantitative and qualitative. The quantitative data consisted of the students' scores on practical and objective tests, and their answers on the pre and post surveys. The qualitative data consisted of responses to semi-structured interviews and daily journal entries.

CHAPTER IV

Results and Data Analysis

The data collected in this study was of two distinct forms: quantitative and qualitative. The quantitative data consisted of standardized science test scores from the PLAN test, results from a pre and post survey, and scores from practical tests and objective tests. The PLAN scores were collected from the counseling department at the school. The pre and post surveys were distributed to all of the subjects in the study both before and after the students' dissection experience. A sample of the pre and post surveys can be found in Appendix C. The practical and objective tests were given at the conclusion of the dissection experience to both the students who actually dissected and those who completed their dissection virtually. A sample of the written objective test can be found in Appendix E, and the printed slides from the practical test can be found in Appendix F. The results from the practical and objective tests, and gain scores from the attitudinal surveys were analyzed using SPSS version 10.0.

The qualitative data collected from this study came from two sources: data from semi-structured interviews and data collected from the students' journals. Approximately 10% of the subjects in the study were chosen by their teachers to participate in the interviews. The students were interviewed individually and asked 6 identical questions. The students' answers are described by examining the questions individually. A sample of this questionnaire is located in Appendix D.

In addition to the interviews, 10% of the students' journals were chosen by the teachers as good examples of the students' work and as rich sources of data. These journal entries, describing the students' thoughts and feelings about their dissection experience, were analyzed using a modified form of Spradley's ethnographic analysis.

Research Questions

Specifically, this research attempted to answer the following questions:

1. Does a virtual fetal pig dissection, as compared to an actual fetal pig dissection, significantly affect female students' knowledge of anatomy?
2. Does a virtual fetal dissection, as compared to an actual fetal pig dissection, significantly affect female students' attitudes toward dissections, toward the use of computers, or toward biology? The hypotheses developed to answer these questions and the results obtained from the analysis of the data are discussed individually.

Research Question 1

Research Question 1 can best be answered quantitatively by examining the students' test scores on the practical and objective tests. All of the students were given the same practical and objective tests regardless of the type of dissection they performed. To compensate for any existing differences in the students' performance, an ANCOVA test was conducted on the results using the students' science standardized test scores from the PLAN test as a covariate.

Quantitative Data

The first hypothesis that addressed the students' acquisition of knowledge was:

Hypothesis 1: The mean scores of the practical tests taken by the students completing a virtual fetal pig dissection will be greater than the mean scores of those completing an actual dissection.

The practical test given to the students consisted of twenty-seven PowerPoint slides that contained pictures of organs and structures from actual fetal pig specimens. Each of the forty-five organs or structures in question was highlighted through the use of a white arrow containing the corresponding question number. The teachers showed this PowerPoint practical test on a large computer monitor in front of the class. The students were instructed to fill in the name of the highlighted structure(s) on each slide on a numbered answer sheet. This practical test was graded by the teachers, and scored out of forty-five points. An ANCOVA was performed on the students' test scores using the students' PLAN scores as covariates. In addition, Levene's Test of Equality of Error Variances was performed ($F=.319$, $p=.573$). Since the probability of the test is greater than the alpha level, the assumption of homogeneity of error variance is maintained. The results indicate that the students who completed a virtual dissection scored higher (37.5760) than the students who completed an actual dissection (30.6522). This difference was significant ($F= 62.037$, $p<.001$) at the .05 level. Because a significant difference was found between the practical test scores of the two groups, the null hypothesis can be rejected. These results indicate that the mean scores from the practical test of the students who performed a virtual fetal pig dissection are significantly higher than the mean scores of those students who performed an actual dissection.

Table 2
ANCOVA Summary Table for Practical Test Scores

Source	SS	df	MS	F	Sig.
Between groups	337.004	1	337.004	8.744	.003
Within Groups	2390.932	1	2390.932	62.037	<.001
Total	249022.000	194			

Hypothesis 2: The mean scores of the objective tests taken by the students completing a virtual fetal pig dissection will be greater than the mean scores of those completing an actual dissection.

The objective test given to the students consisted of sixty questions pertaining to the anatomy and physiology of the fetal pig. This test was distributed as a packet to the students who were instructed to fill in the ovals corresponding to their answers on a standardized answer key. An ANCOVA test was performed on the students' test scores using the students PLAN scores as covariates. In addition, Levene's Test of Equality of Error Variances was performed (F=.027, p=.870). Since the probability of the test is greater than the alpha level, the assumption of homogeneity of error variance is maintained. The results of the ANCOVA test indicate that the students who completed a virtual dissection scored higher (44.7760) than the students who completed an actual dissection (43.7681). This difference was significant (F=6.188, p=.014) at the .05 level. Because a significant difference was found between the objective test scores of the two groups, the null hypothesis can be rejected. These results indicate that the mean scores on the objective test of the students who performed a virtual dissection were significantly higher than the mean scores of the students who actually dissected a fetal pig.

Table 3
ANCOVA Summary Table for Objective Test Scores

Source	SS	df	MS	F	Sig.
Between groups	433.121	1	433.121	9.347	.003
Within Groups	286.765	1	286.765	6.188	.014
Total	386104.000	194			

Research Question 2

Research Question 2 can best be answered using both quantitative and qualitative data. This data consisted of the students' responses to pre and post surveys, their responses to interview questions, and their written journal entries. All of the students in this study were given pre surveys before their dissection experience, and post surveys after the completion of their dissection experience. Approximately 10% of the students were chosen by their teachers to participate in semi-structured interviews. The interviews were conducted by this researcher in the biology lab at the school, and were held approximately 1-2 days after the completion of the students' dissections. Approximately 10% of the journals were chosen by the teachers to be examined by the researcher as a rich source of data.

Quantitative Data

Research Question 2 is composed of three parts: the students' attitudes toward dissections, toward the use of computers, and toward biology. Questions from the pre and post surveys were grouped together as to how they correspond to each of the three parts of the research question. In addition, there are four hypotheses that were designed to answer this question, and the results pertaining to each hypothesis are discussed individually.

Attitude toward actual dissections

Hypothesis 3: A virtual fetal pig dissection as an integral part of a biology laboratory experience will serve to positively affect the students' attitudes toward actual dissections.

Three of the questions on the pre and post surveys dealt with the students' attitude toward actual dissections. These questions were designed to determine if students who performed virtual dissections, as compared to those who performed an actual fetal pig dissection, showed an attitudinal change the dissection of animals. A reliability analysis was performed on these questions and an alpha score of .7121 was produced. These questions can be found in Table 4.

Table 4
Survey Questions - Attitude toward Actual Dissections

Attitude toward Actual Dissections
1. All students should dissect an animal.
2. It is OK to use animals for educational purposes.
6. Dissections are necessary to learn anatomy.

A gain score was calculated for both the pre and post responses to the questions corresponding to the students' attitude toward actual dissections. Two-group ANOVA tests were performed to determine the change, if any, in the gain scores. The students who actually dissected a fetal pig reported a negative change (-.0976) in their gain score, and the students who virtually dissected reported a positive change (.4667). An ANOVA test was run to determine if these differences were significant. The results of the

ANOVA test show that when comparing the scores across the two groups, the change in gain score of the virtual dissection students' attitude toward actual dissections was significant (F=5.393, p=.021) at the .05 level. These results indicate that the students who virtually dissected a fetal pig reported a positive change in their attitude toward dissections, and that the null hypothesis must be rejected. These results can be found in Table 5.

Table 5
ANOVA Summary Table for Attitude toward Actual Dissections

Source	SS	df	MS	F	Sig.
Between groups	15.508	1	15.508	5.393	.021
Within Groups	575.086	200	2.875		
Total	590.594	201			

Attitude toward virtual dissections

Hypothesis 4: A virtual fetal pig dissection as an integral part of a biology laboratory experience will serve to positively affect the students' attitudes towards virtual dissection.

Three of the questions on the pre and post surveys dealt with the students' attitude toward virtual dissections. These questions were asked of the students to determine if any attitudinal change was found toward the virtual dissection experience. A reliability analysis was performed on these questions and an alpha score of .8734 was produced. These questions can be found in Table 6.

Table 6
Survey Questions - Attitude toward Virtual Dissections

Attitude toward Virtual Dissections
9. Dissections can be performed on computers.
10. I can learn just as much from a dissection on the computer as from a real dissection.
13. Virtual dissections can teach a lot about anatomy.

A gain score was produced for both the pre and post responses to the questions corresponding to the students' attitude toward virtual dissections. Two-group ANOVA tests were performed to determine the change, if any, in the gain scores. The students who actually dissected a fetal pig reported a negative change (-.3659) in their gain score. The students who virtually dissected also reported a negative change (-1.6639). An ANOVA test was run to determine if these differences were significant. The results of the ANOVA show that when comparing the scores across the two groups, the change in gain scores of the students' attitude toward virtual dissections was significant ($F=13.435$, $p<.001$) at the .05 level. These results indicate that the students in both groups had a negative change in their attitude toward virtual dissections. This shows that the students who participated in a virtual dissection felt significantly more negative about the experience after they had completed their dissection. The students who completed an actual dissection also felt more negative toward a virtual dissection once they had completed their laboratory exercise. The null hypothesis regarding attitude toward virtual dissection must be rejected. Although significant, these results differ from the results of the students' positive attitudinal change toward actual dissections. The results from the ANOVA test on these gain scores can be found in Table 7.

Table 7
ANOVA Summary Table for Attitude toward Virtual Dissections

Source	SS	df	MS	F	Sig.
Between groups	81.794	1	81.794	13.435	<.001
Within Groups	1211.579	199	6.088		
Total	1293.373	200			

Attitude toward computers

Hypothesis 5: A virtual fetal pig dissection as an integral part of a biology laboratory experience will serve to positively affect the students' attitudes toward computers and their educational usage.

Five of the questions on the pre and post surveys dealt with the students' attitude toward computers. A reliability analysis was performed on these questions and an alpha score of .8141 was produced. These questions can be found in Table 8.

Table 8
Survey Questions - Attitude toward Computers

Attitude toward Computers
4. I like to work with computers.
5. Computers are useful tools for education.
8. Computers are useful tools for science.
11. I feel comfortable working on computers.
12. I use computers at least once a week at home for educational purposes.

A gain score was produced for both the pre and post responses to the questions corresponding to the students' attitude toward computers. A two-group ANOVA test was performed to determine the change, if any, in the gain scores. The students who actually dissected a fetal pig reported a negative change (-.1084) in their gain scores, and the students who virtually dissected also reported a negative change (-.4622). An ANOVA test was run to determine if these differences were significant. The results of the ANOVA show that the change in gain scores of the students' attitude toward computers was not significant ($F=1.186$, $p=.277$) at the .05 level. The null hypothesis cannot be rejected as a result of these findings. These results indicate that students from both groups in the study reported that they felt more negatively toward computers once they had completed their dissections. Although these results are not significant, it is educationally significant to note that a negative shift in attitude occurred in the students who interacted with computers to complete their virtual dissection. The ANOVA results can be found in Table 9.

Table 9
ANOVA Summary Table for Attitude toward Computers

Source	SS	df	MS	F	Sig.
Between groups	6.119	1	6.119	1.186	.277
Within Groups	1031.604	200	5.158		
Total	1037.723	201			

Attitude toward biology

Hypothesis 6: A virtual fetal pig dissection as an integral part of a biology laboratory experience will serve to positively affect the students' attitudes toward biology.

Two of the questions on the pre and post surveys dealt with the students' attitude toward biology. A reliability analysis was performed on these questions and an alpha score of .8360 was produced. These questions can be found in Table 10.

Table 10
Survey Questions - Attitude toward Biology

Attitude toward Biology
3. I like Biology.
14. Science is one of my favorite subjects.

A gain score was produced for both the pre and post responses to the questions corresponding to the students' attitude toward science. A two-group ANOVA test was performed to determine the change, if any, in the gain scores. The students who actually dissected a fetal pig reported a negative change (-.3133) in their gain score, and the students who virtually dissected also reported a negative change (-.0992). An ANOVA test was run to determine if these differences were significant. The results of the ANOVA show that the change in gain score of the students' attitude toward science was not significant ($F=1.536$, $p=.217$) at the .05 level. Although these results are not significant, it is educationally significant to see that the students from both groups felt more negatively toward biology once they had completed their dissections. The ANOVA results can be found in Table 11.

Table 11
ANOVA Summary Table for Attitude toward Biology

Source	SS	df	MS	F	Sig.
Between groups	2.256	1	2.256	1.536	.217
Within Groups	296.665	202	1.469		
Total	298.922	203			

Knowledge of similarity of anatomy

The remaining question on the survey dealt with the students' knowledge of the similarity of anatomy between humans and fetal pigs. Question 7 reads, "Pigs are anatomically similar to humans." A gain score was produced for both the pre and post responses to the question. An ANOVA test was performed to determine the change, if any, in the gain scores. The results indicated that the students who virtually dissected a fetal pig achieved a higher gain score (.4250) than the students who actually dissected (.1928). This difference of gain scores was significant (F=4.914, p=.028) at the alpha level, signifying that the students who virtually dissected agreed more positively to this question at the end of their dissection experience. The ANOVA results for the gain scores for Question 7 can be found in Table 12.

Table 12
ANOVA Summary Table for Question 7: Pigs are anatomically similar to humans

Source	SS	df	MS	F	Sig.
Between groups	2.646	1	2.646	4.914	.028
Within Groups	108.241	201	.539		
Total	110.887	202			

In addition to the above data, two more hypotheses were designed to answer Research Question 2.

Hypothesis 7: Students interviewed at the completion of the virtual dissection will respond more positively about their dissection experience than those who completed an actual dissection.

Qualitative Data: Interview Question Analysis

Semi-structured interviews were held with 22 students, which comprised approximately 10% of the total sample. Eight of these students completed the actual dissection and 14 completed the virtual dissection. The students' responses to each of the questions are discussed. These responses will be divided as to the dissection method in which the students participated. A copy of the questions asked in these interviews can be found in Appendix D.

Question 1: What was your experience with dissections prior to this class?

Actual Dissection

Of the students who actually dissected, 3 had never dissected prior to this fetal pig dissection. The remaining 5 students had dissected frogs and earthworms. Two of these students also dissected a flower, and 1 of the students had dissected owl pellets. Of the students with prior dissection experience, 2 described it as a bad experience. One of the students described it as "the worst experience ever. I sliced open my fingers." The other student stated, "I didn't do a frog because I threw up in 7th grade. So I copied pages out of an encyclopedia. I went to the library, made copies and got an A."

Virtual Dissection

Ten of the 14 students who completed a virtual dissection had previous dissection experience. Nine of these students had dissected a frog and 4 of the 9 students also dissected an earthworm. One student reported that she had dissected a lamb's heart and stated, "it was pretty cool." Two of the students who dissected a frog stated they also dissected another specimen. One of these students stated she had dissected a flower, and another had dissected an owl pellet. Of the students who had prior dissection experience, 8 reported that they "liked it" or "it was okay." Two of the students reported that although they participated in a dissection with their partner, they didn't touch the specimen during their dissection experience.

Summary

These responses to the first interview question indicate that the students in both groups had similar dissection experiences prior to the study. Most of the students had previously dissected frogs and worms and reported it had been a positive experience.

Question 2: How do you feel about the use of animals for dissections in educational settings?

Actual Dissection

Three of the 8 students who actually dissected thought that it was fine to use animals for dissections as long as it was performed for educational purposes. Three additional students felt that it was okay to use the fetal pigs because they were going to be killed anyway. They felt that it was fine to use animals as long as the animals were not killed specifically for that purpose. In addition, one of these students felt that the dissection was "good for people interested in science. People who don't have anything to do with science may not want to do an actual dissection." And, although she agreed that animal dissection was okay, 1 of the 8 students who completed an actual dissection felt that the schools shouldn't use so many specimens and also thought that "it was gross, they stunk." Another student agreed with the use of the pigs by responding, "It was better than nothing. The pig is the best to use because it resembles you in a way."

The eighth student who performed an actual dissection disagreed with the use of the fetal pigs. She stated, "I don't like it. On principle, this is a Catholic school, you can't use aborted fetuses for tissue research but you can use these pig fetuses? I think that tissue research would be more important than entertaining high school students."

Virtual Dissection

One of the 14 students who performed a virtual dissection stated that she agreed with the use of animals for educational purposes. She said, "I think it is fine. If anyone wants to go into the field, they need a hands-on visual experience. As long as the animals aren't killed for this purpose and put to good use. You could see how the body parts worked and how they are used." Six of the students responded in a similar vein. Four of these students responded that people who plan to enter the medical profession need this practice for medical school and college biology.

Three of the students who performed a virtual dissection felt that it was okay to use the fetal pigs as long as they weren't killed specifically for the purpose of dissection. One of these students felt that schools didn't need to use so many specimens stating that teachers should "just use a couple to show the class." Another of these students felt it was "fine" to use animals for educational purposes and the remaining student felt that it was "sad" to use the animals, but stated that they were "good to learn from."

Summary

The responses to the second interview question indicate that most of the students in both of the groups felt that it was okay to use animals for educational uses, as long as the animal was not killed specifically for that purpose. In addition, 5 of the students responded that the students who were planning on entering a medical field should be dissecting animals. A valuable suggestion by two of the students was that only a limited number of specimens were needed, or that the teacher should "just use a couple to show the class."

<u>Question 3</u>: How would you describe your fetal pig dissection experience?

Actual Dissection

Six of the 8 students who completed an actual dissection stated that the dissection was hard, that it was difficult to find the organs and know what to cut. One of these students summed up their views by saying that she had difficulty "finding the right parts and taking out the right things." Although these students reported that they had difficulties, five of these students concluded that the overall experience was positive, with one student stating that she felt "it was good to actually get the chance to see what organs look like." One student who completed an actual dissection summed up her experience by stating, " I think it was the best thing I have done this year. I was nervous the whole time, the cutting was nerve-wracking, but it was fun." The 7th student who actually dissected a fetal pig echoed this sentiment by saying "I am glad it's over. Every day the smell grossed me out." Although this student was "grossed out," she did report a positive experience overall.

The remaining student, of the 8 students who actually dissected, responded, "I had a negative experience. I did not want to dissect cute little pigs, I wanted to play with them."

Virtual Dissection

Many strong feelings emerged from the interviews with the students who performed virtual dissections. Eight of the 14 students stated that the dissection was "complicated," "chaotic," "horrible," "frustrating," "annoying," and "stressful." One of these students summed up these thoughts by saying "It was very stressful and I was aggravated. You didn't know where the body parts were on the computer. I was very stressed out with it, and I needed a lot of explanations." One student who performed a virtual dissection disagreed and felt that you could see the organs clearer when looking at an actual specimen. Another of these students said "It was frustrating because the packet didn't match. It was the first time for the teachers and both the teachers and students didn't know what to do." One student disagreed with this idea by stating that the teacher "did a good job, I feel so bad we stressed her out."

The 4 students who stated they liked the virtual dissection all agreed on the fact that the organs were easier to locate by using computers. One of these students felt that "It was very educational, I really liked it. It showed the organs to you and it was easier than finding them in the pig." One student stated an additional benefit in that "It didn't gross me out and I got all the information I needed."

Summary

The majority of the students from both groups stated that they felt that the dissection laboratory was difficult. In addition, students from both groups responded that the dissections were stressful. Although students in both groups voiced the sentiment, more students who completed the virtual dissection complained of being stressed by the experience. Another difference that emerged was that the students felt that the teachers who conducted the virtual dissection were inexperienced with the procedure. This feeling was not voiced by any of the students who actually completed a dissection. Additionally, a few comments were raised as to the difficulty of being able to orient the specific organs and structures as to their position in both the virtual and actual fetal pigs.

Question 4: How do you feel about the fact that some people performed a virtual dissection instead of having performed a dissection on an actual animal?

Actual Dissection

Three of the 8 students who performed an actual dissection responded that they would have preferred to complete their dissection on the computer. One student stated, "I would have rather done it virtually. I don't think that students should be forced to dissect. Very few of us are going into medical schools."

Three students who actually dissected disagreed with the virtual dissections. One student disagreed by stating, "Virtual is on the computer, and you can't feel the texture. You need to feel it. It is better for those students who want to dissect on the computer, but it would be boring. Who's going to remember? I will remember pulling out the intestines." Another student agreed with this assessment by saying, "Computers can be done at any time, but I will never be able to dissect a pig again." However, 1 of the 8 students stated that dissection should be done with actual specimens. She said, "Even though it is gross, and you might want to do it virtually, I think you get more out of it if you actually dissect."

Two of the students said that it really didn't matter which way the students dissected, as long as they were learning.

Virtual Dissection

Three of the 14 students who were interviewed and who had completed a virtual dissection felt that it was okay that they had performed the dissection on a computer. One of the students said, "I thought it was fair. I didn't have a problem with it. We ended up seeing the pig in the lab, and I wasn't jealous."

The 11 other students who virtually dissected did not think it was fair that they were unable to dissect an actual fetal pig. One of these 11 students stated, "It was not fair. They got to do the real pig and I have been waiting since freshman year to dissect."

One of these students stated that she thought it was unfair and that if a student was more proficient on the computer she should have the choice, but this student preferred to actually dissect a fetal pig. In terms of having a choice, another of these students stated, "I understand it was an experiment, but it is my personal opinion that everyone should dissect. If someone is strongly opposed, then they should have a choice."

Summary

Three of the 8 students from the actual dissection wanted to complete their dissection on the computers. In addition, 3 students who completed a virtual dissection wanted to complete their experience on the computers. The problem voiced by the 11 remaining students who completed their dissection on the computer was that they felt that they were denied the chance to actually dissect the fetal pig and that it was not fair that they did not have the chance to experience the actual dissection. The students did have the option of opting out of the experiment but did choose to participate. The fetal pig dissection experience is seen as a tradition by the students of the school, and many who were interviewed felt that they were denied the chance to participate in this traditional activity. One original thought voiced up by two students who actually dissected was that it did not matter which type of dissection was performed as long as the students learned something from the experience.

<u>Question 5</u>: What is your opinion about the use of computers in the classroom?

Actual Dissection

Only 1 of the 8 students interviewed who had performed an actual dissection objected to the use of computers in the classroom. She stated that she felt that computers were hard to work with and that "they have no role in education." The other 7 students thought computers were useful in education. Their thoughts ranged from "really helpful," and "it makes life a whole lot easier," to " I am a computer freak. If it were up to me I would be on the computer all the time."

Virtual Dissection

All of the 14 students who had completed a virtual dissection and were interviewed stated that they liked computers. Their comments included: "they are awesome," very helpful," and "good for research." However, one of the students included the following in her response: "Computers are very good, but not for dissections." One student stated that computers have other uses. She stated, "the world is going at such a fast pace and you have to keep up. Computers help with understanding stuff, not only for education."

Summary

The majority of the students in both groups felt that computers were useful in education. A common response from the students was how useful the Internet was for educational research. Only one of the students who were interviewed responded that computers had no place in education.

Question 6: Do you have any comments on the fetal pig dissection to share?

Actual Dissection

Of the 8 students interviewed who actually dissected a fetal pig, 5 of these responded that they were glad that they actually dissected. As one student said "It was the best thing I will remember from sophomore year. People would ask me all the time if I had done the pig yet."

Two of the 8 students who actually dissected expressed a desire to have performed the dissection virtually. One of these students commented, "I failed my test. I can usually learn from pictures and I like the fact that you can take the pictures home with you (on the Internet). The pig was only there for an hour." The student was referring to the fact that she was only able to view the specimen for the length of time she was in class, and that the virtual dissection was online and she would have been able to study it at home.

Virtual Dissection

Two of the 10 students who responded to this question stated that the virtual dissection would have been easier for them if the teachers had a better understanding of what they were supposed to do. One of these students expressed it as "these teachers had to help us more, they didn't know what we were doing."

Three of the 10 students complained that the quizzes and tests were too hard, and one of these students said “I went from straight A’s to F’s.” In addition, 1 of the 10 students summed up her virtual dissection experience by stating, “It was very stressful and I didn’t like it.”

Four of the 10 students who answered this question and had completed a virtual dissection were glad they had performed the dissection virtually. One of these students stated, “I think it was easier to do it on the computer because you could see the organs better than in a real pig.”

Summary

The responses made by the students to this last question reiterated their earlier comments. Five of the 8 students who actually dissected the fetal pig were glad they had the chance to participate in the actual dissection. One new response, voiced by students of both groups, was that the tests and quizzes were hard and that their grades had dropped since they had begun the dissections.

Qualitative Data: Journal Data Analysis

The data collected from the students’ journals comprised the students’ feelings toward dissection and working with their partners. The teachers in this study collected journals from their students that they felt would be a rich source of data. Nine journals were collected from the students who completed actual dissections, and 15 were collected from the students who completed the virtual dissections. These 24 selections comprised approximately 11% of the journals completed by the 224 subjects.

Five domains emerged from the descriptive data reported in the journals of the students who actually dissected a fetal pig. The domains that emerged from the studying of the data were: positive and negative descriptors describing the process of actually dissecting, positive and negative feelings evoked from the process, and descriptions of partnership.

Hypothesis 8 was developed to help answer Research Question 2. The data gathered from the students' journals served to support or reject this hypothesis.

Hypothesis 8: Students daily journal entries will show that the students will respond more positively about their virtual dissection experience than those who completed an actual dissection.

Actual Dissection

The first theme that emerged was that of the students' descriptions of the dissection process. The students used both positive and negative descriptors to explain how they felt about the dissection. These descriptors were divided into two domains: positive and negative. Seven negative descriptors and five positive descriptors were culled from the students' journal entries. The positive description domain is illustrated in Table 13. The negative description domain describing the dissection process can be found in Table 14.

Table 13
Actual Dissection: Dissection Process – Positive Descriptor Domain

Included Terms	Semantic Relationship	Cover Term
Neat		
Amazing		
Cool	is a kind of	positive descriptor
Fun		
Interesting		

Table 14
Actual Dissection: Dissection Process – Negative Descriptor Domain

Included Terms	Semantic Relationship	Cover Term
Hard		
Difficult		
fast-paced	is a kind of	negative descriptor
nerve-wracking		
Complicated		
Smelly		
Gross		

The second theme that emerged from the review of the students' journals was one of their feelings toward their dissection experience. This theme has been divided into two domains: positive feelings and negative feelings. As with the descriptors used to describe their dissection experience, the students recorded more negative feelings in their journal entries as compared to the positive feelings they expressed. The positive feeling domain can be found in Table 15, and the domain consisting of negative feelings toward dissection can be found in Table 16.

Table 15
Actual Dissection: Feelings – Positive Descriptor Domain

Included Terms	Semantic Relationship	Cover Term
Interested		
Excited		
Amazed	is a kind of	positive feeling
Surprised		

Table 16
Actual Dissection: Feelings – Negative Descriptor Domain

Included Terms	Semantic Relationship	Cover Term
Disgusted		
Revolted		
Scared		
Apprehensive	is a kind of	negative feeling
Annoyed		
Squeamish		
Uncomfortable		

The third theme was one of partnership. The students wrote in their journals of how they felt they had worked with their partners. All of the descriptors expressed by the students in their journal entries about working with their partners were positive. The domain of partnership descriptors appears in Table 17.

Table 17
Actual Dissection: Partnership Domain

Included Terms	Semantic Relationship	Cover Term
Comfortable		
got along well		
working together	is a kind of	description of partnership
great time		
laughed together		
worked as a team		

Following Spradley's (1979) developmental research sequence, a taxonomic analysis was then constructed to include the five domains pertaining to the data from the actual dissection journals. This taxonomic analysis can be found as Figure 1, in Appendix G.

Summary

Although the students expressed both positive and negative thoughts and feelings about their dissection experience, the students who actually dissected a fetal pig used more negative descriptors in their journals. This indicates that the students have a negative attitude toward their fetal pig dissection experience. On a different note, the students expressed only positive descriptors when they described working with their partners.

Virtual Dissection

The students who completed a virtual dissection also used both positive and negative descriptors to explain how they felt about the dissection. As with the students who actually dissected, the students who completed a virtual dissection used more negative descriptors to describe the dissection experience. The positive description domain is illustrated in Table 18. The negative description domain describing the dissection process can be found in Table 19.

Table 18
<u>Virtual Dissection: Dissection Process – Positive Descriptor Domain</u>

Included Terms	Semantic Relationship	Cover Term
Exciting		
memorable		
cool	is a kind of	positive description
interesting		

Table 19
<u>Virtual Dissection: Dissection Process – Negative Descriptor Domain</u>

Included Terms	Semantic Relationship	Cover Term
gross		
hard to see		
disgusting	is a kind of	negative description
confusing		
stressful		
difficult		
complex		

The students who completed a virtual dissection also expressed their feelings toward their dissection experience. This theme has been divided into two domains:

positive feelings and negative feelings. Negative feelings were expressed in greater number than positive ones by the students who virtually dissected. The positive feeling domain can be found in Table 20, and the domain consisting of negative feelings toward dissection can be found in Table 21.

Table 20
Virtual Dissection: Feelings – Positive Descriptor Domain

Included Terms	Semantic Relationship	Cover Term
glad		
happy		
excited	is a kind of	positive feeling
interested		

Table 21
Virtual Dissection: Feelings – Negative Descriptor Domain

Included Terms	Semantic Relationship	Cover Term
sad		
confused		
uneasy		
bad	is a kind of	negative feeling
disgusted		
queasy		

The third theme was one of partnership. The students who completed a virtual dissection wrote in their journals of how they felt they had worked with their partners.

The students who virtually dissected used only positive descriptors to describe working with their partners. The domain of partnership appears in Table 22.

Table 22
Virtual Dissection: Partnership Domain

Included Terms	Semantic Relationship	Cover Term
glad to be with		
had fun together		
got along well	is a kind of	description of partnership
laughed together		

A taxonomic analysis was then constructed to include the five domains pertaining to the data from the virtual dissection journals. This taxonomic analysis can be found as Figure 2, in Appendix G.

Summary

The results from the examination of descriptors used to describe the dissection experience were remarkably similar across both groups. Both groups of students, those who actually and virtually dissected, used more negative descriptors than positive ones to describe both the process and their feelings toward the dissection experience. In addition, both groups used only positive descriptors to describe their working relationship with their partner.

To complete the summary of the descriptors culled from the students' journals, three componential analysis diagrams were constructed to compare the domains across the two different types of dissection. The componential analysis of process descriptors can be found in Table 23, the componential analysis of feelings descriptors can be found in Table 24, and the componential analysis of partnership descriptors can be found in Table 25.

Table 23
<u>Componential Analysis of Process Descriptors</u>

Domain	Descriptor	Actual Dissection	Virtual Dissection	Both
Positive Descriptors	exciting	No	Yes	No
	cool	Yes	Yes	Yes
	interesting	Yes	Yes	Yes
	memorable	No	Yes	No
	fun	Yes	No	No
	neat	Yes	No	No
	amazing	Yes	No	No
Negative Descriptors	hard	Yes	No	No
	difficult	Yes	Yes	Yes
	fast-paced	Yes	No	No
	nerve-wracking	Yes	No	No
	complicated	Yes	No	No
	smelly	Yes	No	No
	gross	Yes	Yes	Yes
	disgusting	Yes	Yes	Yes
	confusing	No	Yes	No
	stressful	No	Yes	No
	complex	No	Yes	No
	hard to see	No	Yes	No

Table 24
Componential Analysis of Feeling Descriptors

Domain	Descriptor	Actual Dissection	Virtual Dissection	Both
Positive Feelings	interested	Yes	Yes	Yes
	excited	Yes	Yes	Yes
	glad	No	Yes	No
	happy	No	Yes	No
	amazed	Yes	No	No
	surprised	Yes	No	No
Negative Feelings	sad	No	Yes	No
	confused	No	Yes	No
	uneasy	No	Yes	No
	bad	No	Yes	No
	queasy	No	Yes	No
	disgusted	Yes	Yes	Yes
	uncomfortable	Yes	No	No
	squeamish	Yes	No	No
	annoyed	Yes	No	No
	apprehensive	Yes	No	No
	scared	Yes	No	No
	revolted	Yes	No	No

Table 25
Componential Analysis of Partnership Descriptors

Domain	Descriptor	Actual Dissection	Virtual Dissection	Both
Partnership Descriptors	got along well	Yes	Yes	Yes
	had fun together	No	Yes	No
	glad to be with	No	Yes	No
	laughed together	Yes	Yes	Yes
	working together	Yes	No	No
	great time	Yes	No	No
	comfortable	Yes	No	No
	worked as a team	Yes	No	No

Summary

To evaluate the data gathered pertaining to the students' descriptions of their dissection experiences, the number and use of positive descriptors was compared to the number and use of negative descriptors. The students who actually dissected used 5 positive descriptors and 8 negative descriptors to describe their experience. The students who virtually dissected used 4 positive descriptors and 7 negative descriptors. Each of the groups used three more negative descriptors than positive descriptors to describe their dissection experience. Both groups used two of the descriptors to positively describe the dissection experience, "cool," and "exciting." Three of the negative descriptors, "difficult," "gross," and "disgusting," were used by both groups to describe the dissection process.

The comparisons between descriptors used by the students have been made by matching the exact words used by both groups. However, closer examination of these terms reveals that the students had very similar responses to their dissection experience. The terms "cool" and "neat" are synonyms. The terms "exciting " and "fun" could also be described as synonyms, as could "hard" and "difficult," and "confusing" and "complex." If these relationships between words are used, these results indicate that there is essentially no difference between the descriptions given by the students who actually dissected a fetal pig and those given by the students who virtually dissected. It should be noted that both groups used the terms “gross,” and “disgusting.” The students who virtually dissected, and did not touch a specimen, still found the process “gross,” and “disgusting.”

To evaluate the feelings expressed by the students toward their dissection experience in both of the groups, the number and use of positive and negative descriptors was evaluated. The students who actually dissected used 4 positive descriptors to describe their positive feelings, and 7 negative descriptors. The students who virtually dissected used 4 positive descriptors and 6 negative descriptors. Two of the positive descriptors “interested,” and excited,” were used by both groups to describe their feelings toward their dissection experience. Both of the groups used the term, “disgusted,” to describe their feelings toward their dissection experience. Again, although the exact matches of descriptors has been noted, many of the descriptors can be described as synonyms. These results indicate that there is essentially no difference between the feelings expressed by the students in either group.

All of the descriptors used to describe the students' partnerships were positive. The students who actually dissected used 6 different descriptors, and the students who virtually dissected used 4 descriptors. Both of the groups used the two descriptors, "got along well," and "laughed together," to describe how they worked with their partners during their dissection experience. Since all of the descriptors used by the students were positive, it must be concluded that the students in both groups had a positive experience working with their partners.

Summary of Quantitative and Qualitative Results

Research Question 1 asks how a virtual dissection, as compared to an actual dissection, affects the students' knowledge of anatomy. An attempt was made to answer this question quantitatively through the comparison of practical and objective test scores across the groups. The results indicated that the students who virtually dissected a fetal pig scored significantly higher on both the practical and objective tests.

Research Question 2 asks how a virtual dissection, as compared to an actual dissection, affects the students' attitudes toward dissections, computer usage, and biology. This question was answered both quantitatively and qualitatively. The pre and post survey questions provided quantitative data, and the interviews and journal entries provided the qualitative data.

According to the significant results of gain scores and two-group ANOVA tests, the students who virtually dissected responded more positively to dissections than those who actually dissected. Another significant result was found in the students' change in attitude toward virtual dissections. Although both groups reported a negative change, the students who virtually dissected reported a greater negative shift in their attitudes toward virtual dissections. The changes in the students' attitudes toward both computers and biology were not significant. Although it is educationally significant to note that both groups of students reported negative shifts in their attitudes toward computers and biology. The students who virtually dissected reported a greater negative shift in their attitude toward computers than those who completed an actual dissection. The students who actually dissected reported a greater shift in their attitude toward biology than those who completed a virtual dissection.

The qualitative data consisted of the students' responses to interviews and journal entries. These responses and entries were gathered from a purposefully selected group consisting of approximately 10% of the sample. This qualitative data served to provide insight to the students' thoughts and feelings concerning their dissection experience. The interview responses of the students from both groups were very similar. Most of the students had similar prior dissection experience, and felt that it was okay to use animals for educational purposes, as long as the animals were not killed specifically for that purpose. Both groups of students found the dissection experience to be difficult and stressful, and that computers were useful in education. Most of the students who virtually dissected felt that it was not fair that they did not get to participate in an actual fetal pig dissecting experience.

The journal entries of the students also provided similar results. The students from both groups used similar descriptors to describe their feelings toward the dissection process, their experience with the dissection and how they worked with their partners. The qualitative data gathered from both groups added insight to the students' responses to the survey questions.

Apparently, the students had an overall negative response to the dissection experience whether they actually or virtually dissected. And, although they responded negatively to the experience, the students who virtually dissected scored higher on both their tests of knowledge acquisition. Educationally significant facts that emerged were the students in both groups had a negative attitudinal change toward virtual dissections, computers, and biology. A more complete discussion of these findings is found in Chapter 5.

CHAPTER V

Discussion and Conclusions

This study attempted to determine if a virtual fetal pig dissection could be used as a viable alternative to an actual fetal pig dissection. Viability was defined as knowledge acquisition and positive attitudinal change. The research questions for this study were: (1) How does a virtual fetal pig dissection, as compared to an actual fetal pg dissection, affect female students' knowledge of anatomy? and (2) How does a virtual fetal pig dissection, as compared to an actual fetal pig dissection, affect female students' attitudes toward dissections, toward the use of computers, or toward biology?

This chapter contains a summary of the results of the study, a discussion of how these findings support the research, and implications for future research and future practice.

Summary of the Study

The results of the quantitative data indicated that the students who performed a virtual dissection scored significantly higher on the practical and objective tests. In addition, the students who performed a virtual dissection exhibited a significant positive change in their attitude toward dissections. However, they showed a significant negative change in their attitude toward virtual dissections. Neither the attitudinal change toward computers or biology was significant for the two groups.

The results of the qualitative data were gathered from two sources: semi-structured interviews and daily journal entries. The results of the interviews indicate that the students had similar prior dissection experience, similar feelings toward the use of animals for dissection purposes, and similar feelings toward the use of computers in education. Although both groups of students found their dissection experience difficult and stressful, the students who virtually dissected voiced stronger feelings toward the stressfulness of their experience. They cited the inexperience of their teachers and difficulties with identifying structures on the computer as sources of this stress. Most of the students who virtually dissected also felt that they had been denied the chance to take part in the traditional fetal pig dissection. This dissection experience has been a tradition at the school for more than 30 years.

These results are discussed as they pertain to each of the research questions.

Research Question 1 – Knowledge Acquisition

Knowledge acquisition was measured quantitatively through the use of practical and objective tests. Statistical tests showed that there was a significant difference between the scores earned by the students who dissected virtually and those who actually dissected a fetal pig. The students who participated in the virtual dissection scored higher on both of these tests.

The difference in mean scores of the practical test were both statistically significant and educationally significant. The students who virtually dissected received a mean score of 37.5760 points. This mean score translates to an 83.50%, which is a letter grade of C at Archbishop Stephens. The mean score of the students who actually dissected was 30.6522 that translated to a score of 68.12%. This mean score would fall into the F grade range at the high school. This is an educationally significant result in that the average score of the students who virtually dissected was two grade levels higher than the average scored by the students who actually dissected. Additionally, the construction of the actual dissection at the school should be examined to determine if it could be changed in any way that might contribute to the students' test scores on the practical. Future research is needed to determine if the PowerPoint practical, while easier to set up and administer, is adequately testing the students' who complete actual dissections knowledge of anatomy.

The results of the comparison of the objective test score grades were significant, but not educationally significant. The students who virtually dissected received a mean score of 44.7760 (74.63%), and the students who actually dissected received a mean score of 42.7681 (71.28%). Although this difference in mean scores is significant, both of these scores fall into the D grade range at Archbishop Stephens. So, although the students who virtually dissected scored significantly higher on their objective tests, both groups of students scored in the same letter grade range.

One reason why the students who participated in the virtual dissection scored higher on the practical test could be that the test was composed of PowerPoint slides which were displayed on a large computer monitor. As the students who completed a virtual dissection worked exclusively on computers, they might have had an advantage because they were familiar with the medium. A few of the biology teachers had for the past few years been using PowerPoint slide shows for their practical tests. These computerized tests eliminated the need for the extensive preparation time inherent in that type of practical test. The teachers would spend an enormous amount of time setting up the individual specimens and placing the pins in the organs or structures to be identified. In addition, the students could move the pins while they were viewing the specimen.

This change of location of the pins created problems for the students who later viewed that specimen. It is for these reasons that some of the teachers switched to a PowerPoint practical test. Although the familiarity with the computer may have been a contributing factor, this fact did not necessarily skew the results. The students who completed an actual dissection would have been tested using the same media, as the biology teachers at the school had begun using the PowerPoint practical tests a few years before. Since this type of practical test was already in use at the school, I did not think that the comparison between the actual and virtual groups on the PowerPoint test would be partial to one group or the other.

It is more difficult to find a reason for the students who virtually dissected to have performed better on the objective test. Other than the treatment, the only other mitigating factor could be that the virtual dissection was scheduled almost one and a half months after the actual dissection. This could mean that the students had the opportunity to learn more anatomy in their biology classes. Through discussion with the teachers, I could not find any discernable difference in the amount of material covered across the groups. So, it is apparent that completing the virtual dissection enabled the students to score significantly higher on their objective tests. The fact that one group had more time in their biology classes to study anatomy may have been a source of contamination. However, discussions with the teachers highlighted that fact that they had followed slightly different chapter sequences so that the actual dissection group would be exposed to as much anatomy as possible before their scheduled dissection. Although this may have been a source of contamination to the test grades, I do not think it was a contributing factor.

Research Question 2 – Attitudinal Change

The students' attitudes toward dissections, virtual dissections, computers, and biology were analyzed both quantitatively and qualitatively. Significant results were found in the positive attitudinal change of the virtual dissection group toward dissections. This finding means that the students who actually dissected felt less positive about the process of dissection after they had completed their dissection exercise. The answers to the interview questions and journal entries provided some insight into the students' feelings toward dissections. However, it became obvious that the students had similar feelings toward dissections across the groups. I was surprised to find that the students who virtually dissected thought that the dissection was "gross," and "disgusting." At least, the students who virtually dissected did not complain of the smell of the specimens. This was a common complaint of the students who actually dissected. Perhaps working with the "smelly" specimen was a contributing factor in the lower attitudinal score of those who actually dissected. In addition, some of the students used the interviews and journals to voice complaints about the injustice of dissections. They spoke of animal rights and the killing of innocent animals. This feeling may have also been a contributing factor of those who actually had the experience of dissecting a real specimen.

Significant results were also found in the students' attitudinal change toward virtual dissections. Both groups of students experienced a negative shift in attitude toward dissections done on the computer. The fact that the students who completed an actual dissection experienced a negative shift in their attitudes toward virtual dissections is difficult to explain. Perhaps the fact that a couple of students reported that they were glad that they had this chance to finally dissect a pig provides some insight to this difference. Archbishop Stephens High School traditionally requires its biology students to dissect a fetal pig. This event has become almost a rite of passage at the school, and the students were probably responding to the fact that the students who virtually dissected missed out on the opportunity. The students who virtually dissected complained in interviews and in their journals that they felt it was not fair that they did not get to participate in this event. Based on the fact that fetal pig dissection is a tradition at the school, I was not surprised that this finding.

There was no significant difference in the students' attitudes toward computers and biology. Perhaps these attitudes are based on long-term exposure and one event like a two-week dissection experience was not enough to change their long held beliefs.

The question that did not fit into the three constructs directly addressed one of the objectives of the dissection laboratory experience. Namely, that the students would compare and contrast human anatomy. Question 7 reads: Pigs are anatomically similar to humans. The students who virtually dissected achieved a significantly higher gain score (.4250) than those who actually dissected (.1928). I think that this result is educationally and statistically significant because the students who virtually dissected came away from their dissection experience with a better understanding of how similar the anatomy of a fetal pig is to a human. I was surprised by this result because I thought that the students who spent two weeks with the flesh and blood fetal pig would certainly see the similarities with greater clarity. Efforts should be made in future dissections at the school to stress these similarities as they are listed as an objected of the laboratory experience.

Discussion of how these Findings Support the Research

The literature reviewed for this study covered four broad categories: dissection, science, educational technology and gender issues. The findings from this study are discussed as they pertain to each of these categories.

Dissection Research

The results of this study are not supported by some of the literature on virtual dissections. According to opponents to dissection, the students need hands-on experiences to learn anatomy (Offner, 1993; Sweitzer, 1996). The fact that the students who completed a virtual dissection scored higher on their practical and objective tests means that they learned not only as much anatomy but perhaps more anatomy. According to Orlans (1988), an actual dissection can aid the teacher in teaching the students to have a responsible attitude toward the use of animals. There was no difference in the feelings of the students from either group in their attitude toward the use of animals. The majority of the students who were interviewed responded that they thought that it was okay to use animals for dissections, as long as they weren't killed for that purpose. Students who dissected virtually and actually both voiced concern for the plight of animals, and showed no difference in caring for the animals.

These results did support the findings of some dissection studies. Fowler and Brosius (1968) and Predevac (2001) found that the students in their studies scored higher on knowledge acquisition tests when exposed to an alternative to dissection. Fowler and Brosius (1968) studied high school students, but Predevac (2001) used undergraduate college students for his study. Both of these studies used mixed-gender classes, and the students in Predevac's study had previously dissected the animal on which his study is based. Future research is definitely needed to compare different groups of females in different surroundings and socioeconomic groups. It is my hope to further this research and to then compare the results with different groups of male high school biology students.

Science Research

In respect to the literature advocating a changing environment in the science classroom, this virtual laboratory exercise was certainly a prime example (see, for example, Bruner, 1996; National Research Council, 1996; Rakow, 1999; Rutherford & Ahlgren, 1989). The students completed the virtual dissection with very little instruction from the teachers. The teachers mainly facilitated the instruction by roaming the area and answering questions as needed. The teacher of the students who actually dissected had to do much more demonstration and give many more instructions. This virtual laboratory showed how the teachers and students can work together as partners in science.

Although this dissection laboratory exercise is not based on discovery learning or inquiry (Bruner, 1996; National Research Council, 1996), the non-linearity of the virtual dissection did allow the students to search anywhere on the site for information they needed. They were free to re-examine body systems they had completed, or go ahead to another body system that they would learn later. This non-linearity did allow for a limited amount of discovery for the students. They had more freedom to complete the assignments using any of the links on the web site. The students also had the ability to search for other relevant sites on the Internet. I observed students going freely back and forth from the virtual dissection to other dissection sites looking for more information.

This hypermedia allows the students to explore a topic in depth, and to make it their own. This finding is consistent with that of Clark, Hosticka and Huddlestun (1999).

The science standards developed by the National Research Council (1996) are not specific in terms of dissections. These standards only expect the students to learn body structures and functions and are not explicit in how this should be accomplished. The virtual fetal pig dissection does allow the student to learn these structures and functions, and according to their test scores, does so as well as an actual dissection. However, a comment was made by a couple of the students to the effect that they could not tell to what the structure in question, on the computer screen, was connected. They felt that it was easier to see the structures in the actual specimen. This is true in the respect that an actual specimen shows all of the organs and structures at one time, and the virtual dissection was divided into organ systems. This was a design flaw in the virtual dissection. I think that this would be an easy thing to change and improve upon on the web site.

Educational Technology Research

The literature on educational technology consisted of mixed results. Mellon stated, "I am doubtful that any tool of learning can have the same impact as a good teacher" (1999, p.14). I think that the results of this study are consistent with this statement. Although the students who performed a virtual dissection scored higher on their tests, they did a lot of complaining about the stressfulness of the experience. They complained that the teacher did not know what she was doing and consequently could not help them as much as they needed. The teacher who conducted the actual dissection had been teaching dissections for 30 years. The teachers who conducted the virtual dissection were new to the experience. Although the results of the knowledge acquisition tests were significant, I firmly believe that a good teacher is necessary for the proper implementation of any technology in the classroom.

Studies have shown that using computers in the classroom added excitement and increased motivation for learning (Gilliver, Randall, & Pok, 1998; Hakkarainen, Lipponen, Jarvela, & Niemivirta, 1999). Both groups of students experienced a decline in their attitude toward computers. I cannot account for the negative change of the students who completed an actual dissection. However, the students who completed a virtual dissection did experience some problems with their computers. During two of the scheduled days for the virtual labs, the server housing the virtual dissections was down. I was able to talk to the teachers to have them connect directly to the original dissection. This meant that they were able to experience the virtual dissection without the added pictures and instructions that were incorporated to more closely mimic the traditional experience. In addition, while observing the virtual dissection, I noted that the students were seated very close to each other in order to share the computers. Also, in the library, the noise and crowd of students varied day to day. I am sure that these additional distractions added stress to the students' experiences and contributed to their negative shift in attitude toward computers.

Gender Research

Several issues relating to gender were discussed in the literature reviewed for this study. Weinburgh (1995) found that girls need a positive attitude toward science to achieve higher science scores. The virtual dissection in this study caused both groups of students to have a negative gain in attitudinal scores toward science. Although this negative gain score was not significant across the groups, it is educationally significant in that girls may not respond favorably to dissections. Future studies could focus on the aspects of dissections that may lessen a girl's attitude toward science, and make efforts to create a more pleasant experience for female students.

Roychoudhury, Tippins and Nichols (1995) found that it was important to create a "cooperative and supportive environment" for female science students. (p.902) This finding was upheld by the results of this study. The girls who were interviewed shared only positive comments about their partnership experience. In addition, they expressed the "stressful" environment in which they performed the virtual dissection. Perhaps the students felt that the library was not a supportive environment.

In terms of gender studies, this study focused specifically on females enrolled in high school biology. It is beyond the scope of this study to comment upon the interactions between males and females in science classes. It is my hope that the results of this study could be used as a baseline measure for future research in this area.

Implications for Future Research

Since this study focused on females enrolled in a single sex biology class, it would be interesting to repeat the study on males enrolled in a single sex biology class. This would provide an interesting comparison as to how males and females react to the virtual dissection without the interfering factors inherent in a mixed-gender class. In addition, the males should be enrolled in a school of similar demographics.

Once this study is conducted with males, it would be interesting to conduct the study in a mixed-gender classroom. This would allow the researcher to compare the results of the females in a single-sex class with those enrolled in a mixed-gender class. In addition, the males could be compared across the two types of classrooms.

The subjects in this study were mostly white, middle-class students. Future study is needed using subjects of various demographic backgrounds. In addition, these students were enrolled in a parochial high school. Future study is needed to determine if these results can be generalized to students required to dissect in a public school setting.

Although, according to the results of this study, this virtual dissection has proven to be a viable alternative, teachers may choose to utilize it along with an actual fetal pig dissection. Future study is needed to determine if students may benefit from the exposure to both types of dissection. Some possible scenarios could be to use the virtual dissection before, during, or after the actual dissection. These results may illustrate the best use of a virtual laboratory.

Another area of additional research could be to re-design the traditional laboratory experience and compare the new design to the traditional one. As a dissection laboratory exercise is currently designed, there is little or no inquiry or discovery learning taking place. Efforts should be made to include these two aspects into the dissection experience. This should prove to create a more beneficial learning experience. However, research is needed to illustrate this point.

Future research is also needed to determine if students frequently register negative feelings against biology and dissections immediately after completing a dissection exercise. The students in this study were questioned immediately after completing the laboratory exercise. It is possible that after completing a two week laboratory experience that requires much time and effort that students experience negative feelings. It would be enlightening to re-examine the subjects at a later date to determine if their feelings toward biology and dissections remain as intense as time passes.

Implications for Future Practice

This study shows that the virtual dissection is a viable alternative to actual dissection in terms of the knowledge acquired during the laboratory exercise. This result enables teachers to assign a virtual alternative to students who object to actually dissecting a fetal pig.

In view of the students' negative feelings toward biology and dissections, biology teachers may need to reexamine their dissection practices to determine if there are any features of the laboratory exercise that could be modified to make them more appealing to the students.

Conclusion

In summary, the results of this study were that the students who virtually dissected scored significantly higher on their practical and objective tests. In addition, the students who virtually dissected, as compared to those who actually dissected, showed a significantly positive attitudinal change toward dissections. The students who virtually dissected, as compared to those who actually dissected, also showed a significant negative attitudinal change toward virtual dissections. This fact may be due to the traditional nature of the fetal pig dissection at the school. No significant attitudinal changes were found toward computers or biology.

Technology is prevalent in today's schools, and teachers must learn to incorporate this technology into their curricula in meaningful ways. This study shows that students can learn using a virtual dissection in a high school biology class. Biology teachers should take heart that there is technology available to teach anatomy to their students, and feel free to suggest a virtual dissection alternative to their students. Gone are the days of lengthy reports for students who object to the dissection. Gone are the days of the students only being able to view specimens for one hour in the lab. A well-designed virtual fetal pig dissection either online or downloaded to CD-ROMs may be the answer to the expense and moral and ethical considerations of animal dissections. Further research is needed to determine if these results generalize to females in mixed–gender classes. Hopefully, the results of this study can be used as a baseline for this future research.

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APPENDICES

Appendix A

Human Subjects Approval

UNIVERSITY OF NEW ORLEANS
COMMITTEE ON THE USE OF HUMAN SUBJECTS

Form Number: 9JAN02 ***(please refer to this number in all future correspondence concerning this protocol)***

Principal Investigator: Rebecca S. Maloney **Title:** Graduate Student

Department: Curriculum and Instruction **College:** Education

Name of Faculty Supervisor: Richard Speaker, Ph.D. ***(if PI is a student)***

Project Title: Virtual fetal pig dissection as an agent of attitudinal change and knowledge acquisition in female high school biology students.

Date Reviewed: February 4, 2002

Dates of Proposed Project Period: From 2/02 **to** 2/03*****
***approval is for one year from approval date only and may be renewed yearly.**

Note: Consent forms and related materials are to be kept by the PI for a period of three years following the completion of the study.

☒ **Full Committee Approval**
☐ **Expedited Approval**
☐ **Continuation**
☐ **Rejected**
☐ **The protocol will be approved following receipt of satisfactory response(s) to the following question(s) within 15 days:**

____
____
____

Committee Signatures:

[signature] Matthew S. Stanford, Ph.D. (Chair)
[signature] Scott Bauer, Ph.D.
[signature] Gary Granata, Ph.D.
______________________ Betty Lo, M.D.
[signature] Hae-Seong Park, Ph.D.
______________________ Jane Prudhomme
______________________ Jayaraman Rao, M.D. (NBDL protocols only)
______________________ Richard B. Speaker, Ph.D.
[signature] Gary Talarchek, Ph.D.

Appendix B

Consent Form

CONSENT FORM

1. Title of Research Study
VIRTUAL FETAL PIG DISSECTION AS AN AGENT OF ATTITUDINAL CHANGE AND KNOWLEDGE ACQUISITON IN FEMALE HIGH SCHOOL BIOLOGY STUDENTS

2. Project Director
Rebecca S. Maloney (504) 280-1261 Dr. Richard Speaker (504) 280-6605

3. Purpose of the Research
The purpose of this research is to determine if a virtual fetal pig dissection can change female high school students' attitude toward dissection and computer usage, be used as a viable alternative to actual dissections, and also serve to partially fulfill the requirements for a doctoral degree.

4. Procedures for this Research
The students will complete a pre-survey to determine knowledge of subject, attitudes toward dissection, and computer use. The students will complete a virtual fetal pig dissection, or an actual fetal pig dissection under the direction and supervision of their Biology teacher. The students will then be given a post-survey to determine changes in knowledge, and attitudinal changes toward dissection, computer use, and the subject matter. A random sample of students will be interviewed and asked approximately 5 questions by the Project Director to ascertain any additional thoughts and/or feelings that the students have toward the project.

5. Potential Risks of Discomfort
The students' biology teacher will be present at all times to minimize any difficulty with the use of the computer dissection or the actual dissection. She will also be present to minimize embarrassment while being interviewed. If you wish to discuss these or any other discomforts you may experience, you may call the Project Director listed in #2 of this form.

6. Potential Benefits to You or Others
Many current research studies illustrate the need to develop viable alternatives to animal dissection. This research project will help to determine if a virtual fetal pig dissection can be implemented in place of an actual fetal pig dissection.

7. Alternative Procedures
Completing survey materials and participating in interviews are completely voluntary. Your participation is entirely voluntary and you may withdraw consent and terminate participation at any time without consequence.

8. Protection of Confidentiality
At no time will the students' names be recorded, or associated with the survey materials, or interview questions. This assures that confidentiality will be as tightly maintained as possible.

****

I have been fully informed of the above-described procedure with its possible benefits and risks and I have given permission of participation of this study.

______________________	______________________	______________
Signature of Subject	**Name of Subject (Print)**	**Date**
______________________	______________________	______________
Signature of Parent	**Name of Parent (Print)**	**Date**
______________________	______________________	______________
Signature of Person Obtaining Consent	**Name of Person Obtaining Consent (Print)**	**Date**

Appendix C

Pre and Post Surveys

Pre-Survey ID Number ________

Please read each statement carefully. Circle the number that most correctly corresponds with your agreement or disagreement with each statement below.

Strongly Disagree	Disagree	Agree	Strongly Agree
1	2	3	4

1.	All students should dissect an animal.	1	2	3	4
2.	It is OK to use animals for educational purposes.	1	2	3	4
3.	I like Biology.	1	2	3	4
4.	I like to work with computers.	1	2	3	4
5.	Computers are useful tools for education.	1	2	3	4
6.	Dissections are necessary to learn anatomy.	1	2	3	4
7.	Pigs are anatomically similar to humans.	1	2	3	4
8.	Computers are useful tools for science.	1	2	3	4
9.	Dissections can be performed on computers.	1	2	3	4
10.	I can learn just as much from a dissection on the computer as from a real dissection.	1	2	3	4
11.	I feel comfortable working on computers.	1	2	3	4
12.	I use computers at least once a week at home for educational purposes.	1	2	3	4
13.	Virtual dissections can teach a lot about anatomy.	1	2	3	4
14.	Science is one of my favorite subjects.	1	2	3	4

Comments:

Post-Survey ID Number ________

Please read each statement carefully. Circle the number that most correctly corresponds with your agreement or disagreement with each statement below.

Strongly Disagree	Disagree	Agree	Strongly Agree
1	2	3	4

1.	All students should dissect an animal.	1	2	3	4
2.	It is OK to use animals for educational purposes.	1	2	3	4
3.	I like Biology.	1	2	3	4
4.	I like to work with computers.	1	2	3	4
5.	Computers are useful tools for education.	1	2	3	4
6.	Dissections are necessary to learn anatomy.	1	2	3	4
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11.	I feel comfortable working on computers.	1	2	3	4
12.	I use computers at least once a week at home for educational purposes.	1	2	3	4
13.	Virtual dissections can teach a lot about anatomy.	1	2	3	4
14.	Science is one of my favorite subjects.	1	2	3	4

Comments:

Appendix D

Interview Questions

Interview Questions

1. What was your experience with dissections prior to this class?

2. How do you feel about the use of animals for dissections in educational settings?

3. How would you describe your fetal pig dissection experience?

4. How do you feel about the fact that some people performed a virtual dissection instead of having performed a dissection on an actual animal?

5. What is your opinion about the use of computers in the classroom?

6. Do you have any comments on the fetal pig dissection that you would like to share?

Appendix E

Objective Test

Biology 1 – Fetal Pig Test **Name ____________________**

Matching. Match the descriptions on the left with the structures on the right:

1.	Brownish structure which is leaf shaped and curves over the stomach.	A. Appendix
2.	Tube which came from the aorta and ran straight to the middle of the kidney.	B. Esophagus
3.	Gland in the neck area on each side of the trachea.	C. Mesentery
4.	Membrane holding all of the loops in the intestine in position.	D. Muscle
5.	Tube which was attached to the trachea and ran to the stomach.	E. Pericardium
6.	Membrane surrounding the heart.	AB. Peritoneum
7.	Gland which poked out from under the jaw bone into the neck area.	AC. Scrotal Sac
8.	Membrane which lines the abdominal cavity.	AD. Salivary Gland
9.	Found at the junction of the large and small intestine at the end of the caecum.	AE. Spinal Cord
10.	The stringy material in the neck area.	BC. Spleen
		BD. Thymus
		BE. Thyroid
		CD. Renal Artery
		CE. Ureter

Match the structures on the left with the correct number of parts which each pig has:

11.	Digits	A. 1
12.	Lobes of the liver	B. 2
13.	Ureter	C. 3
14.	Urethra	D. 4 or more
15.	Testis	
16.	Oviducts	
17.	Ventricles	
18.	Vena Cavae	
19.	Bronchioles	
20.	Thyroid	

Match the organ on the left with the system to which it is more closely associated:

21.	Kidney	A. Circulatory
22.	Oviduct	B. Digestive
23.	Thyroid	C. Endocrine
24.	Aorta	D. Excretory
25.	Anus	E. Respiratory
26.	Bulbous Gland	AB. Reproductive
27.	Gall Bladder	
28.	Glottis	
29.	Urinary Bladder	
30.	Umbilical Vein	

Multiple Choice.

31. The trachea is **easily** distinguished from the esophagus because:
A. the trachea has cartilaginous rings
B. the esophagus has cartilaginous rings
C. the trachea is dorsal to the esophagus
D. the trachea is anterior to the esophagus

32. To remove the digestive system from the pig, first you must cut the:
A. trachea B. liver
C. aorta D. colon

33. The age of the fetal pig can be estimated by measuring:
A. the entire length of the pig including the tail
B. the circumference of the head
C. the tip of the snout to the attachment of the tail
D. the height of the pig

34. The trunk of the pig is divided into cavities called:
A. respiratory and digestive B. cardiac and alimentary
C. thoracic and abdominal D. pulmonary and digestive

35. The urogenital opening is found:
A. only in males B. only in females
C. in both male and females D. not to be functional in the adult pig

36. Mature males have swellings near the anus called:
A. scrotal sacs B. urogenital openings
C. penis D. papilla

37. In order to expose the organs in the thoracic cavity, these bones have to be cut away:
A. pelvic B. humerus
C. ribs and sternum D. vertebrae

38. The umbilical vein runs:
A. along the sides of the bladder
B. from the umbilical cord through the liver to the heart
C. to the liver
D. from the aorta to the umbilical cord

39. The structure which passes through the diaphragm and into the heart is the:
A. superior vena cava B. anterior vena cava
C. inferior vena cava D. pulmonary vena cava

40. This prevents food from entering the trachea:
A. glottis B. larynx
C. epiglottis D. soft palate

41. Which of the following describes the esophagus:
    A. pearly white tube with rings of cartilage
    B. small red round solid structure on the trachea
    C. muscular, hollow tube
    D. big green tube at the posterior end

42. Urine passes from the kidney and out of the body by the following pathway:
    A. ureter, bladder, urethra B. urethra, bladder, ureter
    C. bladder, ureter, urethra D. bladder, urethra, ureter

43. What two structures of the female pig form the urogenital sinus?
    A. uterus and urethra B. ureter and urethra
    C. urethra and rectum D. sperm ducts and rectum

44. The diaphragm is ____________ in relationship to the liver.
    A. dorsal B. ventral
    C. lateral D. anterior
    E. posterior

45. The kidney is ______________ in relationship to the intestines.
    A. dorsal B. ventral
    C. anterior D. posterior

46. The pathway of the egg is:
    A. ovary, uterus, oviduct, urogenital canal
    B. ovary, urogenital canal, oviduct, uterus
    C. urogenital canal, uterus, oviduct, ovary
    D. ovary, oviduct, uterus, urogenital canal

TRUE and FALSE. Answer A for TRUE and B for FALSE.

47. Only the female has nipples.
48. The pancreas looks a lot like the intestines.
49. The artery which comes from the front of the heart and goes up and over the heart and all the way down by the backbone is the aorta.
50. The umbilical cord contains two arteries and one vein.
51. The human heart has exactly the same parts as the pig's heart.
52. The umbilical artery carries blood away from the fetal pig.
53. Testes in some pigs may be found in the abdominal cavity.
54. Male pigs have one urethra, but female pigs have two.
55. In order to observe the reproductive structures of the male pig, one must lift up the stomach.
56. The bladder is attached to the underside of the umbilical cord.
57. The umbilical artery must be cut in order to enter the chest cavity.
58. The spinal cord is embedded in bone.
59. Brain tissue is tough and solid.
60. The alveoli are easily identified in every pig.

Appendix F

Practical Test

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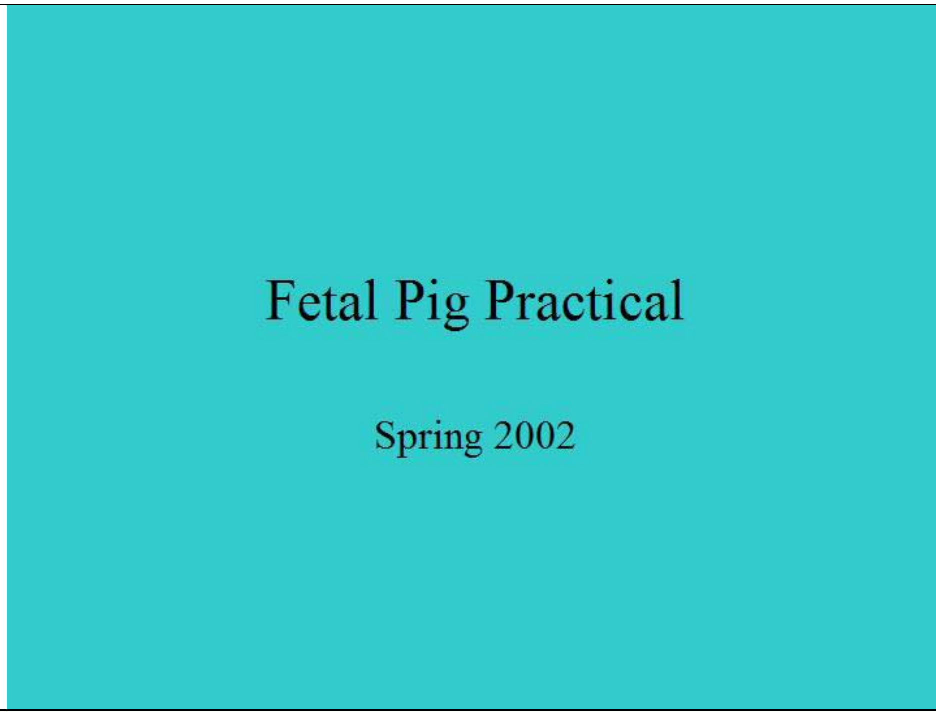
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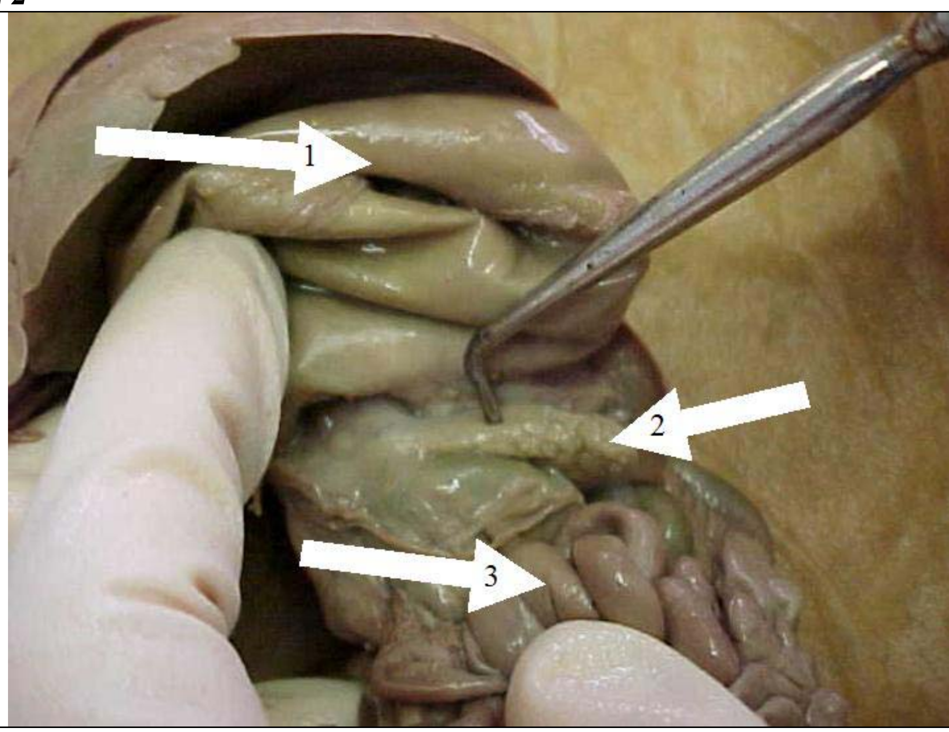

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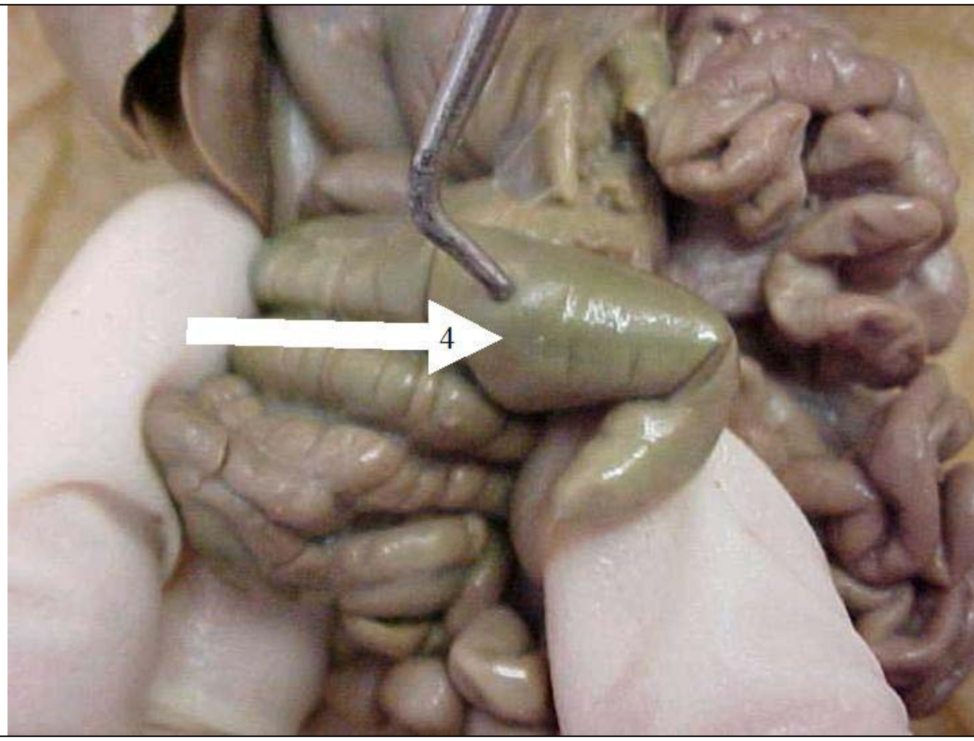
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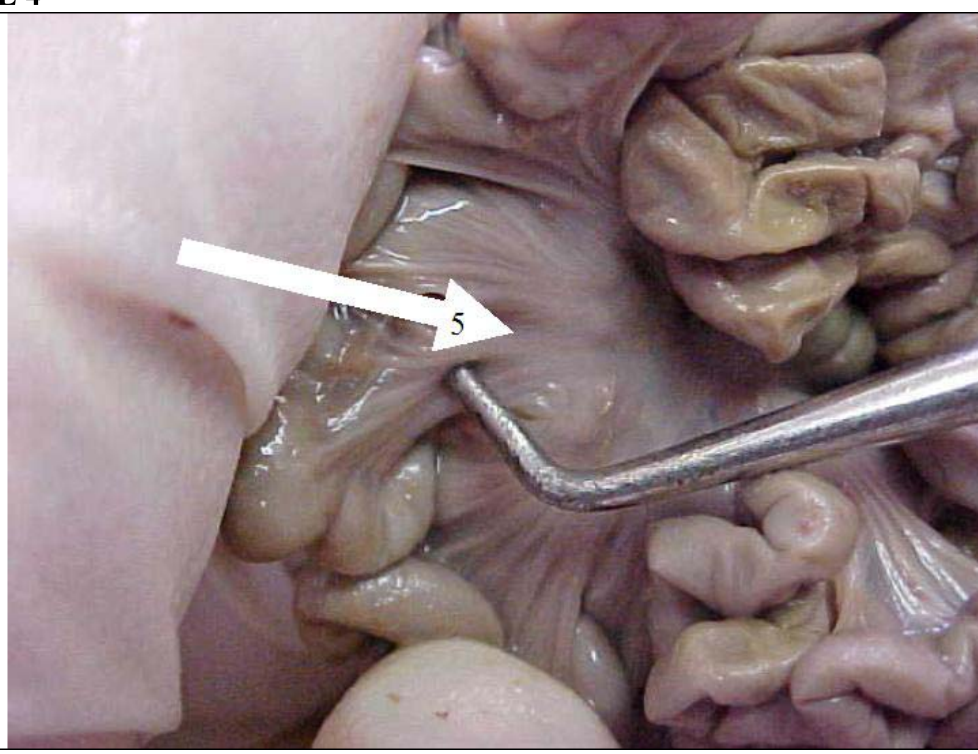

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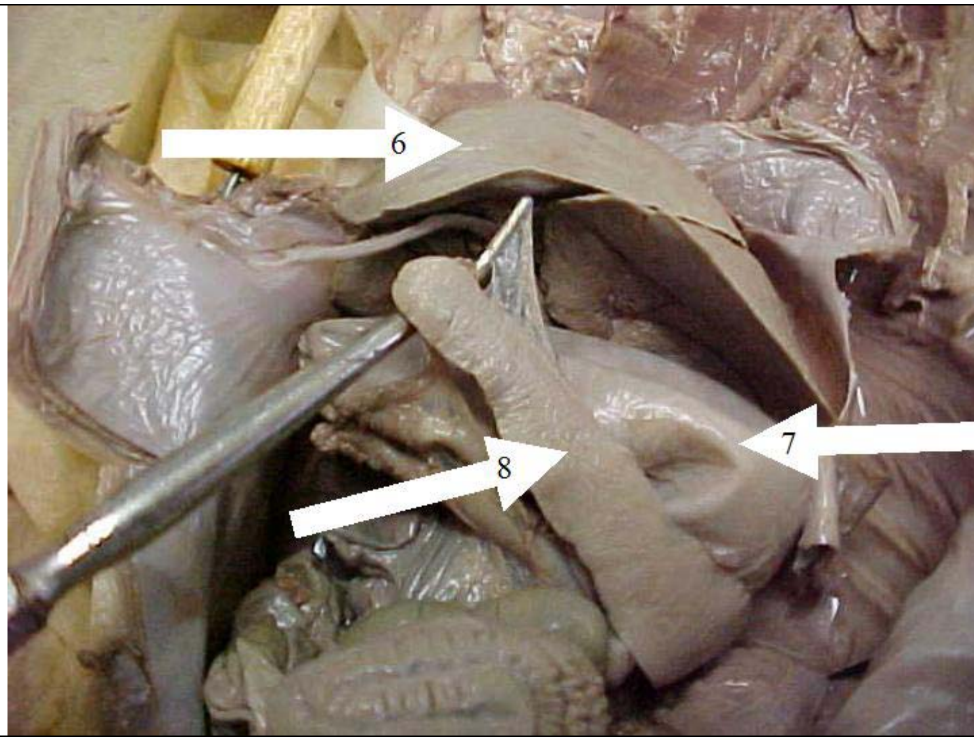

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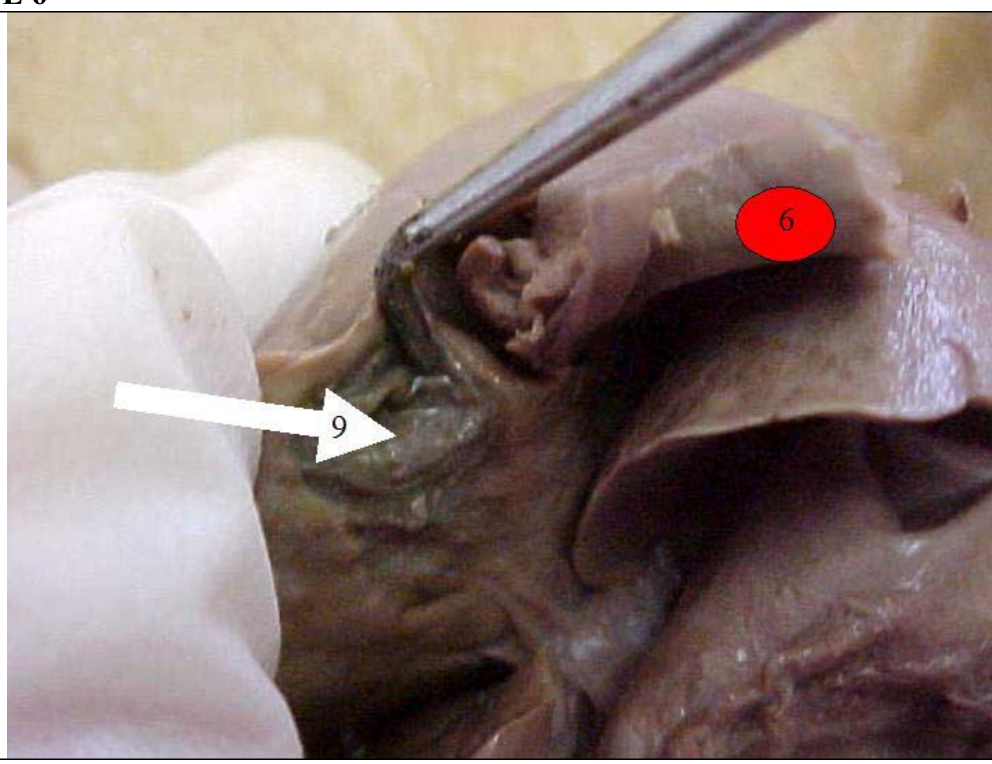

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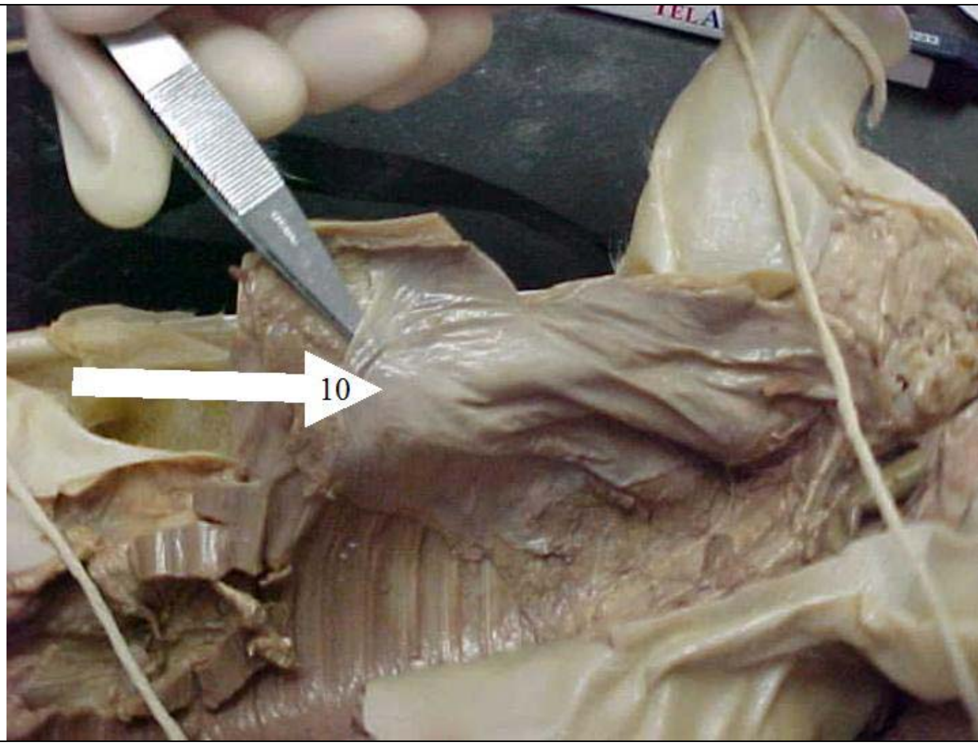

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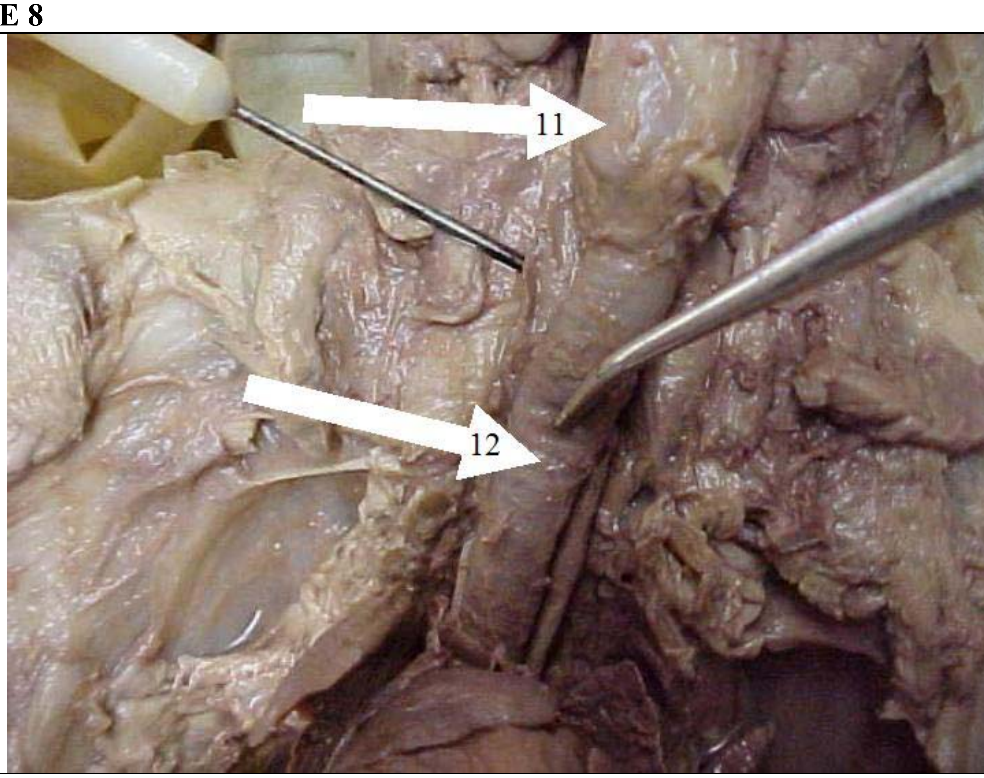

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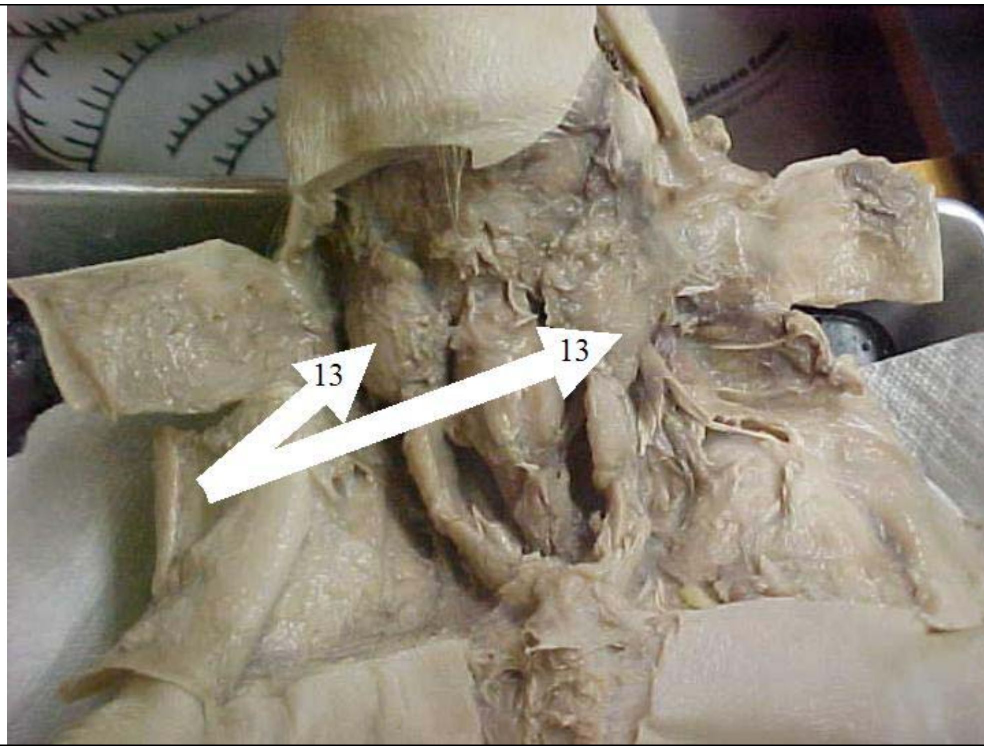
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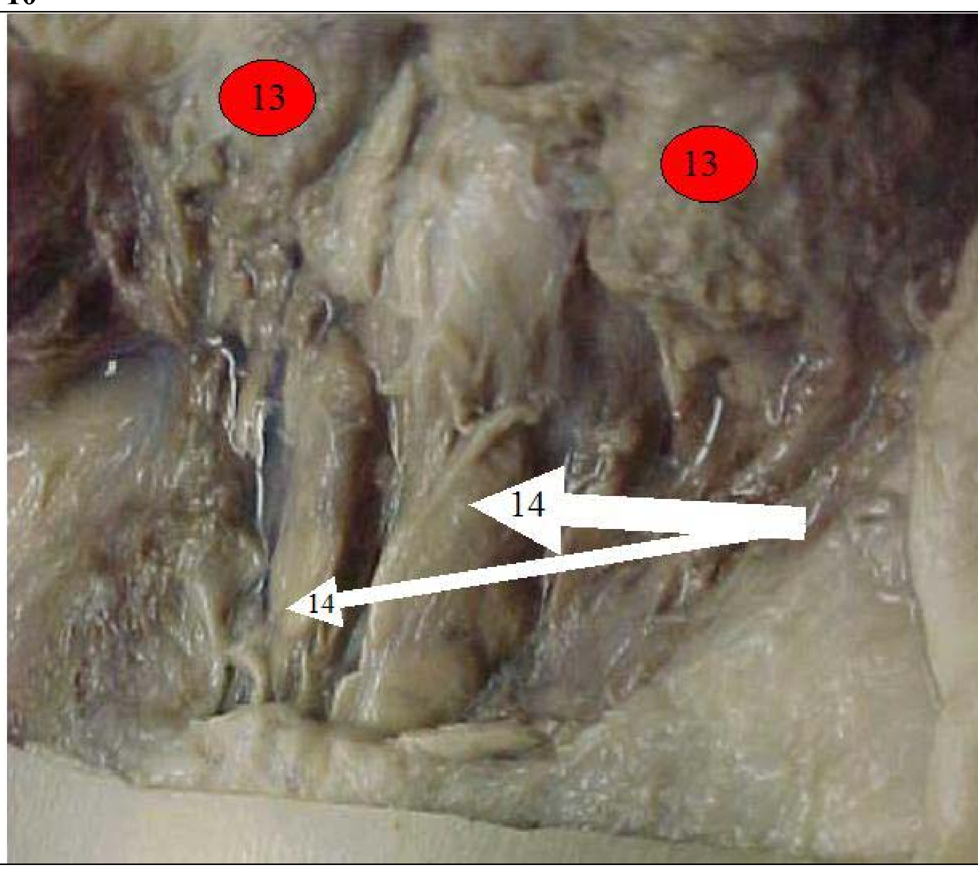

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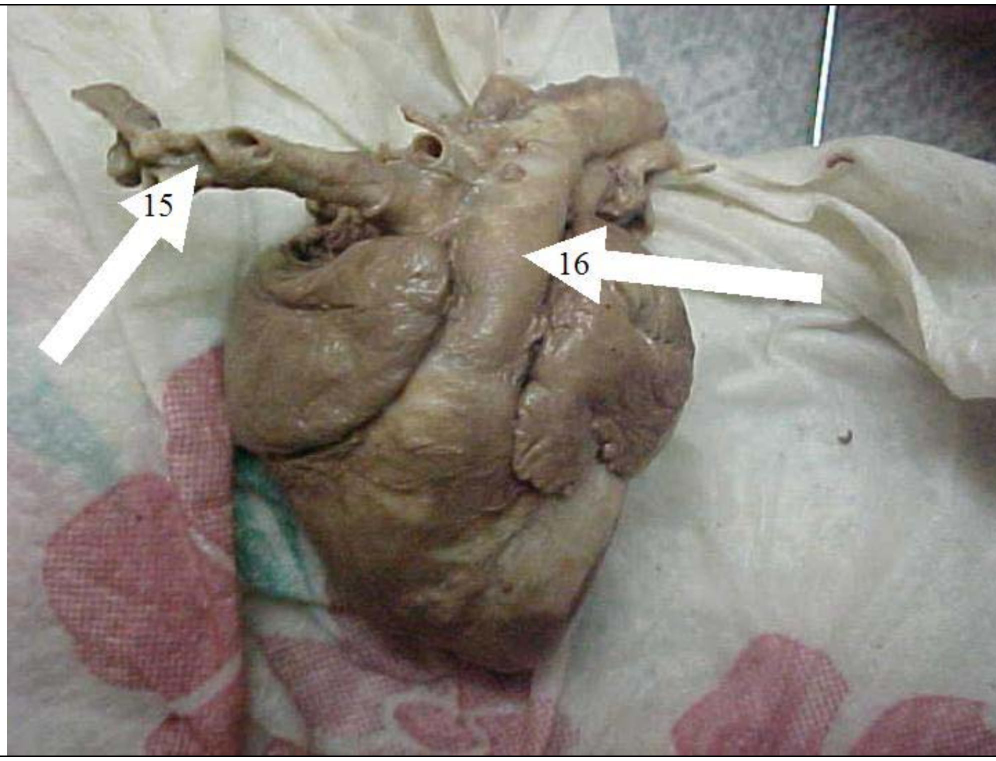

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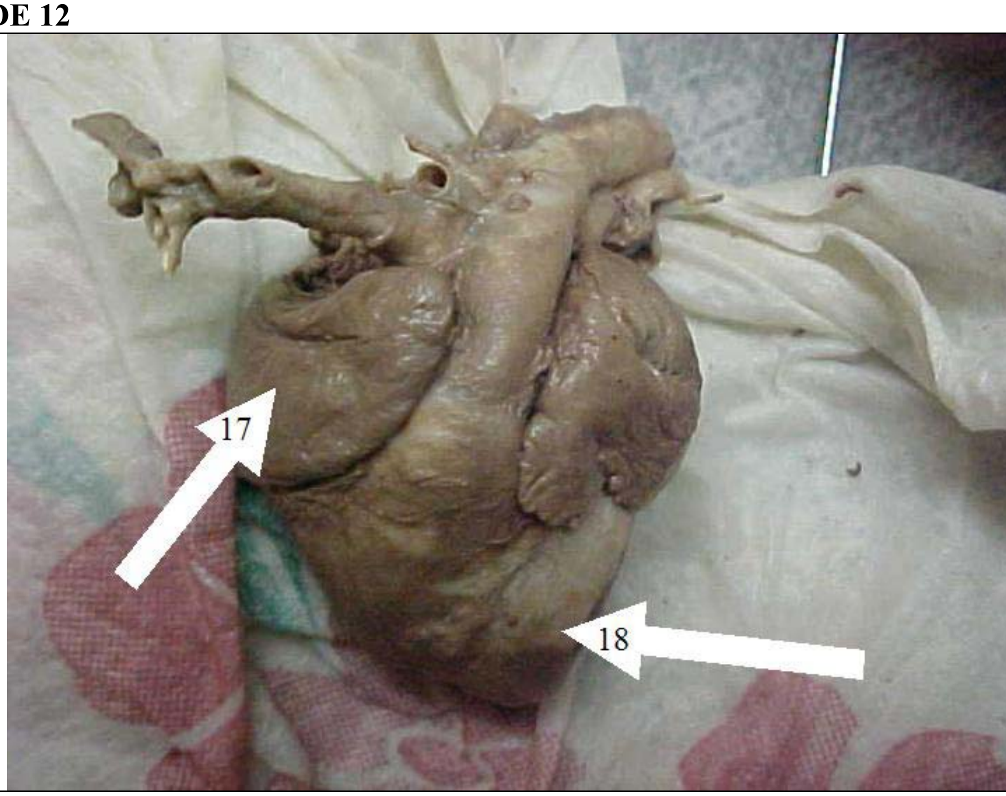

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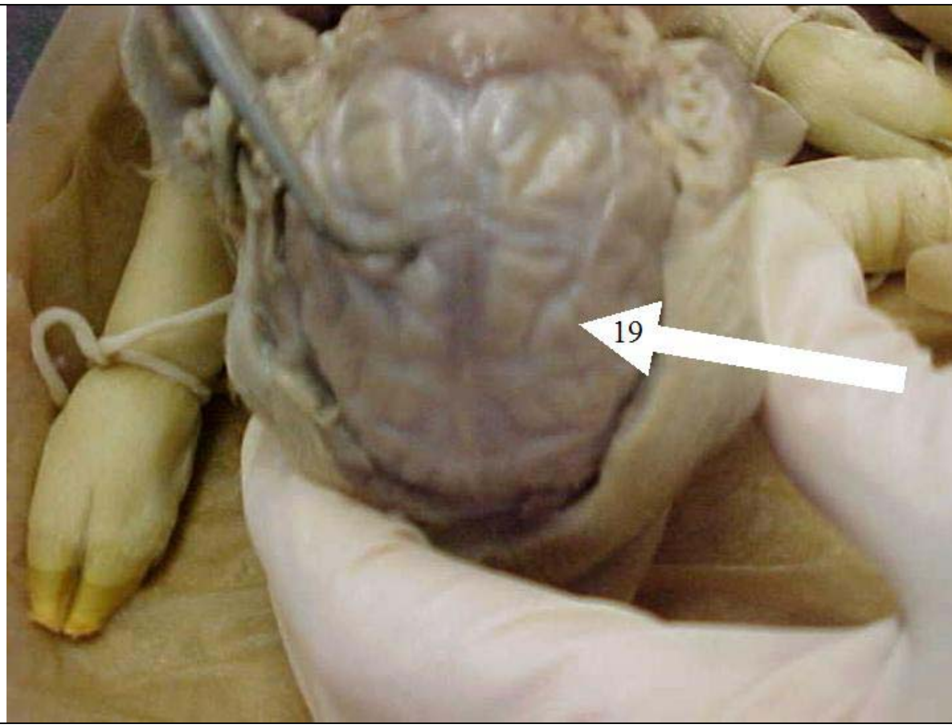

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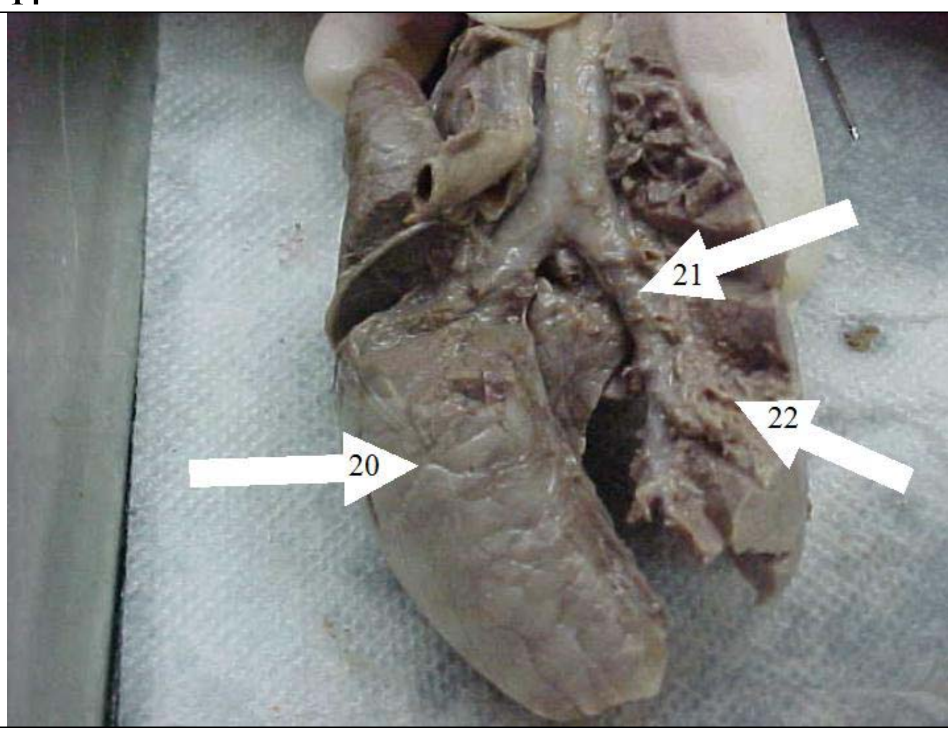

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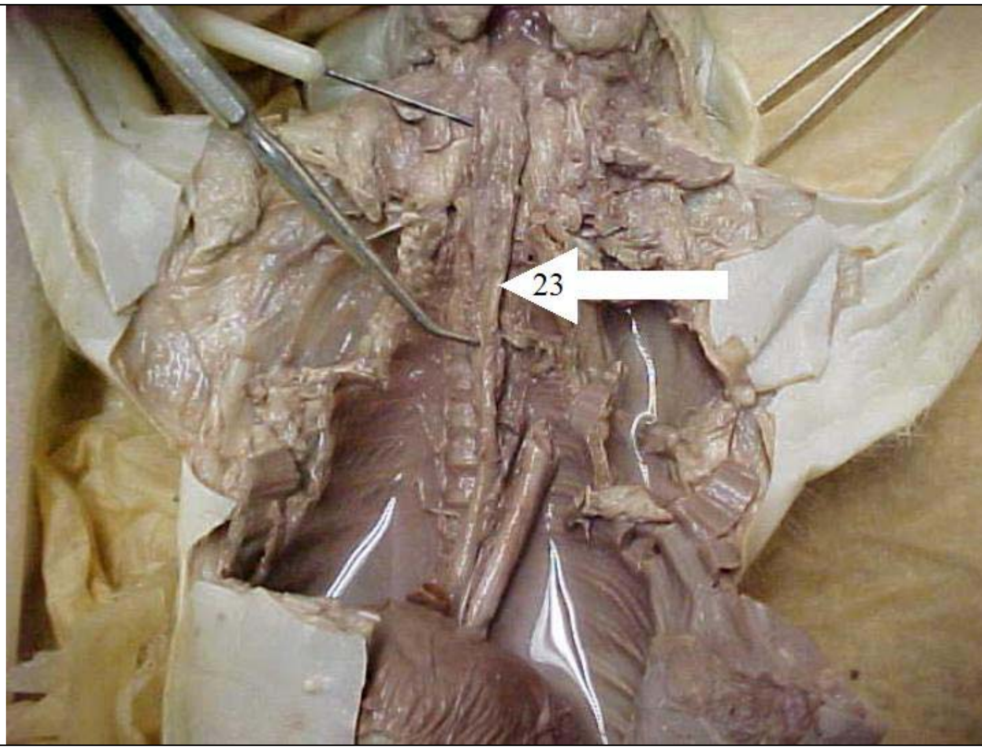
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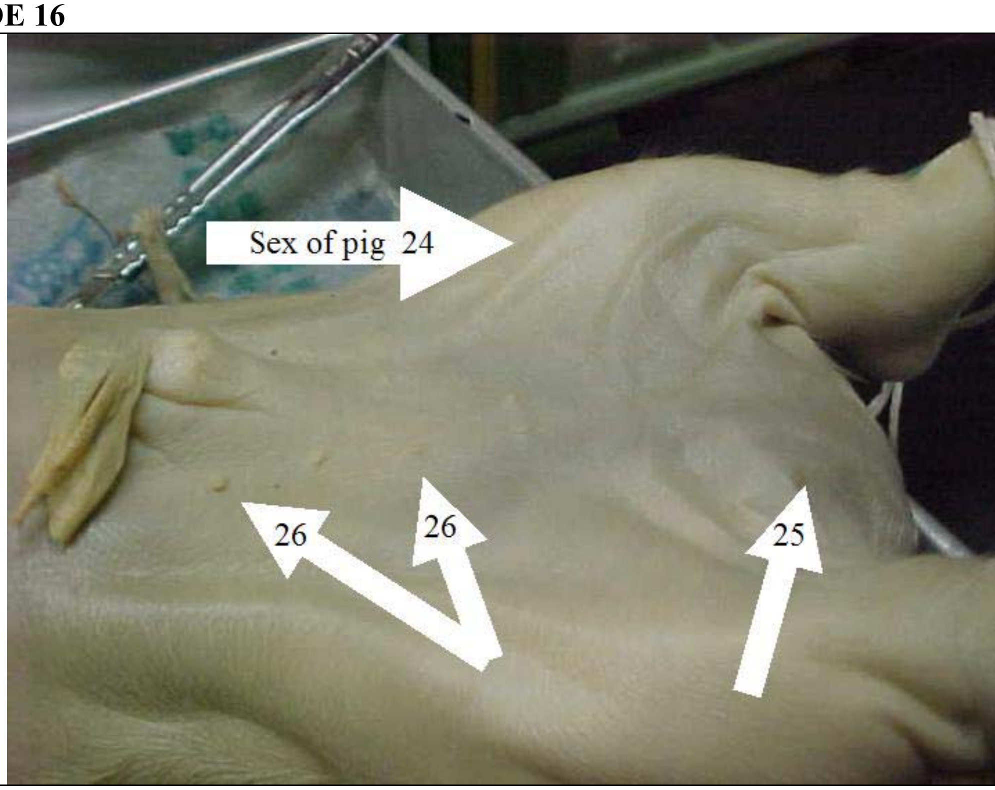

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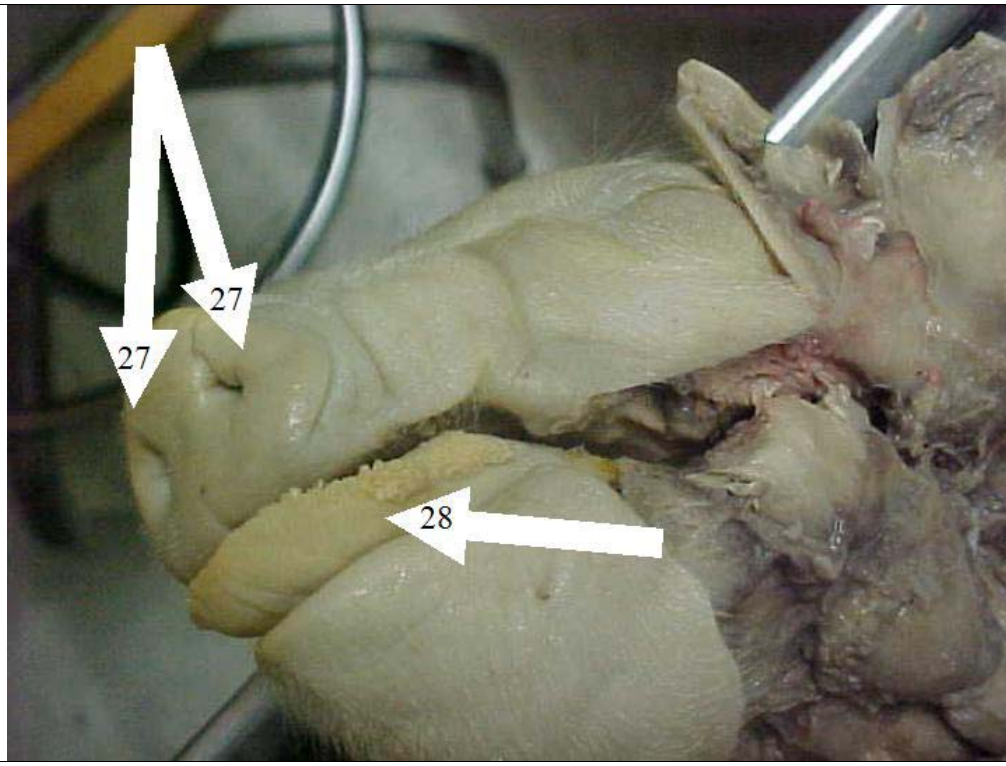

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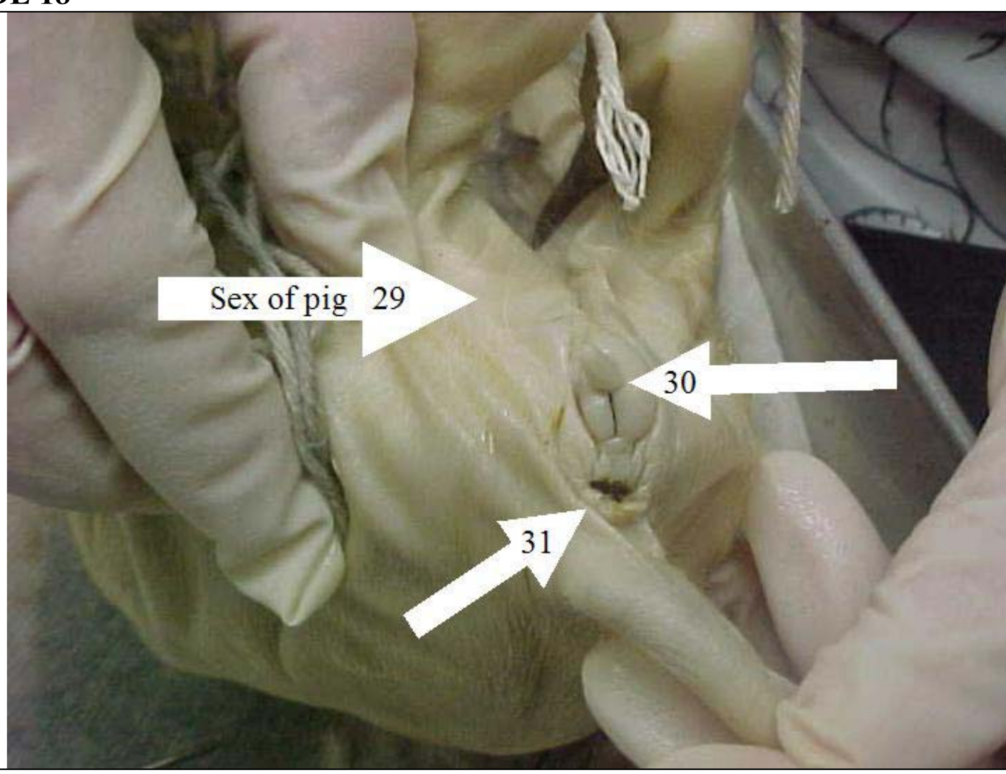

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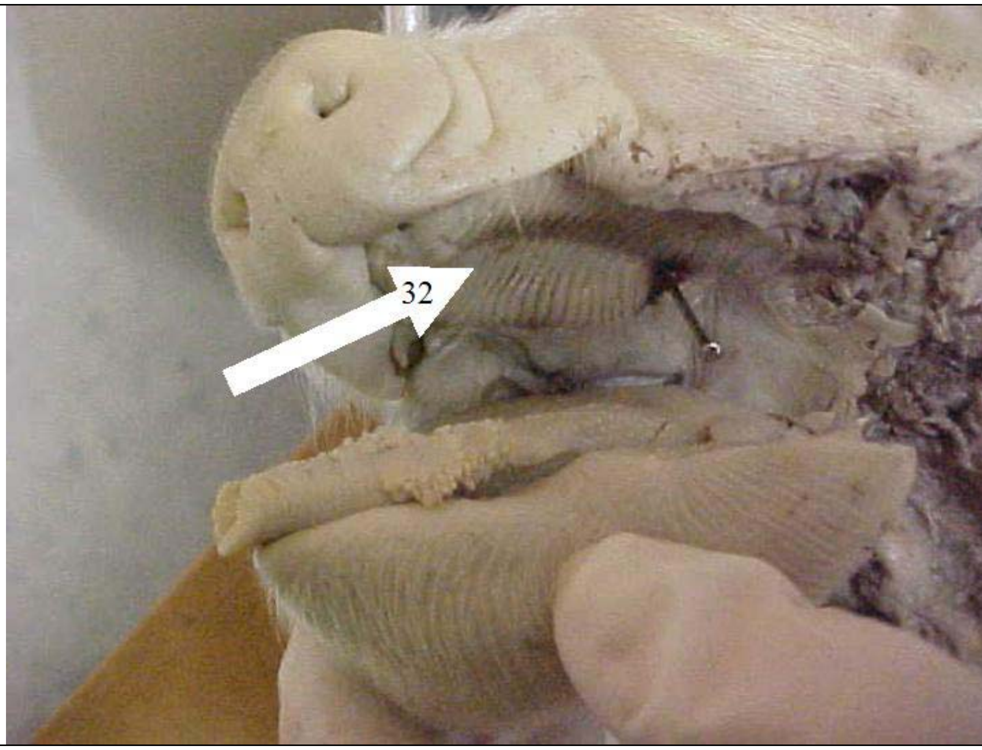

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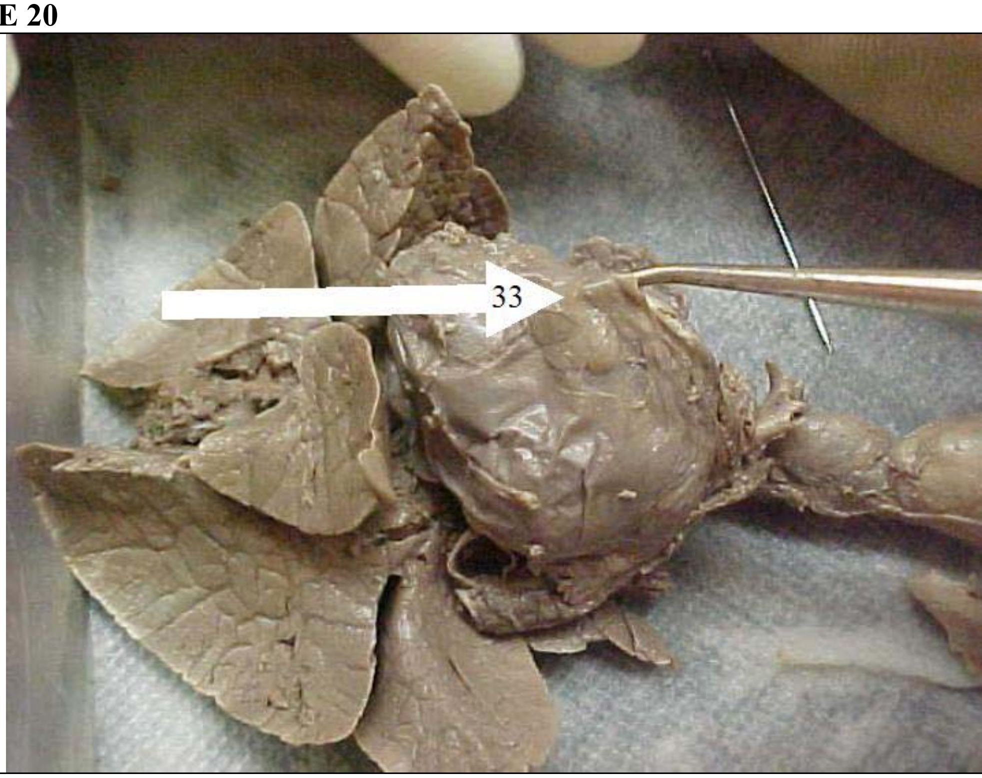

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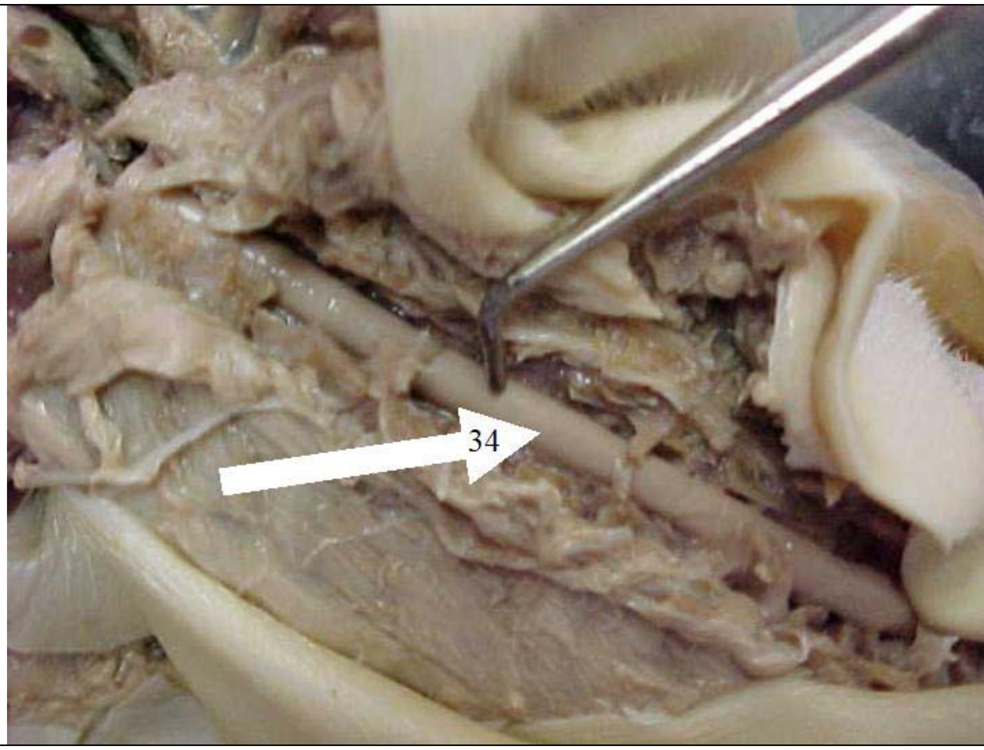

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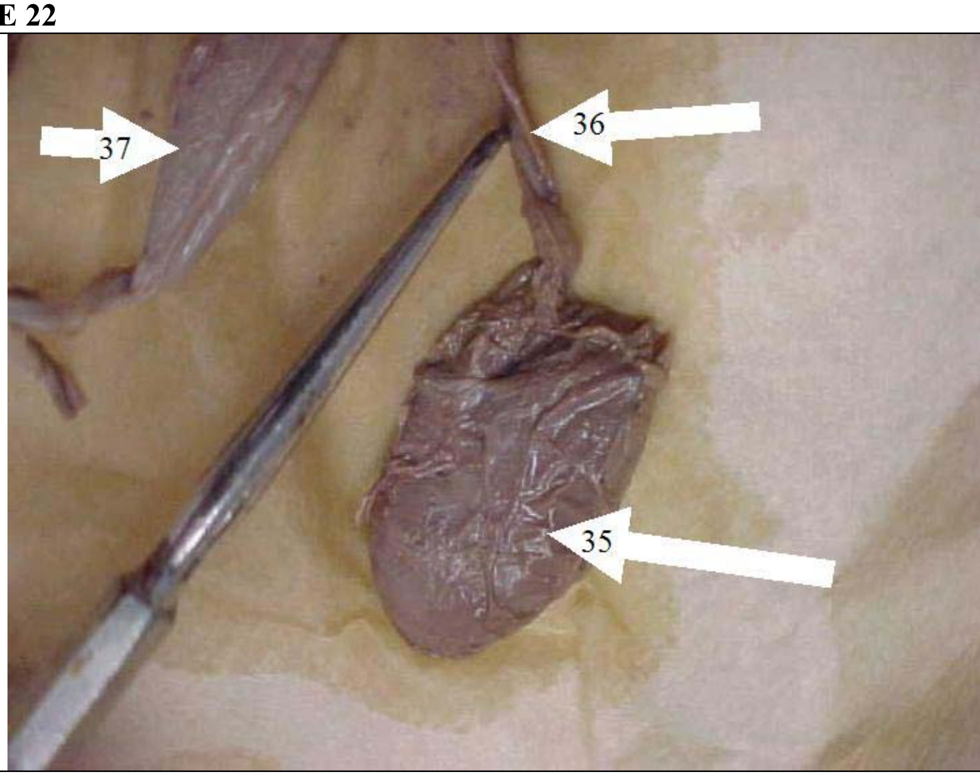

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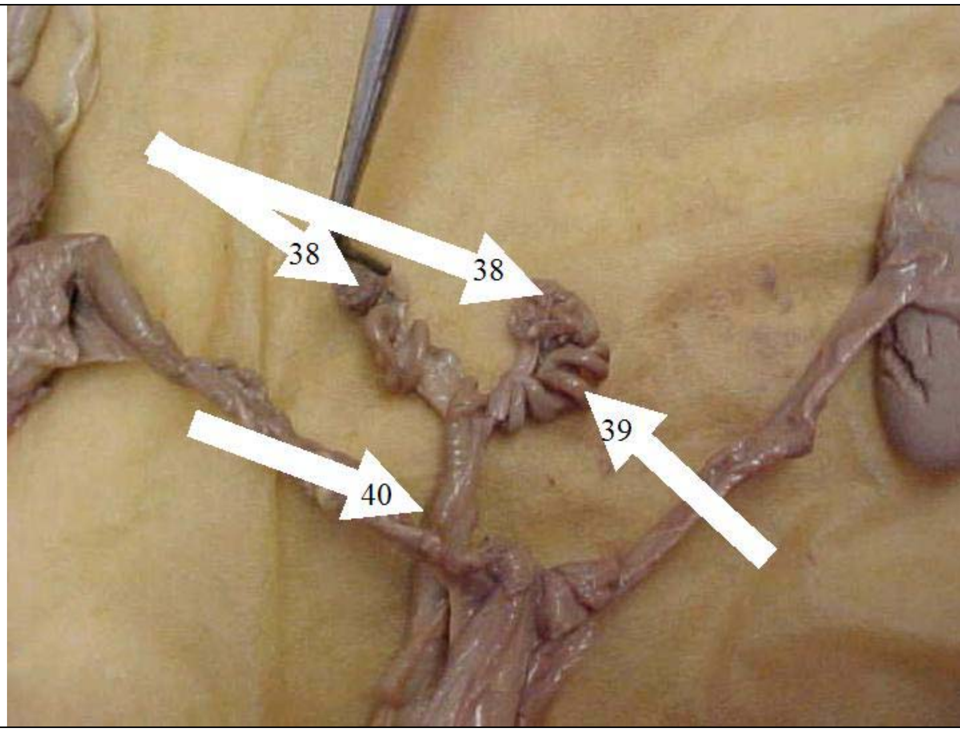
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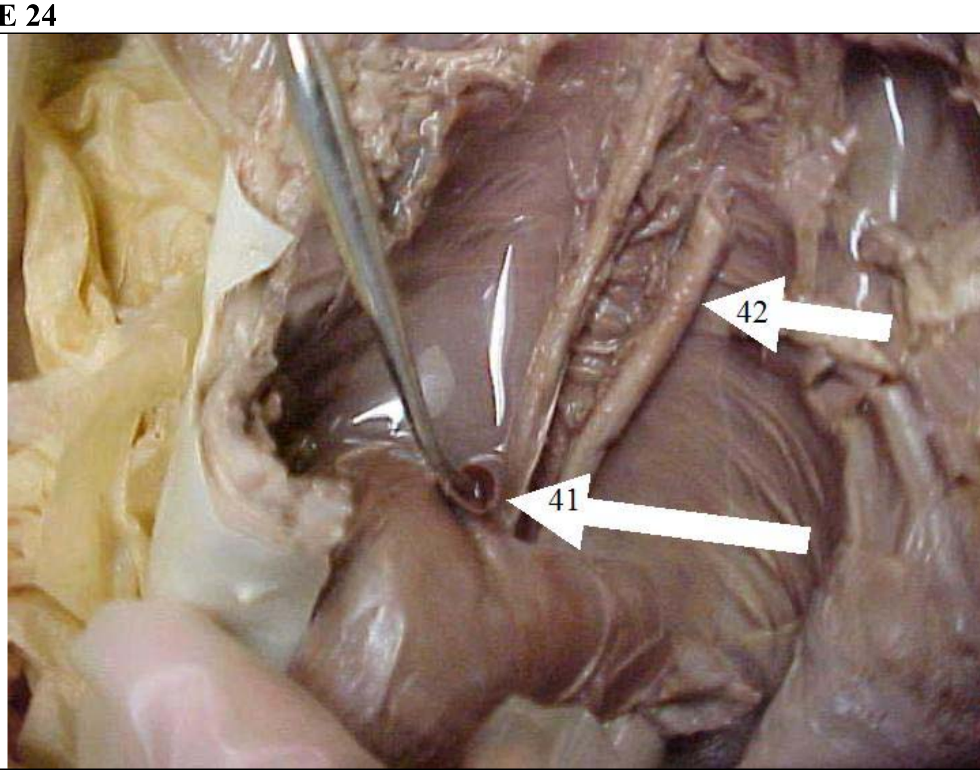

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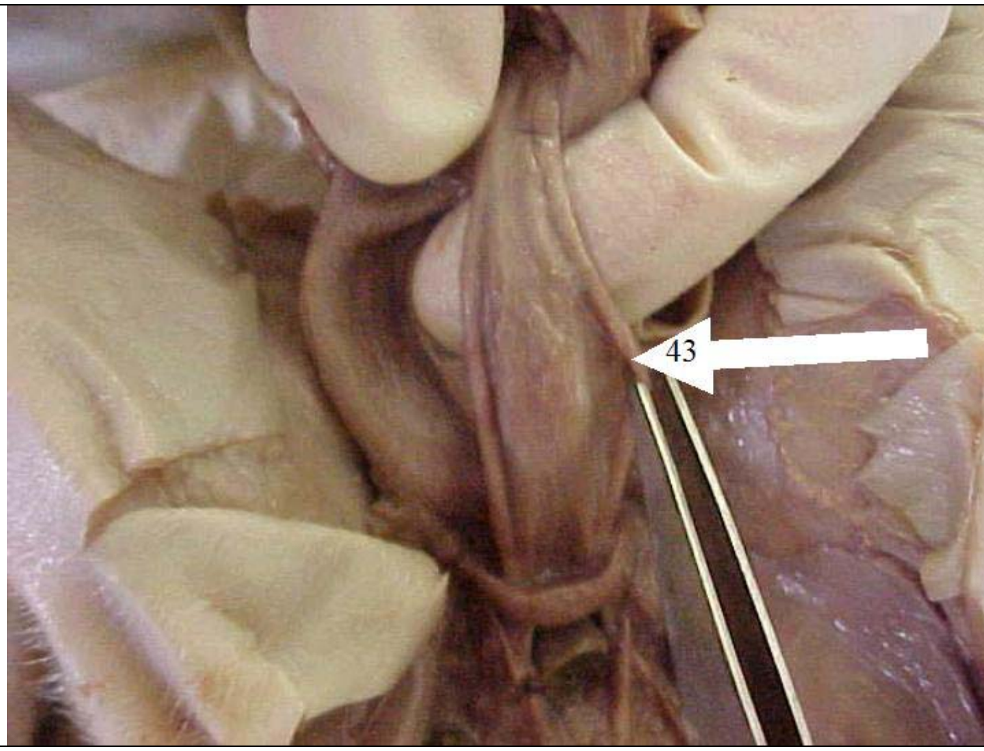
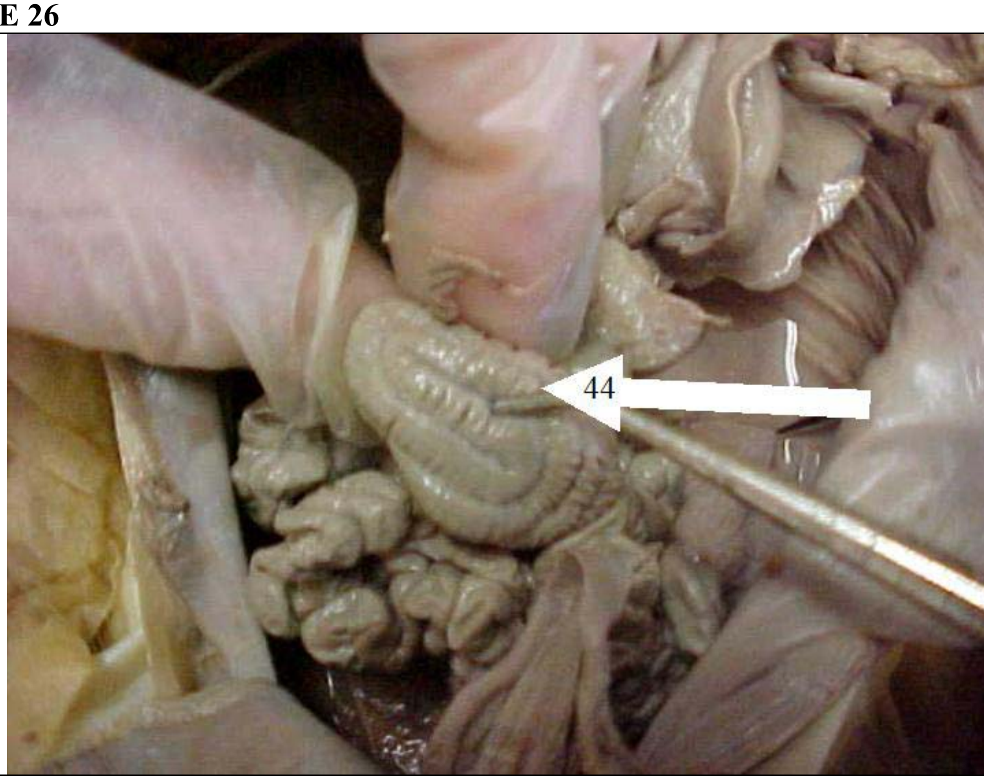
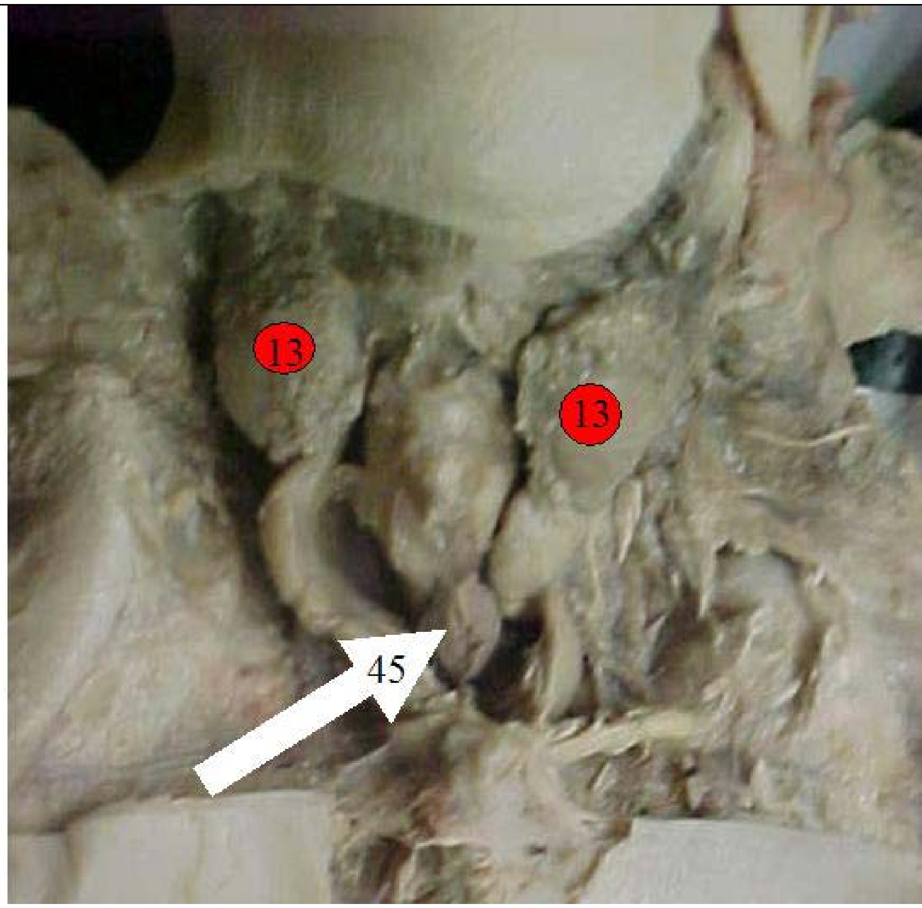


SLIDE 26



SLIDE 27



Appendix G

Taxonomic Analysis Figures 1 and 2

Figure 1. Taxonomic Analysis – Actual Dissection

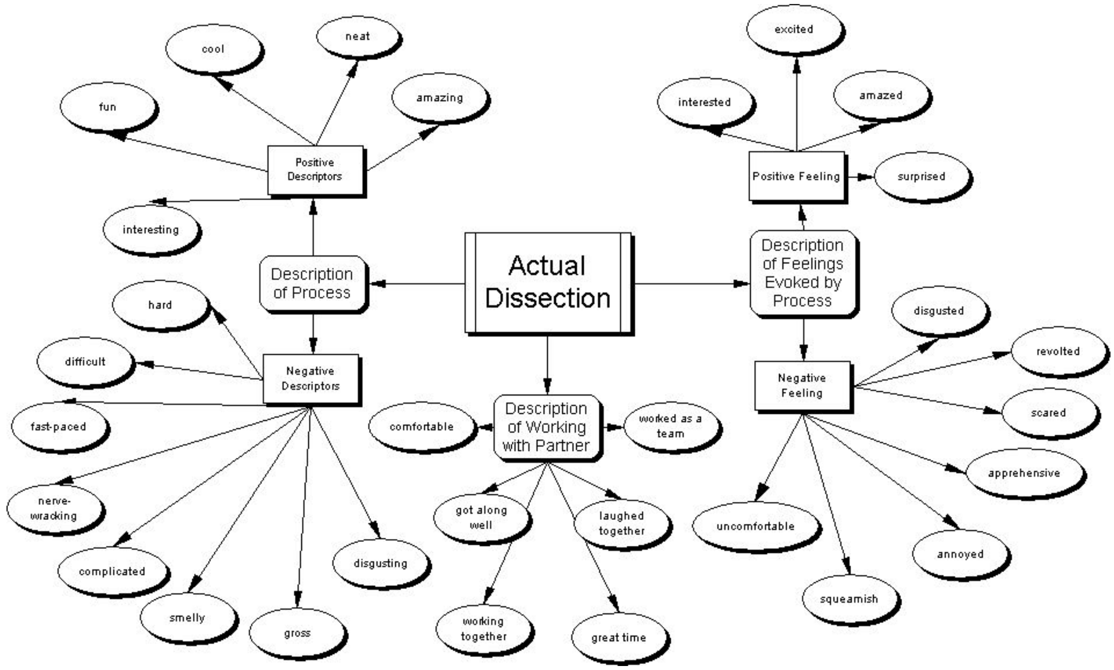
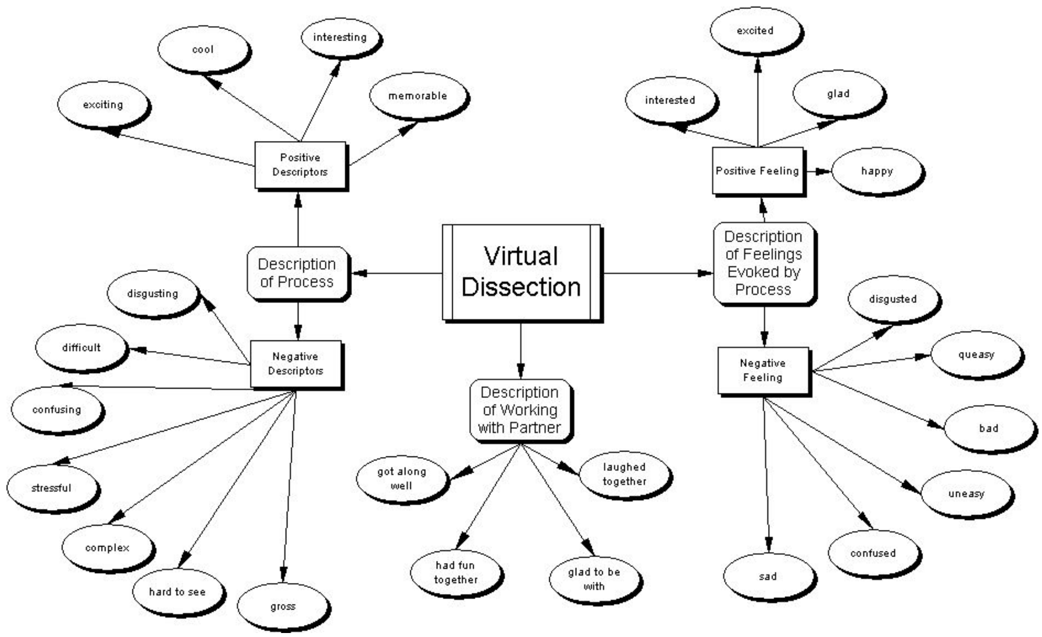


Figure 2. Taxonomic Analysis – Virtual Dissection



VITA

Rebecca S. Maloney graduated summa cum laude from the University of New Orleans with a Bachelor of Science in Science Education. She received a Master of Education degree in Curriculum and Instruction from the University of New Orleans.

Rebecca currently serves as the Counselor/Academic Specialist for the Classic Upward Bound Program at the University of New Orleans. Prior to this position, she taught Earth Science and Biology II at Archbishop Chapelle High School. At Chapelle she developed and supervised a peer tutoring program in science, wrote the instruction manual for their electronic grade book program and helped train the teachers in its use, served on their standards based education committee, and gave numerous workshops to the faculty.

Rebecca holds membership in the Louisiana Science Teachers Association, Phi Kappa Phi Honor Society, and Golden Key National Honor Society.

DOCTORAL DISSERTATION REPORT

Candidate: Rebecca Maloney

Program of Study: Curriculum & Instruction

Title of Dissertation: VIRTUAL FETAL PIG DISSECTION AS AN AGENT OF KNOWLEDGE ACQUISITION AND ATTITUDINAL CHANGE IN FEMALE HIGH SCHOOL BIOLOGY STUDENTS

Approved:

Major Professor & Chair
Richard B. Speaker, Jr.

Dean of the Graduate School

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Date of Examination

November 5, 2002