A comparison of traditional animal dissection and computer simulation dissection

Debra Elisabeth Kiehl
A COMPARISON OF TRADITIONAL ANIMAL DISSECTION AND

COMPUTER SIMULATION DISSECTION

A Thesis
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San Bernardino

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Debra Elisabeth Kiehl
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Approved by:

Herbert K. Brunkhorst, Ph.D. First Reader

Joseph Jesunathadas, Ph.D. Second Reader

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ABSTRACT

The purpose of this study was to compare the instructional effectiveness of traditional animal dissections and computer simulation dissections related to student achievement and attitudes. The sample used was 84 seventh-grade life science students from one middle school in Riverside, California. Four class periods, similar in student achievement and ability, were selected to participate in the study. The control group comprising of two class periods dissected a preserved frog specimen using conventional dissection tools. The experimental group, comprising of two other class periods, completed an interactive computer simulation of a frog dissection, using laptop computers. An achievement test and an attitude survey were administered to the students upon completion of the activity. Mean scores of the test and survey were used for data analyses. A t-test of independent means and Cohen’s d were used to measure the differences between means. The results indicated that there was no significant difference among the means in student achievement when using traditional animal dissection or computer simulation dissection. However, when looking at students’ attitudes
toward traditional dissection, there was a significant difference in the means between the control group and experimental group indicating that students preferred the type of dissection they completed. Overall, students have a positive attitude towards traditional dissection.
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Ah yes, frog dissection day is approaching. It’s the activity students have been looking forward to all year. Students will be engaged, follow directions, absorb the content, and enjoy the activity. Six hundred dollars later and students finally receive their preserved frog specimens. They respond with, “Eewww! Gross! They stink.” One student raises her hand and requests to leave the room, claiming she is on the verge of vomiting. Another student refuses to do the dissection because she believes dissection is morally and ethically wrong. When I turn around, after two seconds of being preoccupied, the first words out of my mouth are, “Darrin, do not test the scalpel’s sharpness with your finger!” After cutting open the frog, an attempt is made for students to identify a specific internal organ, the liver. However, even with the aid of diagrams, a projected image of the dissected frog, and step-by-step instructions, I still hear, “Mrs. Kiehl, where is the liver?”
Statement of the Problem

Even under the most stringent classroom management plan, this scenario depicts my personal experiences with hands-on dissections in the classroom. Though frog dissections, along with other animal dissections, are engaging activities for students to learn about physiological anatomy, they are at times chaotic, stressful, and unpleasant for both teachers and students. The purpose of this study is to investigate an alternative to traditional hands-on frog dissection and compare its effectiveness in teaching the frog anatomy in the middle school science classroom. The effectiveness will be based on student acquisition of the content and student attitude about the dissection process.

Despite being a cornerstone of traditional biology and life science curriculum, animal dissections in the 21st century are wrought with controversy. The ethical issues that arise include the inhumane treatment of animals, the depletion of wild animal populations, and risk of developing callousness toward the value of animal life. Legislation has even intervened to give students the option of not dissecting. Currently, there are nine states in the
United States, including California, with dissection-choice laws. Five other states have policies that have not yet been enacted into law (Balcombe, 1997).

Dissections present obstacles for schools, teachers and students. Many schools cannot afford the cost of dissection materials. For teachers, dissection activities turn into discipline issues in which students use sharp dissection tools inappropriately, do not follow directions, and try to impress or disgust their friends. Dissections can also be stressful for teachers with the preparation and clean up of the dissection and limited class time available to complete the activity. Additionally, students’ dependence on the teacher’s assistance during dissections is intensely demanded. Even when teachers provide support of diagrams and projected images, students still have difficulty identifying organs independently and often require the teacher to personally interact with each and every lab group. Students also experience discomfort from dissections. They complain about the odor of preserved specimens and some students become physically ill from the sight of cutting open a dead animal. Other students do not consent to animal dissection, because they believe it is
unethical. With so many negative issues surrounding dissection in the classroom, there must be other ways to effectively teach the anatomy of frogs without involving costly materials, sharp scalpels, and smelly specimens.

Purpose of the Study

There are several alternatives to traditional animal dissections. Models, videos, websites, and software programs are among some of the alternative sources on the market to assist in the teaching of frog anatomy. These alternatives are criticized for their “lack of realism and opportunities for student involvement” (Kinzie, Strauss & Foss, 1993). As a result, only realistic, interactive dissection software will be considered.

The software chosen for this study is a virtual dissection program by Froguts Incorporated entitled Froguts. It is a computer simulation of a dissection that encourages student interaction, contains advanced, realistic graphics, and tutors students. The interactive portion of the software insists that students manually select dissection tools, perform dissection procedures, identify organs, and complete various assessments. The
graphics are advanced; they look identical to the real frog because of improved technology in photography and computer programming. The program also tutors students individually, revealing many facts about frogs throughout the dissection with a focus on their external and internal anatomy. Froguts software is comparable to traditional dissection because it permits student interaction, makes the experience realistic through advanced graphics, and teaches students one-on-one about frog anatomy.

If this high-tech software program can teach students just as effectively, and affect their attitudes as positively as traditional frog dissections, then there are benefits for schools, teachers and students in using the software as a substitute for traditional dissections. Schools can save money on the non-consumable (dissection tray and tools) and consumable (preserved specimens) dissection materials. Teachers can spend less time in the classroom carrying out dissections and worry less about scalpels being in the hands of 12-year-olds. Additionally, students can be relieved from seeing and smelling animal specimens and will no longer feel obliged to protest against animal dissections in front of their peers.
Research Questions and Hypotheses

Does interactive virtual dissection teach middle school students about the frog's anatomy as effectively as traditional dissections? In previous studies, it has been found that alternatives to animal dissection, such as interactive video discs (Kinzie et al., 1993), CD-tutorials (Marszalek & Lockard, 1999), and even lecture (McCollum, 1988) have been just as effective, if not more effective, than traditional animal dissections. These conclusions were based on the evaluation of student test scores following a dissection. However, with new technology, advanced graphics, and the increased student interaction utilized by the Froguts software, results of this study may differ from previous studies. Therefore, the first testable null hypothesis for this study is $H_0$: There is no difference in the means of student knowledge about the anatomy of frogs and their function using traditional dissection methods or Froguts interactive computer software. The alternate hypothesis is $H_1$: The mean of student knowledge about the anatomy of frogs and their function for the control group is not equal to the mean of the experimental group.
Another important reason for this study is to learn how each type of dissection affects students' attitudes toward traditional dissection. Does interactive dissection software affect students' attitudes toward dissection differently than traditional dissection? As a seventh grade life science teacher, my students have generally expressed positive views toward dissection, but the overwhelming evidence in the literature has documented student negativity. The results from several studies indicated that students felt that they should be given a choice to participate in dissection alternatives (Brown, 1989; McKernan, 1991). Results from a different study showed that 72.5% of students felt that it was wrong to breed animals for dissection (Millett & Lock, 1992). One particular study discovered that fetal pig dissections might dissuade students, especially girls, from pursuing careers in scientific fields (Solot & Arluke, 1997).

While some students have a disdainful attitude toward dissections, other students are positively engaged by the prospect of completing a dissection. During the first week of the school year, students are already asking about when they are going to dissect. Only on rare occasions do
students complain about or refuse to do dissections. In fact, one study showed that 67% of college students felt that dissection was an effective tool and that much could be learned through dissection (Sieber, 1986). Most studies emphasize a negative attitude for traditional dissection or positive attitude toward alternatives. Consequently, the second testable null hypothesis for this study is H₀: There is no difference in the means of student attitudes toward dissection using traditional dissection or Froguts interactive computer software. The alternate hypothesis is H₁: The mean of student attitudes from the control group is not equal to the mean from the experimental group.

Limitations and Delimitations

Limitations

The purpose of this study was to determine the effectiveness of Froguts in teaching middle school students the anatomy of the frog. There were several limitations that should be mentioned for this study involving the sample population and the Froguts software program. The number of students in the sample was below the anticipated amount due to students failing to turn in permission slips
and student absenteeism on critical instructional days. To address this limitation, data from students who did not turn in their permission slips and/or were absent after the first day of the study, were not considered in the analyses.

Another limitation was the scheduling of the study. The study was conducted at the very end of the school year during a holiday week. This presented several problems due to the short week and the timing of the study. There were only four days during the instructional week due to a national holiday, which limited the length of the study. The timing of the study presented several built-in distractions to students; end-of-the-year activities, anticipation of summer vacation, and student absences due to students leaving school early for family vacations.

An unanticipated limitation was the use of the Likert scale for the attitude survey. The 20-item survey was based on a five-point Likert scale in which students had to respond to each statement with: "Strongly Agree, Agree, Neutral (Does not Apply), Disagree, and Strongly Disagree." It was not discovered until after the construction of the survey that Likert scales are often discouraged due to the
option of choosing “Neutral.” Middle school students are not always confident in their answers, which may persuade them to choose “Neutral” for many of their answers. In order to counteract this result, students were instructed to try their best to have an opinion about each of the statements and to only choose “Neutral” if they really did not have an opinion or if the statement did not apply to their experiences.

The Froguts software used for the study also presented limitations. The Froguts software included more information about frogs than was provided by the traditional dissection. In order to narrow down the content from the software program, students in the experimental group were given a lab worksheet, which was also given to students who performed the traditional frog dissection. The advanced vocabulary that was verbalized during the one-on-one tutorial was not grade-level appropriate. The software did not provide any support in alternate languages, since the program only offered instruction in English. This may have been a limitation because some of the students that participated in the study were English Language Learners with language skills ranging
from Beginning to Advanced. However, there were accommodations made for students with low language skills during the study. English learners were paired with students possessing high language skills, and a bilingual aide was present throughout the study. Additionally, the assessment and survey given toward the end of the study were translated into Spanish.

Delimitations

The focus of this thesis was to compare the effectiveness of interactive dissection software to traditional frog dissection. This topic was condensed from a broader topic that would have compared the effectiveness of several types of dissection alternatives including videos and other interactive software programs. However, several of these dissection alternatives such as interactive videodiscs, CD-tutorials and lectures were studied in the past (Kinzie et al., 1993; Marszalek & Lockard, 1999; McCollum, 1988). The effectiveness of Froguts had not been studied in formal research. Therefore, during this study, Froguts was evaluated for its effectiveness in teaching students the anatomy of the frog and its influence on the attitudes of students.
CHAPTER TWO
LITERATURE REVIEW

History

It is unclear when animal dissections first became a part of biology education. Orlans reports that use of animal dissections in science education began in the 1920's (Orlans, 1993). In an effort to emphasize learning through inquiry, the Biological Sciences Curriculum Study (BSCS) included animal dissections as a part of the biology curriculum developed in the 1960’s (Rudolph, 2002). However, as an increasing number of animal specimens were used in education, concerns about the ethical treatment of those animals arose. Included in the dissection complaints were frog pithing, highly invasive science fair projects (Balcombe, 2000) and other issues. In response, the National Science Teachers Association (NSTA) and the National Association of Biology Teachers (NABT) adopted a “Code of Practice” in 1981 for pre-college biology curriculum:

No experimental procedure shall be attempted in mammals, birds, reptiles,
amphibians, or fish that shall cause the animal pain or discomfort or that interferes with its health. As a rule of thumb, a student shall only undertake those procedures on vertebrate animals that would be done on humans without pain or hazard to health. (NABT, 1981)

Four years later, NSTA revised the wording to discourage procedures causing "unnecessary pain or discomfort." Dr. Jonathan Balcombe, an associate director for The United States Humane Society, claimed that this rewording would allow for more leeway in animal experimentation because "unnecessary" is subjective and can be interpreted differently among educators (2000). With NABT's support, animal dissections continued in the classroom at the discretion of teachers until the late 80's when an issue arose that changed legislation.

In 1987 a California high school student named Jenifer Graham objected to dissecting a frog as a requirement in her biology class and declined to participate in the class activity. The school refused to allow dissection
alternatives, claiming that there is "no substitute for the actual dissection experience" (Orlans, et al., 1998). She subsequently received a lower grade in her biology class and therefore took the matter to court. The judge dismissed the case, but offered a compromise to dissect a frog that had died of natural causes in order to change her grade. Unfortunately, the compromise fell through, but as a result of the court case, there was a surge of protest activity and change in legislation (Orlans, et al., 1998).

There are currently nine states in the United States that have dissection-choice laws in place. Five other states have policies that have not yet been enacted into laws (Balcombe, 1997). Today the debate continues. There are reasonable arguments for removing animal dissections from the pre-college biology classroom. However, there are also sufficient arguments for continuing to use traditional animal dissections.

Traditional Animal Dissection

One of the main arguments for continuing the use of traditional animal dissections in the science classroom is that it fosters scientific inquiry; a key concept outlined
in the National Science Education Standards (NRC, 2000). Activities promoting scientific inquiry and hands-on experiments engage students, provide them with meaningful experiences, and permit them to make connections with their background knowledge. When structured appropriately, dissection in the classroom does just that. However, if the dissection is poorly supervised, the activity is reduced to having little or no meaningful learning (Hertzfeldt, 1994; Solot & Arluke, 1997; Long, 1997).

Well-structured, carefully planned, and closely monitored dissections can result not only in a meaningful learning experience, but can even foster an increased respect for life. According to Berman (1984) and Igelsrud (1987), allowing students to use scientific inquiry to explore the anatomy of an organism generates an appreciation for the uniqueness of life. Furthermore, teachers can use that appreciation to stress the importance of preserving and respecting animal life (Berman, 1984; Igelsrud, 1987). On the contrary, Russell (1996) points out the irony in studying life through dissections by first destroying it. Solot and Arluke (1997) found that dissections create a desensitized, callous view towards
animals. Either message can be conveyed to students, the reverence and appreciation for animal life or the desensitized callousness towards animals. It is the teacher who ultimately influences which message is communicated (Balcombe, 2000).

Another argument for traditional animal dissections is that no dissection alternative: models, lectures, videos, or even interactive computer simulations, can replace the benefits of hands-on dissections. A genuine dissection provides students with a rich multi-sensory experience, permits visual-spatial thinking, and provides realism to the students, while allowing them to hone their dissection skills (De Villiers & Monk, 2005). Sensory experiences make learning come alive to students. Through dissections, students can use their senses to experience the sights, odors, textures, and sounds of discovering the tissues of once-lived animals. A proponent of traditional dissections, Schrock (1990), claims that no media can provide the "full sensory experience" authentic dissection provides. On the contrary, a common complaint among students is the offensive odor of preserved specimens. When Shapiro (1992) asked a group of Maine legislators what
they remembered about high school dissections, one response was the "pungent smells." Some students can even become nauseated by specimens’ scent and appearance. In a study completed in 1994, 50% of 106 Australian schools reported ethical objections and students nauseated by dissection (Smith).

Envisioning, handling, rotating, and manipulating objects during dissections enable students to practice visual-spatial thinking (Lord, 1990). Three-dimensional models can teach the same material, but when the animal is real, students become more engaged. In fact, when students know a specimen is real, their attention is heightened and they process the information they learn as "real" (Offner, 1993). On the other hand, Balcombe (2000) makes the point that the "realness" of the specimens used in the dissections is reduced after they are preserved, embalmed and shipped.

Dissection skills such as handling a scalpel, separating tissue, and making incisions cannot be taught any other way except by actually dissecting a real animal. Quentin-Baxter and Dewhurst (1990) made it clear that alternative programs are valuable in preparing students for
dissections, but they cannot effectively teach dissection procedures and techniques. Kinzie, Strauss and Foss (1993) also studied the success of alternative programs in teaching students dissection skills, but their study did not make a comparison between the dissection skills and techniques of students after using a computer simulation program and those performing a traditional dissection. Balcombe (2000) claims that one could practice dissecting skills on a "non-animal apparatus" instead of justifying the destruction and dissection of millions of animals each year just to practice those skills. Another reason why many educators continue using traditional dissections is because there are contradictions in the literature concerning the use and effectiveness of computer-based instructional simulations (Haury, 1996).

Interactive Dissection Software

From lecture and three-dimensional models to interactive videodiscs and computer simulations, dissection alternatives have evolved over the past 20 years. Today's dissection alternatives have become more realistic with the aid of computer technology and schools are now using
websites and CD-ROM's to replace traditional dissections. In 1991, Kinzie and Strauss developed an interactive videotopic entitled The Interactive Frog Dissection, which has been used in various studies and is currently available online for free. Digital Frog and Dissection Works are two additional CD-ROM programs that act as interactive computer simulated dissections. These programs have also been used in several studies. In studies conducted involving these three programs, there were contradicting results in the achievement scores of students who participated in the interactive alternative and those who performed an actual dissection.

In 1991, Kinzie and Strauss developed the Interactive Frog Dissection to be used as a dissection alternative. In 1993, they teamed with Foss to put their software to the test by completing a study that involved 61 high school students. The interactive videotopic was studied as a substitute for traditional dissection and as a pre-dissection preparation tool. Student achievement was assessed for both groups in which students completed an achievement test assessing student knowledge of frog anatomy and dissection procedures. It was found that there
was no significant difference between the achievement of students who completed the computer simulation as a substitute for dissection and the students who completed the traditional dissection. There was, however, a significant difference in achievement between students who used the interactive videodisc as a preparation tool and those that did not (Kinzie et al., 1993). In 1994, Strauss and Kinzie completed a pilot study, again comparing the Interactive Frog Dissection and traditional dissection in a high school biology classroom. Only 17 students were part of this study. Again, results indicated no significant difference in student achievement between the two types of dissection (Kinzie & Strauss, 1994).

In 1999, Marszalek and Lockard used a CD-tutorial called Digital Frog and a desktop microworld to compare its instructional effectiveness with that of a traditional dissection. This study involved 280 seventh-grade students in 14 different classes. Students were given a pre-test, post-test and delayed post-test after participating in the traditional dissection, CD-tutorial, or desktop microworld. The desktop microworld is a compilation of different videos, CD-ROMs and websites. Their results determined
that traditional dissection is significantly more effective than the CD-tutorial and desktop microworld when the instructional objective is immediate gain of knowledge. When the objective is long-term retention, then there is no significant difference between the traditional dissection, CD-tutorial, and desktop microworld. There was a significant difference in anxiety levels among students from the three groups. Students in the traditional dissection group experienced significantly less anxiety than those in the CD-tutorial and microworld groups. Marszalek and Lock explain that these results may have occurred because students had prior experiences with traditional dissections and no prior experiences with either the CD-tutorial or desktop microworld (1999).

In 2001, Kariuki and Paulson compared an interactive CD-ROM called Dissection Works to preserved worm and frog dissections. The study involved 104 high school biology students from a rural school in Tennessee. The control group dissected a preserved worm and frog, while the experimental group used the Dissection Works CD-ROM to complete equivalent dissections. An achievement test was given after each dissection that included a section in
which students had to identify organs of a dissected earthworm or frog specimen. The data were analyzed using a t-test for independent means. Results indicated that there was a significant difference between achievement of students in the control group and experimental group. The group that dissected the preserved animal specimens performed significantly better on the tests than those in the experimental group. Kariuki and Paulson explained that this was most likely due to the students' familiarity with the actual dissected specimen, which was used for the test for both groups. Students in the experimental group had only experienced the images from the CD-ROM and were likely unfamiliar with the genuine specimen.

Students' Attitudes Toward Dissection

The effectiveness of an instructional method, such as dissection, can be measured by examining student achievement. However, there are other factors that need to be considered, such as student attitude toward the task or activity. "Attitude is commonly defined as a predisposition to respond positively or negatively to [concrete objects such as] things, people, places, events,
or ideas" (Crawley III, Simpson, Koballa & Oliver, 1994). Attitudes toward science have been measured as a research tool since the late 1920’s. Gardner (1975) stated that attitude research is important to study because the ultimate goal of science is to “stimulate joy, wonder, satisfaction and delight in children [through their] encounters with science.” By examining the attitudes of students, an instructional method can be analyzed in its effectiveness.

In 1989, Leonard compared college students’ attitudes toward conventional laboratory experiments versus videodisc simulations. His results indicated no significant difference between the responses of each group. However, students from the simulation group preferred setting up, handling, and observing the actual lab apparatus and organisms. Leonard concluded that computer technology is a great supplement to the science classroom, but should not substitute for “'wet' laboratory experiences.” Other studies are specific to dissection: researchers have compared traditional dissections and alternatives to dissection and their effects on students’ attitudes. This
information is then used to determine the value of each instructional method.

In an annotated list of studies created by Balcombe (1997), cumulative results show that many students have reservations about traditional animal dissections. In a study completed by Brown (1989), 50% of 142 ninth graders responded that they would choose an alternative to dissection if provided and 90% believed that students should be given that choice. McKernan (1991) compiled the responses of 972 high school students about their attitudes toward dissection. Results showed that 72% felt that students should be allowed to use dissection alternatives. Approximately 16% claimed to have requested a dissection alternative or to be excused from the dissection. Millett and Lock (1992) surveyed 468 14- and 15-year-olds of which 72.5% felt that animals should not be bred for dissections and 38% "would object to any animal material being used for dissection." Solot and Arluke (1997) studied 15 sixth graders and through their behaviors during the dissection and student interviews, concluded that dissection may encourage callousness towards animals and nature and may discourage girls from pursuing careers in science.
On the contrary to the above results are studies that have shown positive attitudes towards dissection. Lord and Moses (1994) found that 80% of the undergraduate students who participated in the study did not object to the dissection of preserved animals. In 1986, 67% of a group consisting of 211 college students and 39 life science professionals, felt that dissection was an effective tool and that much could be learned through dissection (Sieber). Kinzie, Strauss and Foss (1993) did a study with 61 high school students to compare the change in attitude of students who either completed a traditional dissection or a computer simulation dissection. Their results indicated students' attitudes about dissection and dissection alternatives did not change significantly over time. However, in their 1994 study involving 17 high school students, Kinzie and Strauss (1994) found that over time, students who used the simulation became less positive about the value of animal dissection while students who performed the authentic dissection became more positive. The researchers point out that this may be due to a student's preference to the instructional method they first experienced.
Conclusion

There are many valid arguments defending or criticizing the instructional use of traditional animal dissections in the classroom. Today, students are more frequently seeking alternatives to dissection. The majority of the current research indicates that there is no difference in achievement between students who perform a traditional dissection and those who use a dissection alternative although it is possible for the achievement among those groups to differ (Kariuki & Paulson, 2001). Dissection alternatives are very effective as a preparation tool for traditional dissections (Kinzie et al., 1993; Leonard, 1989). Students' attitudes seem to be relatively negative towards animal dissection. There are not many studies communicating positive attitudes. Students' attitudes regarding dissection and dissection alternatives may or may not change over time. Most of the research indicates the need for further research. Findings may sustain the instructional effectiveness of dissection alternatives. As technology continues to advance, computer simulated dissections may continue to increase in
instructional effectiveness over traditional animal dissections.
CHAPTER THREE

METHODOLOGY

Subjects

The total number of students intended to participate in the study was 126 seventh grade students at a middle school located in Riverside, California. As permission slips were obtained and attendance was recorded, the sample was reduced to 94 students, as only students who returned a signed permission slip and attended all four days of the study would be considered in data analysis. The sample was reduced even further to 84, to equalize the numbers of students in the control and experimental groups. The details of this process are explained below. The school is identified as a Title I school as 57.4% of students receive free or reduced price lunch. Seventy-five percent of students are Hispanic, 15.9% of students are Caucasian, 4% are African-American, 2.6% are Asian or Pacific Islander and the remaining 2.5% are from other ethnicities (PISA, 2006). The participants were seventh graders with an average age of 12.58 (SD = 0.62). The students in the sample came from four 53-minute long life science classes
taught by a single instructor. The two class periods selected to participate in the control group were similar in student ability and achievement to the two class periods selected in the experimental group. The study was conducted over four consecutive days during a holiday week, which occurred toward the end of the school year, following a unit on anatomy. All students had previously completed a traditional dissection of a sheep's eye and had taken a similar assessment to the instrument utilized in this study. Therefore, all participants were familiar with dissection instruments, general lab protocol, and testing procedures.

Procedures

Before the study was conducted, approval was granted to the researcher to complete the study from the CSUSB Institutional Review Board and from the school principal. Parents granted individual students written permission to participate in the study (see Appendix A). Four class periods were selected to participate in the study. The two class periods comprising the control group performed a traditional dissection using a preserved frog specimen and
conventional dissection tools. The two other classes comprising the experimental group completed a computer simulation of a frog dissection using the Froguts software. The study took four days to complete; three days were used to introduce, study, and review the anatomy of the frog and the fourth day was used for the completion of the assessment and survey. Attendance was recorded for each day.

On the first day of the study, the teacher told the students which type of dissection they would be completing, the traditional dissection or Froguts computer simulation. Students were also informed that everyone would have the opportunity to participate in either type of dissection after the study was over. All students received identical lab worksheets to be filled out during the activity. In most of the class periods, students were paired in order to share supplies. In both control groups, students paired on their own initiative. In one experimental group, students paired together and had their own individual computers. In the other experimental group, which contained students whose English language skills ranged from beginning to intermediate, students were paired heterogeneously.
according to language skills and therefore shared a computer. Students received their materials, either a preserved frog and dissection tools for the control group or laptop computers for the experimental group. The teacher was continuously accessible to both groups. In the control group, the teacher used a video device to project an actual dissected frog to enable students to follow the procedures of the dissection correctly and appropriately. In the experimental group, the teacher monitored the students to ensure facility with computer operation. One class period in the experimental group had a bilingual assistant translating the information on the computer for some of the students and providing extra assistance for students to complete the lab handout. At the end of the day for both groups, the teacher discussed the answers to the questions from the first half of the lab handout.

On the second day of the study, the traditional dissection group was able to complete the remainder of the dissection with the exception of the nervous system. Because the brain is very difficult to access, students were instead shown the nervous system organs of a frog that was dissected by the teacher. Students in the Froguts
computer simulation group continued to work on the laptops, completing their lab handout. For both groups, the teacher remained accessible to students and at the end of the day reviewed the correct answers on the second half of the lab handout.

The third day was used to finish any remaining uncompleted work and to review the information learned. Students who still needed to complete the dissection or computer simulation had some time to do so. Students who had already completed the dissection or simulation were asked to review the structures and functions of the frog anatomy. The teacher reviewed the answers to the lab handout once more.

On the fourth and final day, students in all groups completed the achievement test and the attitude survey. On the achievement test, questions for both groups were identical; however the students in the traditional dissection group viewed an actual dissected frog while students in the computer simulation group viewed an image of the frog on the laptops during the test. This procedure differs from that used by Kariuki and Paulson who used an authentic dissected specimen during the test for both
groups (2001). The same structures were marked on both types of frogs. Structures of both the dissected frog and virtual frog were marked by flags, which had letters on them that corresponded to the appropriate test questions. After students completed the achievement test, they were instructed to complete the attitude survey.

Instrumentation

The interactive computer software used in the study is called Froguts. In 2001, two graduate students developed the Froguts program, photographing a preserved frog specimen in each stage of the dissection process and then adding animation to the thousands of pictures. Froguts encourages student interaction by allowing students to choose dissection tools, perform dissection procedures, identify internal and external structures of the frog, and ultimately assessing their knowledge. The software also tutors students about important facts regarding frogs. The program was chosen over other computer simulations that contain the same types of interaction and tutoring like Digital Frog 2, Dissection Works, and Interactive Frog Dissection, because the style, theme and presentation is
engaging and age appropriate. The sounds, graphics, and backgrounds are appealing and more modern than other programs.

A teacher-generated lab handout was used for both the control and experimental groups (see Appendix B). The lab handout followed the order of both the traditional frog dissection and Froguts computer simulation, and included the frog's structures and functions and other additional information. Students were required to answer 26 questions and draw six diagrams. Correct answers to the questions were reviewed several times during the first three days of the study.

The 20-item achievement test was a criterion-referenced test covering the frog's internal and external anatomy (see Appendix C). Four of the questions were written as True/False questions and the remaining 16 questions were formatted as multiple choice questions with four choices lettered "a" through "d." For students in the traditional dissection group, each lab table received a dissected frog specimen and all four students at the table examined the dissected frog independently then answered the questions on the achievement test. The frog's structures
were marked with lettered flags. The letters corresponded to specific test questions. For each question, students independently examined the frog at their lab table and chose the correct structure and function of each flagged organ.

In the computer simulation group, each student was given a laptop computer. On the laptop was an image of a dissected frog, the same image they had seen on the Froguts computer program, with labels pointing to various structures in the frog. The labels contained letters, which corresponded to specific test questions. The labels on the computer image were pointing to the same structures as the labels on the dissected frog. For each question, students examined the image and chose the correct structure that was labeled and its correct function out of the multiple choices. The test was translated in Spanish for several students participating in the study. The Kuder-Richardson 20 reliability coefficient calculated for this achievement test was 0.66.

The 20-item survey was constructed using a 5-point Likert scale (see Appendix D). The choices available ranged from “Strongly Agree” to “Strongly Disagree.”
Students were instructed to attempt to commit to an opinion and not to pick "Neutral" for each item, unless there were no other choices that corresponded with the students' attitude. Seven of the items were adopted from a 20-item survey used in a study by Kinzie, Strauss and Foss (1993). The researcher constructed the remaining items. Half of the items conveyed anti-dissection attitudes while the other half conveyed pro-dissection attitudes. Most of the statements on the survey addressed students' attitudes about traditional dissection. Three statements addressed students' attitudes about computer simulation as an alternative to dissection and one statement addressed students' feelings regarding the value and respect of animal life. The seven statements adopted from Kinzie, Strauss and Foss (1993) were reviewed by numerous educators, while several educators reviewed the remaining items constructed by the researcher. The survey was translated into Spanish for students with limited English language skills. The Cronbach Alpha reliability coefficient calculated for the survey was 0.76 for the control group and 0.89 for the experimental group.
Data Analysis

The sample size had to be reduced from 94 students because there were 52 students in the control group and 42 in the experimental group. To reduce the number of students in the control group from 52 to 42, student overall science grades were recorded, sorted and compared to science grades of students from the experimental group. A total of 10 students were selected out of the data analysis from the control group. The total number of students in the sample became 84, with 42 in both the control group and experimental group.

Students' achievement test scores were analyzed using a dichotomous key. The students received a "1" for each question they answered correctly and a "0" for each wrong answer. The total number of points for each student was calculated. This data was used to calculate the Kuder-Richardson 20 reliability coefficient. Also, the data was used to calculate the mean achievement scores. An uncorrelated t-test was done to compare the statistical significance of a possible difference between the mean scores in achievement for the control group and experimental group. The results of this test would
determine whether to accept or reject the first null hypothesis: There is no difference in the mean of student knowledge about the anatomy of frogs and their function using traditional dissection methods or Froguts.

The student’s survey responses were recorded for each student. A point value was assigned to each lettered response in order to calculate the average responses for each group. The point value each letter was assigned depended upon whether the statement conveyed anti-dissection or pro-dissection attitudes. Students who responded “Strongly Agree” to an anti-dissection statement were given 5 points. Each response thereafter reduced in points all the way to “Strongly Disagree,” in which the student received 1 point. If a student chose “Strongly Disagree” for a pro-dissection statement they were given 5 points. Each response thereafter reduced in points all the way to “Strongly Agree,” in which the student received 1 point. The total points were calculated for each student and an average calculated for the entire control group and experimental group. The maximum number of points was 100. A total score of 100 points on the survey would indicate an overall dislike toward traditional dissection, a preference
for computer simulations, and a respect for animal life. A score of 20 would indicate the opposite: an overall preference for traditional dissection, a dislike for computer simulation, and callousness toward animal life. An uncorrelated t-test was done to compare the statistical significance of a possible difference between the mean scores in students' attitudes from the control group and experimental group. The results of this test would determine whether to accept or reject the second null hypothesis: There is no difference in the mean of student attitudes toward dissection using traditional dissection or Froguts.

The percentages of student responses for each attitude survey question were calculated for each group. The percentages for the responses "Strongly Agree" and "Agree" were combined as well as the percentages for "Strongly Disagree" and "Disagree" in order to make comparisons among the three main responses: "Agree," "Neutral," and "Disagree." This information was used to make comparisons in student attitude among the control group and experimental group.
CHAPTER FOUR

RESULTS

Introduction

The following research questions guided the data analysis:

1. Does interactive dissection software teach middle school students about the frog’s anatomy as effectively as traditional dissections?

2. Does interactive dissection software affect students’ attitudes toward dissection differently than traditional dissection?

To begin data analysis, the mean scores and standard deviations for the control and experimental groups were calculated for both the achievement test and attitude survey. The minimum and maximum scores were also identified. The overall results for the achievement test are shown in Table 1 and the results for the attitude survey are shown in Table 2.
Table 1

Overall Results of Achievement Test

<table>
<thead>
<tr>
<th>Group</th>
<th>M</th>
<th>SD</th>
<th>Minimum Score</th>
<th>Maximum Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>14.71</td>
<td>2.87</td>
<td>7</td>
<td>19</td>
</tr>
<tr>
<td>Experimental</td>
<td>14.10</td>
<td>3.41</td>
<td>7</td>
<td>19</td>
</tr>
</tbody>
</table>

Table 2

Overall Results of Attitude Survey

<table>
<thead>
<tr>
<th>Group</th>
<th>M</th>
<th>SD</th>
<th>Minimum Score</th>
<th>Maximum Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>40.57</td>
<td>8.74</td>
<td>24</td>
<td>58</td>
</tr>
<tr>
<td>Experimental</td>
<td>46.71</td>
<td>13.54</td>
<td>21</td>
<td>83</td>
</tr>
</tbody>
</table>

An uncorrelated t-test was used to analyze the difference in means between the control group and experimental group for both the achievement test and
attitude survey. Cohen's d was also calculated to determine the effect size of the difference between means. All data were analyzed as a two-tailed test, using a level of statistical significance of 0.05.

Findings Pertaining to Research Question One

The results of the t-test for research question one indicated no significant difference in achievement between students who completed a traditional dissection and those that used the interactive dissection software ($t = -0.9$, $df = 82$, $p > 0.05$). See Table 3 for t-test results.

<table>
<thead>
<tr>
<th>Group</th>
<th>M</th>
<th>df</th>
<th>SD</th>
<th>t-value</th>
<th>Sig</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>14.71</td>
<td>82</td>
<td>2.87</td>
<td>-0.90</td>
<td>0.37</td>
<td>&gt; 0.05</td>
</tr>
<tr>
<td>Experimental</td>
<td>14.10</td>
<td></td>
<td>3.41</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3

T-test for Independent Means of Achievement Test
The effect size in the difference of the means was also calculated using Cohen’s d \((d = -0.19)\). Based on the criterion defined by Cohen (1988), the results indicated that there was a small difference in the means (small: \(d = -0.2\)). See Table 4 for Cohen’s d results.

**Table 4**

<table>
<thead>
<tr>
<th>Group</th>
<th>M</th>
<th>SD</th>
<th>Cohen’s d</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>14.71</td>
<td>2.87</td>
<td>-0.19</td>
<td>small: (-0.2) medium: (-0.5) large: (-0.8)</td>
</tr>
<tr>
<td>Experimental</td>
<td>14.10</td>
<td>3.41</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

These results verify that the null hypothesis is accepted \(H_0\): There is no difference in the mean of student achievement among students from the control and experimental groups. The alternate hypothesis is rejected.
Findings Pertaining to Research Question Two

The t-test results for research question two indicated a significant difference between the control and experimental groups regarding student attitude ($t = 2.47$, $df = 82$, $p < 0.05$). See Table 5 for t-test results.

<table>
<thead>
<tr>
<th>Group</th>
<th>M</th>
<th>df</th>
<th>SD</th>
<th>t-value</th>
<th>Sig</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>40.57</td>
<td>82</td>
<td>8.74</td>
<td>2.47</td>
<td>0.016</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>Experimental</td>
<td>46.71</td>
<td>13.54</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The effect size for the difference in the means was calculated using Cohen's $d$ ($d = 0.54$). Results indicated that there was a medium difference between the means of the control group and experimental group (medium: $d = 0.5$). See Table 6 for Cohen's $d$ results.
Table 6

Cohen's d of Attitude Survey

<table>
<thead>
<tr>
<th>Group</th>
<th>M</th>
<th>SD</th>
<th>Cohen's d</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>40.57</td>
<td>8.74</td>
<td>0.54</td>
<td>small = 0.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>medium = 0.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>large = 0.8</td>
</tr>
<tr>
<td>Experimental</td>
<td>46.71</td>
<td>13.54</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

These results indicate that the null hypothesis is rejected and the alternate hypothesis is accepted: The mean of student attitudes from the control group is not equal to the mean from the experimental group.

Additional Findings

The percentages of student responses for each survey question were calculated for each group. The data for the responses "Strongly Agree" and "Agree" and "Strongly Disagree" and "Disagree" were collapsed to make comparisons among the three main responses: "Agree," "Neutral" and "Disagree." The percentages of students who agreed with the anti-dissection statements are shown below in Table 7 for the control and experimental groups.
As seen in Table 7, the control group and experimental group are very close in range in responses to statements 1, 7, 8, 9, and 10. However, for statements 2-6, the percentages differ for the control and experimental groups. More students from the experimental group seemed to express uncomfortable and unpleasant feelings towards traditional dissection than students from the control group. Also, more students from the experimental group felt that the interactive computer software taught them about frog anatomy more effectively and was more exciting to them than traditional dissection.
### Table 7

**Percentage of Students who Agreed with Anti-Dissection Statements**

<table>
<thead>
<tr>
<th>Statement</th>
<th>% Agree</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control</td>
<td>Exper.</td>
</tr>
<tr>
<td>1. Animals should not be killed for the purposes of education and research.</td>
<td>43%</td>
<td>40%</td>
</tr>
<tr>
<td>2. Dissecting a dead animal or animal parts makes me feel uncomfortable.</td>
<td>5%</td>
<td>26% *</td>
</tr>
<tr>
<td>3. Dissection is an unpleasant activity.</td>
<td>10%</td>
<td>21% *</td>
</tr>
<tr>
<td>4. I am disturbed by the idea of dissecting an animal.</td>
<td>7%</td>
<td>19% *</td>
</tr>
<tr>
<td>5. I learn better when I use computer programs about anatomy than when I do dissections.</td>
<td>2%</td>
<td>62% *</td>
</tr>
<tr>
<td>6. I think computer programs that teach anatomy are more exiting than dissections.</td>
<td>2%</td>
<td>24% *</td>
</tr>
<tr>
<td>7. My science class would be more enjoyable without dissection.</td>
<td>10%</td>
<td>19%</td>
</tr>
<tr>
<td>8. Teachers shouldn’t spend class time or money on dissections.</td>
<td>10%</td>
<td>17%</td>
</tr>
<tr>
<td>9. The only reason I participate in dissections is because my grade will be affected.</td>
<td>24%</td>
<td>31%</td>
</tr>
<tr>
<td>10. There are better ways to learn about anatomy than doing dissections.</td>
<td>24%</td>
<td>21%</td>
</tr>
</tbody>
</table>

* discussed on page 47
Table 8 shows the percentages of students who agreed with the pro-dissection statements for the control and experimental groups. In Table 8, the percentages of agreeable responses to all pro-dissection statements range from 67-98% for both groups. Students from the control and experimental groups expressed similar feelings for many of the statements. The statements in which there are noticeable differences in responses are statements 1, 2, and 6. More students from the control group expressed that dissecting is fun and interesting and that they feel as though traditional dissections are valuable learning experiences.
<table>
<thead>
<tr>
<th>Statement</th>
<th>% Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Dissecting is fun.</td>
<td>95% *</td>
</tr>
<tr>
<td>2. Dissections make science more interesting.</td>
<td>95% *</td>
</tr>
<tr>
<td>3. I believe dissection is an effective way to study the anatomy of an animal.</td>
<td>74%</td>
</tr>
<tr>
<td>4. I believe dissection is an effective way to study the parts and functions of an animal.</td>
<td>81%</td>
</tr>
<tr>
<td>5. I feel comfortable with doing dissections.</td>
<td>83%</td>
</tr>
<tr>
<td>6. I feel like I learn from dissections.</td>
<td>98% *</td>
</tr>
<tr>
<td>7. I will remember my experiences dissecting more than any other thing I've done this year in science.</td>
<td>83%</td>
</tr>
<tr>
<td>8. I would rather dissect real animals or animal parts than use a computer program.</td>
<td>74%</td>
</tr>
<tr>
<td>9. I've been looking forward to dissecting all year.</td>
<td>90%</td>
</tr>
<tr>
<td>10. Learning about the anatomy of animals through dissections will help me learn about the anatomy of humans.</td>
<td>71%</td>
</tr>
</tbody>
</table>

* discussed on page 49
Summary of Findings

The results of the t-test and Cohen's d indicated that there was neither a statistically nor educationally significant difference in student achievement when students performed a traditional dissection or used the Froguts interactive computer software. The tests indicated that there was a significant difference in student attitudes between the two groups.

The survey results showed that most students responded similarly to all the statements. There were several differences in the percentages of student responses. The majority of students from both groups responded positively to pro-dissection statements.
CHAPTER FIVE

CONCLUSION

Discussion of Findings

Effects on Student Achievement

The mean of the achievement test for the control group was slightly higher than the mean for the experimental group. The difference however was not statistically significant according to the t-test results \((t = -0.9, \, df = 82, \, p > 0.05)\), nor educationally significant according to Cohen’s \(d\) \((d = -0.19)\). Therefore the null hypothesis was accepted.

When the goal of dissection is student achievement both methods of dissection are equally effective in teaching students the anatomy of the frog. These results confirm the results from two studies mentioned in the literature review. According to Kinzie, Strauss and Foss (1993) and Kinzie and Strauss (1994), there was no significant difference in student achievement between the traditional dissection and interactive alternative dissection.
Effects on Student Attitude

The mean of the attitude survey for the experimental group was higher than the mean for the control group. These results indicate that the experimental group had a more negative attitude toward traditional dissection than the control group. The results of the t-test for independent means indicated that the difference between the means was statistically significant ($t = 2.47$, $df = 82$, $p < 0.05$). The results of Cohen’s $d$ indicated a medium significance between the means ($d = 0.54$). Therefore the null hypothesis was rejected and the alternate hypothesis accepted.

The type of dissection students complete affects their attitude toward traditional animal dissection. More students from the experimental group expressed uncomfortable and unpleasant feelings towards dissection, while more students from the control group were positive about traditional dissection. Students from both groups indicated that the type of dissection they experienced (traditional or alternative) was more effective in teaching them the anatomy of a frog, although results from the achievement test indicate that the dissection method used
does not effect student achievement. Overall, the
students’ attitudes towards traditional dissection were
positive.

Implications for Science Teaching

Effectively teaching the anatomy of a frog can be
accomplished by using traditional animal dissections or
computer simulation dissections. If traditional dissection
is the activity preferred by educators, then it is
recommended that traditional dissections be structured
appropriately so that meaningful learning can take place
(Hertzfeldt, 1994; Solot & Arluke, 1997; Long, 1997). If
the learning goal is teaching students dissection skills,
then traditional dissection is considered the only
effective method (Quentin-Baxter & Dewhurst, 1990). The
majority of students enjoy traditional dissections,
claiming that the hands-on activity was fun, interesting,
and memorable. Students prefer setting up, handling, and
observing actual organisms (Leonard, 1989).

Interactive dissection software used as a substitute
for traditional dissection can teach the anatomy of a frog
just as effectively as traditional dissections. There is
no difference in student achievement between the two types of dissections. However, it is recommended that electronic equipment be available to all students ensuring equal access to the computer program for all students. During achievement assessments, it is recommended that the same images seen by the students (either a real or virtual image) be used on the test (Kariuki & Paulson, 2001). Using computer simulations may promote negative feelings toward traditional dissections. However, students are just as interested if not more interested in the computer simulation as they are in the traditional dissection. This may be due to the technologically advanced software that was chosen for this particular study. Froguts' appealing graphics and interactive functions may have influenced students' positive attitudes toward the program, producing a "halo" effect. The interactive computer software is also a very effective preparation tool for traditional dissections according to Kinzie, Strauss, and Foss (1993).

Limitations Evident Within the Study Design

The results may have been affected by several limitations within the design of the study. First, the
Timing in which the study took place presented built-in distractions of a holiday week and end-of-the-school-year activities. If the study could be repeated, it would be executed several months before the end of a school year.

The sample class periods of the population were not random. There were four class periods selected out of the single teacher's five class periods. One of the classes contained students with minimal English language skills. Results may have been different if the sample was from a larger random population of students.

Students in the sample were informed that everyone would have the opportunity to participate in either type of dissection after the study was over. This may have influenced how the students approached the achievement test and attitude survey. Results may have been different if the opportunity was not presented.

Suggestions for Further Research

As recommended by much of the research, further investigations and studies are needed in the comparison between traditional animal dissection and computer simulation dissection. More research should be done using
Froguts as the alternative to traditional dissection with different student populations. Dissecting skills should be used as a variable in comparing the effectiveness of traditional dissection and interactive computer software as a substitute for dissection. Research has only been completed comparing the dissecting skills of students who performed a traditional dissection with or without using an interactive videodisc as a preparation tool.

Another study could investigate the influence of the teacher’s attitude regarding traditional dissections on corresponding student attitudes and motivation. During this study, the teacher had a positive view towards dissection. This may have influenced the attitudes of the students. It would also be interesting to investigate students’ attitudes toward science and determine if there is a correlation between their general opinion of the subject and their views on dissection. A study could also investigate the influence of a first language other than English and cross-cultural studies with Native American populations who in many cases have a different perception of animals in their culture.
APPENDIX A

INFORMED CONSENT FORM
Dear Parent or Guardian,

Your child is being asked to participate in an educational research study. The study is being conducted by your child’s science teacher, Elisabeth Kiehl, under the supervision of Dr. Herb Brunkhorst, Department Chair of Science, Math and Technology Education at California State University, San Bernardino. The study has already been approved by the Institutional Review Board at the university.

The purpose of this study is to examine the effectiveness of virtual lab dissections in the middle school science classroom. During my time as a science teacher, I have used preserved animal dissections to teach students about the organs and organ systems in the human body. It has always been my perception that students look forward to the dissections every year. However, dissections present several problems; the materials are costly, the dissection tools need to be maintained and updated, and on rare occasion, students absolutely refuse to participate in the dissection due to their values and/or belief systems. Therefore, I have looked into dissection alternatives. One dissection alternative that is well made and realistic is an interactive virtual dissection. It allows students to perform the dissection while learning about each part of the specimen. This research study will compare the effectiveness of the interactive virtual dissection in teaching students about the structure and function of the frog versus a traditional frog dissection. The study will also inquire about the attitudes of the students after participating in either dissection.

The study will take place from May 29th to June 8th. Your child will participate in the study by either dissecting a preserved animal or using an interactive virtual dissection. After the dissection, they will take a test that will determine how much they learned from either method of dissection. They will also complete a survey about their attitudes toward dissecting. The students’ names will be kept confidential throughout the study. To treat students fairly, all students will have the opportunity to complete either method of dissecting after the study is complete. There will be no risk to the students or to their grades. Your child’s participation in this study is voluntary. They will not be penalized if they refuse to participate. Students who choose to participate may discontinue the study at any time. Alternative arrangements can be made for non-participants.

If you have any questions regarding the educational research study, please contact Mrs. Kiehl by phone at (951) 351-9216 or by e-mail at elisabeth.kiehl@alvord.k12.ca.us. Please fill out the portion below and return to Mrs. Kiehl by May 25th. Thank you.

Mrs. Kiehl
Science Teacher

☐ Yes, I consent for my child to participate in the educational research study mentioned above. I understand and agree to the above description and conditions of the study.

☐ No, I refuse to allow my child to participate in the educational research study mentioned above.

Child’s Name: _____________________________ Class Period: _________

Parent’s Name: _________________________________

Parent Signature: _____________________________ Date: ____________
APPENDIX B

FROG DISSECTION HANDOUT
FROG DISSECTION

External Anatomy
1. What does the skin absorb? ________________________________
2. What is the function of the nictitating membrane? ________
3. What is the function of the nostrils? _______________________
4. What does the tympanum do? ______________________________
5. How do you tell a male frog from a female frog? ______________
6. Which side of the frog is shown when the belly is up? _________
7. DRAW what a male frog looks like on the outside labeling its thumb, nostrils, nictitating membrane and tympanum. Also, point to and label the ventral side of the frog.

Circulatory System
8. What do arteries do? ________________________________
10. How many chambers does the heart have? _____________
11. DRAW what the heart looks like in the space provided. Label the left atrium, right atrium and ventricle.

Respiratory System
12. How many different ways does a frog breathe? _____________
13. What is the function of the lungs? _________________________
14. DRAW what the lungs look like in the space provided.
Digestive System
15. After the mouth the food goes down a long tube called the ___________________.
16. What is the function of the stomach? ________________________________

17. What is the function of the liver? ________________________________
18. What is the function of the gall bladder? ________________________________
19. What is the function of the pancreas? ________________________________
20. What is the function of the small intestine? ________________________________
21. What is the function of the large intestine? ________________________________
22. Where do leftover feces exit? ________________________________
23. DRAW all the parts of the digestive system in the space provided and label the following: esophagus, stomach, small intestine, large intestine, cloaca, liver, pancreas, and gall bladder

Urogenital System
24. What is the function of the kidneys? ________________________________
25. What is the function of the testes? ________________________________
26. What is the function of the bladder? ________________________________
27. What is the function of the ovary? ________________________________
28. Where do the eggs, sperm and urine exit out of the frog? ________________________________
29. DRAW what a male looks like inside. Be sure to label the kidneys, testes, bladder and cloaca.

Nervous System
30. What is the function of the cerebrum? ________________________________
31. What is the function of the cerebellum? ________________________________
32. DRAW what the brain looks like in the space provided.
APPENDIX C

ACHIEVEMENT TEST
FROG DISSECTION TEST

1. True/False: The frog’s dorsal side is currently facing up.
   a. True
   b. False

2. True/False: The frog shown is a male.
   a. True
   b. False

3. Flag A is pointing to the largest organ in the frog called the
   a. gall bladder
   b. heart
   c. stomach
   d. liver

4. The function of the organ indicated by Flag A is to...
   a. produce bile.
   b. store bile.
   c. pump blood.
   d. produce sperm.

5. Flag B is pointing to which organ?
   a. larynx
   b. lungs
   c. heart
   d. gall bladder

6. How many chambers does the organ indicated by Flag B have?
   a. 2
   b. 3
   c. 4
   d. 5

7. Flag C is pointing to which organ?
   a. pancreas
   b. liver
   c. skin
   d. lungs
8. True/False: The organ indicated by Flag C is the **only** place in the frog’s body where carbon dioxide is exchanged for oxygen.
   a. True
   b. False

9. Flag D is pointing to which organ?
   a. heart
   b. pancreas
   c. stomach
   d. testes

10. The function of the organ indicated by Flag D is to...
    a. absorb water.
    b. produce bile.
    c. store bile.
    d. break down food.

11. Flag E is pointing to which organ?
    a. kidneys
    b. testes
    c. ovaries
    d. lungs

12. The function of the organ indicated by Flag E is to...
    a. produce urine.
    b. produce digestive enzymes.
    c. produce sperm.
    d. produce blood.

13. Flag F is pointing to which organ?
    a. stomach
    b. small intestine
    c. large intestine
    d. pancreas

14. True/False: The organ indicated by Flag F empties its contents out of the cloaca.
    a. True
    b. False

15. Flag G is pointing to which organ?
    a. gall bladder
    b. kidneys
    c. heart
    d. stomach
16. The function of the organ indicated by Flag G is to...
   a. produce bile.
   b. store bile.
   c. store urine.
   d. produce digestive enzymes.

17. Flag H is pointing to which organ?
   a. stomach
   b. small intestine
   c. large intestine
   d. cloaca

18. The function of the organ indicated by Flag H is to...
   a. produce bile.
   b. absorb water.
   c. filter blood.
   d. absorb nutrients.

19. Flag I is pointing to which organ?
   a. kidneys
   b. pancreas
   c. testes
   d. gall bladder

20. The function of the organ indicated by Flag I is to...
   a. produce sperm.
   b. pump blood.
   c. produce bile.
   d. filter blood.
APPENDIX D

ATTITUDE SURVEY
**DISSECTION SURVEY**

Directions: After reading each statement, please decide how much you agree or disagree with each statement. Choose the letter that matches with your opinion. There are no right or wrong answers. You may only choose one letter.

<table>
<thead>
<tr>
<th></th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral (Does not apply)</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Animals should not be killed for the purposes of education and research.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>2. Dissecting a dead animal or animal parts makes me feel uncomfortable.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>3. Dissecting is fun.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>4. Dissection is an unpleasant activity.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>5. Dissections make science more interesting.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>6. I am disturbed by the idea of dissecting an animal.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>7. I believe dissection is an effective way to study the anatomy of an animal.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>8. I believe dissection is an effective way to study the parts and functions of an animal.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>9. I feel comfortable with doing dissections.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>10. I feel like I learn from dissections.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
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<td></td>
</tr>
<tr>
<td>11. I learn better when I use computer programs about anatomy than when I do dissections.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>12. I think computer programs that teach anatomy are more exciting than dissections.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>13. I will remember my experiences dissecting more than any other thing I’ve done this year in science class.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>14. I would rather dissect real animals or animal parts than use a computer program.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>15. I’ve been looking forward to dissecting all year.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>16. Learning about the anatomy of animals through dissections will help me learn about the anatomy of humans.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>17. My science class would be more enjoyable without dissection.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>18. Teachers shouldn’t spend class time or money on dissections.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>19. The only reason I participate in dissections is because my grade will be affected.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>20. There are better ways to learn about anatomy than doing dissections.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
</tbody>
</table>
REFERENCES


