

Which Comes First: Computer Simulation of Dissection or a Traditional Laboratory Practical Method of Dissection

by

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Introduction

Computer simulation has put a new whole spin on science education reform act, redefining the role of teachers and reshaping the classroom learning experience according to National Science Education Standard (NSES) and the National Science Teachers Association (NSTA) (2001). The use of computer simulation tasks to enhance learning in the science classroom either before or after completion of a didactic unit of instruction have become the focus of most recent research studies (Akpan, 2001; Brant, Hooper, & Sugrue, 1991). Science simulations can be an extremely effective tool in helping students understand and experience practical applications of scientific thinking (Akpan, 2001; 1999; Akpan & Andre, 2000; Coleman, 1998). A simulation is a dynamic execution of the processes within a relational model system of an object (Akpan, 2001; Miller & Castellanos, 1996). A computer is not necessary to create a simulation; the technology creates powerful possibilities for the representation and manipulation of relational model systems (Akpan & Andre, 2000; McKinney, 1997).

The present study was designed to examine the impact of using a computer simulation model of an earthworm dissection as a preliminary experience to an actual dissection. To assess whether a simulation used before actual dissection could improve learning of anatomy and physiology is important in generalizing the finding to a technology that is becoming widely available in U. S. classrooms.

Thomas and Hooper (1991) describe a simulation as a computer program containing a manipulable model of a real or theoretical system. The program enables the students to change the model from a given state to a specified goal state by directing it through a number of intermediate states. Thus, the simulation program accepts commands from the user, alters the state of the model, and when appropriate displays the new state. Piagetian theory argues that knowledge is constructed through action. As children exercise existing mental structures in particular environmental situations, accommodation-motivating disequilibrium results and the children construct new mental structures to resolve the disequilibrium (Piaget, 1954). Von Glasersfeld, (1999) adapted Piagetian theory into the idea that learning requires experiences at an enactive level before iconic and symbol experiences can become meaningful. Klausmeier and Allen (1978) argue that conceptual development in a child proceeds through a series of two stages of understanding that involve experiences followed by formal symbolic understanding. Andre (1986) argued that developing effective problem-solving

schemata required appropriate experiences to promote the development of the conditional or pattern recognition component of a schemata. This developmental psychology held that knowledge is not a copy of reality, and only knowledge production reinforce the endogenous nature of knowledge. In other word to know an object is to act on it, to transform it, and to understand the nature of the transformation.

The constructivist position that students should have access to multiple viewpoints and representations for information is partially satisfied by well-constructed simulations (Von Glasersfeld, 1999; Pintrich et al., 1993; Schommer, 1993a & 1993b; Gardner, 1993 & 1994). Thus, simulations provide a potential means of providing students with experiences that facilitate conceptual development. According to Akpan (2001), simulations should be designed with the purpose of immersing students into real-life science encounters that require hands-on activities, higher-order thinking, and collaborative problem solving. Thomas and Hooper (1991) developed a useful taxonomy of uses for simulations and evaluated the effectiveness of simulations with respect to these uses. The first category, experiencing, describes cases in which simulations precede formal instruction, and are used to set the stage for future learning. Experiencing is useful for providing motivation, providing concrete examples, providing an organizing structure, and exposing misconceptions. The second taxonomic category is informing. This use of simulations is simply for the delivery of information, and few learning benefits were found for students using simulations in this manner as compared with the use of computer tutorials, or direct instruction. The third category, reinforcing, is described as the strengthening of learning objectives. The criteria for simulations classified as being used for reinforcing is that they direct the student to apply existing knowledge in the same context it was learned. As with informing, few learning benefits were found for students using simulations in this manner. Using simulations to give initial exposure to students about a concept (experiencing) and using simulations to integrate knowledge and stimulate problem solving behaviors (integrating) seem to be the two most promising classroom applications.

As with many simulations based learning tools, much of the early research on simulations focused on whether or not students could learn from them. Simulations were compared in their effectiveness to non-simulation based media or no instruction at all. In a review of simulation research, Brant, Hooper and Sugrue (1991), using a genetics simulation prior to formal instruction resulted in significantly higher achievement than using the same simulation after formal instruction. Using simulations to give students initial exposure about a concept (experiencing) and using simulations to integrate knowledge and stimulate problem-solving behaviors (integrating) seem to be the most promising classroom applications of simulations in science classroom. When the didactic instruction provides information that relates to the simulation experiences, students may form a meaningful associative link between the instructional information and the experience. Thus a simulation provided before lecture instruction may function as a conceptual change (Gorsky & Finegold, 1992) that allows students to better understand and encode the lecture presented information. In this context the simulation is used as a scaffold (Akpan, 2001). Such students may be better able to recall the lesson presented didactically and reason with the principles taught in

transfer situations than those students who experience simulation after lecture instruction may not have a meaningful model with which to assimilate the instructional information.

Research on how and when simulations are used with respect to other elements (didactic instruction, collaboration, lab experiences, assessment) in instruction is helping to clarify how simulations can be used for maximum effect in the classroom. Also, the effects of keeping students on task using computer simulation either before or after completion of a lecture of instruction have been the focus of a number of research studies (Hooper, 1986; Brant, Hooper, & Sugrue, 1991). Tylinski (1994) had students complete simulation of an earthworm dissection when using either the computer simulation dissection or the traditional hands-on dissection approach. In these studies, students who used traditional hands-on method of dissection did significantly better on the post-treatment measure than the students who performed the dissection using the computer simulation. Brant et al. had students complete a genetics simulation on pig breeding either before or after receiving lectures on genetics in animal breeding. The results of this study indicated that students who received the simulation before lecture instruction performed better on transfer and application posttest measures than students who received the simulation after lecture instruction.

Appropriate use of computer simulations either before or after may help students experience actual dissection, by learning more about physiological system of an earthworm, experience disequilibrium with their current conceptions, and accommodate new conceptions (Gatto, 1993; Quinn, 1993; Woolf & Hall, 1995; Magnusson & Palincsar, 1995; Gokhale, 1996; Roblyer et al., 1997). If in fact computer simulation aside from increasing students interest and motivation, simulation before traditional hands-on dissection provides an experiential base with which new information can be associated or experiences which challenge student prior alternative conceptions, then students who receive the simulation before hands-on dissection should recall more information presented during subsequent dissection than do students who use traditional hands-on dissection after computer simulation instruction. In the current study, students completed computer simulation of earthworm dissection before or after actual hands-on dissection.

Based on the results obtained by (Akpan, 2001, 1999; Akpan & Andre, 2000; Brant et al., 1991) and the theoretical analysis presented above, if computer simulations provide an experiential base or challenge pre-conceptions, then students who engaged in a simulation of dissection before would learn and perform better in the dissection achievement posttest than students who engaged in the dissection before simulated dissection. If simulations act as a motivator, then no difference in posttest achievement between groups who complete computer simulation of dissection before or after actual dissection would be predicted. Therefore, the present study provides a good test of the motivational and conceptual hypotheses; if the simulation functions by providing an effective experiential base or challenges misconceptions, an interaction between computer simulation and position of computer activity before or after dissection is predicted. If computer simulation of dissection activity before actual dissection functions as a motivator, participants who complete either computer activity before performing actual dissection would perform better on posttest than

participants who complete a traditional hands-on dissection before computer simulation of dissection, but no interaction should be expected between the groups and sequence of activity.

In a particularly intriguing study relevant to the issue of dissection, Kinzie, Struss, and Foss (1993) compared the achievement of students who conducted a frog dissection either with or without the use of an preparatory interactive video (IVD) simulation. The participants, 61 high school students enrolled in a general biology class, were divided into four approximately equal groups. The IVD prep group used the interactive video-based simulation as a preparation for the laboratory dissection, which they then performed. The video prep group viewed linear videotape containing the same video materials used in the IVD simulation as a preparatory experience. The dissection-only group conducted the dissection without preparation. The IVD-only group used the IVD simulation but did not dissect. The results indicated that students in the IVD prep group performed the dissection more effectively than those students who received no preparation and more effectively than students whose preparation consisted of viewing the linear videotape (as assessed by classroom observers) than students in the video pre group. It is possible that the interactive video preparation assisted the students' dissection efficiency more than the other treatments due to the increased length of time the students interacted with the IVD system over the videotape. The researchers suggested that this factor should not be considered since "identical video materials were displayed in both treatments, [therefore] the time differential was due to solely to the interactive practice activities contained in the dissection simulation" (p.998).

The present study was designed to examine the issues surrounding the cognitive learning effectiveness, motivational and engagement of a computer simulation by comparing students who completed a computer simulation of dissection before actual hands-on dissection to students who completed a traditional hands-on style method of dissection before computer simulated dissection. The computer simulation of dissection is used as an alternative delivery technique in order for the students to understand the physiological systems of an animal. Supporters of simulation cite that simulations may also be a replacement for the traditional methods of instruction that educators find are no longer acceptable to the values of society or as being offensive to their students ethical values, such as, the use of animals for dissection during the study of the physiological systems of animals. It has been realized through research that a variety of activities must be experienced by learners to provide for individual optimal progress.

Generally, simulations give students an opportunity to apply their learning to a pseudo-real-life situation (Schacter, 1999). Use of simulation programs to supplement traditional classroom lectures is purported by some researchers to increase interest, motivation, and retention, as well as to improve higher order thinking and reasoning skills (Gokhale, 1996; Hogle, 1996; Schacter, 1999 & Tennyson, 1989). Usually, a simulation will require the students to perform application, analysis, and synthesis-level activities (Schacter, 1999; Gokhale, 1996). There is evidence that simulations enhance student's problem-solving skills by giving them an opportunity to practice and refine their higher-order thinking strategies (Quinn, 1993). Computer simulations were found to be effective in stimulating environmental problem solving by community college students (Faryniarz & Lockwood,

1992). In particular, simulation exercises based on the “guided discovery” learning theory were found to be motivating, to expose misconceptions and areas of knowledge deficiency, to assist in integrating information, and to enhance transfer of learning (Akpan, 2001; Mayer, 1992). In three studies, students using the guided version of simulation surpassed unguided students on tests of scientific thinking and a test of critical thinking (Rivers & Vockell, 1997). As a result of implementing properly designed simulation either before or after activities, the role of the teacher changes from a mere transmitter of information to a facilitate of higher-order thinking skills (Woolf & Hall, 1995; Queen, C. N. 1993).

Reality-based-content and information received immediately usually provides its own motivation for students. Akpan (2000) suggest that simulation may offers an advantage over natural events in that simulation brings a sense of immediacy to the learning task and may challenge the students to participate more actively. Simulations pursue answers to sequential problems. According to Akpan and Andre, (2000, 2001), simulations can provide a model whereby students play a role and interact with the computer. Computer simulations, specifically used to replace the use of specimens in dissection, could be used without losing the goals of pertinent teaching objectives. Simulation experiences provide the opportunity for students to see certain processes that happen “too quickly” or “too slowly” in real life and enable them to use cognitive strategies and logical thinking skills.

Females performed significantly differently than the males in the “Short Answer” section of the pre/posttest. Differences between the genders in science achievement and science interest are greatest in the area of physical science (Kahle & Meece, 1994). The present study focused on biological content. Procedures that are effective for one gender may not work the same for the other gender (Akpan, 1999). In the Tylinki (1994) study the results showed that there was no significant difference in the learning patterns by gender when using either the computer simulation or the traditional hands-on method of dissection. The lack of gender differences found in the Tylinki study is not necessarily predicted in the current study. In addition to the physiological differences that exist between males and females, some cognitive differences appear as well. According to Kahle, Meece, (1994) and Dresel et al., (1998) “males seem to perform better on tests of mathematical reasoning and visual and spatial problems; females tend to excel in tasks involving verbal abilities.” Naglieri, Rojahn, and Johannes (2001), supported these differences in cognitive abilities, but suggest that part of the lack of scientific ability for females may be due to cultural values, societal expectations, and sex-role stereotypes.

According to Coleman (1998), “Current evidence favors the idea that the capacity to solve formal operational problems develops equally in males and females, but the realization of this ability in solving particular problems depends upon a person’s past experience” (p. 56). The use of computer simulation equalizes learning opportunities and expands learning challenges for a wide range of students. Using compelling classroom footage, simulation features innovations that are empowering to all types of learners. According to Magnusson and Palincsar (1995), simulations are seen as a powerful tool to teach not only the content but also thinking or reasoning skills necessary

to solve problems in the real world. This study was designed to determine whether the effectiveness of simulations in improving students' actual dissection performance and learning of anatomy and physiology of earthworm dependent upon the sequence in which simulation activity is presented.

Method

Participants

The participants were 95 students (49 males, 46 females), ranging in age from 14-15, enrolled in ninth-grade life science freshmen biology course in a mid-size, mid-Eastern, high school of 679 students. These students had some prior experience in animal dissection, but had no experience in the use of a simulated interactive dissection. These students participated in the study as part of a normally scheduled laboratory involving earthworm dissection. Because it was a regularly scheduled class activity, all students in the classes participated in the activity. All ninety-five participants in academic biology classes volunteered to participate in the study as well as completed a pretest and posttest. The data from those students who signed, and whose parents returned, permission slips were used in this study.

Design

The study used intact classes and was randomly assigned to their classes at the beginning of academic school year in a manner to roughly equalize ability across sections. The basic design was a two group pre-treatment and post-treatment comparison using the traditional wet lab hands-on method of dissection as the control treatment before or after students used the interactive computer simulation of dissection as the experimental treatment.

Materials

Dissection

An annelid (*Lumbricus Terrestris*), most common earthworm in the United States was used for the actual dissection. The participants were given the instruments typically used for dissections: for example, blunt probe, scissors, scalpel, needle probe, forceps, dissection pan, surgical gloves, goggles, and ward safe preservative.

Objectives for the traditional dissection

The dissection activity had the overall goal of helping students actively involved in learning to recognize, identify and describe the function of each anatomical structure and physiological functions of an earthworm. It was important for the validity of the study that the traditional hands-on curriculum paralleled the computer simulation curriculum specially for middle school students, by using the same descriptors for the body parts of the earthworm and the descriptors of their functions

as was listed in the middle school curriculum. In order to meet this goal five science educators in the field standardized the names and functions to be studied in the traditional hands-on dissection, with the terminology used in the computer simulation.

Computer Simulation of Dissection

The Earthworm Software, an interactive computer simulation of an earthworm dissection, was supplied by Carolina Biological Company. The software simulates, on a screen, an actual earthworm dissection. It also incorporates QuickTime movies and microscopic pictures to illustrate functions that are normally hidden from view. The software allowed the students to review the structures and functions and to read detailed descriptions that explained the physiological functions of the structures within the anatomy of the earthworm. It reinforces learning with a review quiz after presenting each system. In the quiz, the participants matched the function to the structure.

Simulation of dissection goals

The main instructional goals and objectives of the interactive computer program was to provide a system for identifying and matching invertebrate anatomical structures and functions of the earthworm similar to the curriculum requirements established for the hands-on dissection. The purpose was to help students learn lower order cognitive skills. The computer simulation program graphically represented structures and functions of the earthworm synonymous with the structures and functions the students would be looking for in the hands-on dissection. The program provided on-line reference material pertaining to the anatomical structures of the earthworm and their functions.

Earthworm achievement test

The same test was used as a pretest and posttest. This test consisted of 22-items (fill in the blank, matching, and short answer). The instrument was developed and tested for validity and reliability by five experts in the field of Biology from my school district. The test had been reviewed by three members of the high school science department who had taught the academic biology course for a combined total of 20 years. Ten fill in the blank questions focused on earthworm internal physiological organ functions and ten matching questions were related to functional knowledge of earthworm anatomy and physiology. Two short answer questions were strictly identification related to the earthworm adaptations.

Procedure

The setting for the study was a high school in a mid-size, mid Eastern school district with approximately 679 students. The participants were told of the experiment four weeks prior to the dissection and simulation experiences and completed the anatomy physiology pretest at this time.

Dissection control session

The control groups (one per class section) used the traditional hands-on method for dissecting the earthworm. The control and experimental groups were supervised by a experienced biology teacher. The participants in the control group performed their dissection in a standard typical biology classroom. The posttest was administered the same day after the dissection was completed.

Simulation experimental session

The experimental groups (one per class section) used the computer simulation software as their delivery technique for dissection. The subjects in the experimental group were assigned to a computer lab. The posttest was administered the same day after the dissection was completed.

Results

This experiment compared the learning effectiveness of an interactive computer simulation of dissection with a classroom, hands-on dissection lesson. Using a randomized design model, the students were randomly placed in one of the two treatments. Each group was administered two instruments both before and after treatment to determine the effects of each treatment. In total, 95 students completed both the pre and posttest. Each class section consisted of a control and experimental group.

The gender makeup of the total group was evenly split. Table 1 presents the breakdown of male and female as well as the control and experimental groups.

Table 1
Number of students by group

	Male	Female
Section 1 Control	8	11
Section 1 Experimental	15	11
Section 2 Control	10	14
Section 2 Experimental	16	10
Total Students	49	46

Comparing the total number of correct responses revealed the Experimental Group had more correct responses than the Control Group on both the Pretest and Posttest. When individual Pretest sections were compared, the Experimental Group had 11 more correct answers for the "Fill in the Blank section", 1 more correct answer for the "Matching section", but the Control Group had 6 more correct answers for the "Short Answer section".

The Posttest scores revealed the Control Group had 21 more correct answers for the "Fill in the Blank section", while the Experimental Group had 53 more correct answers for the "Matching section" and 8 more correct answers for the "Short Answer section". Table 2 presents the number of correct responses for pre and posttest results.

Table 2
Number of correct responses

	Pretest		Posttest	
	Control	Experimental	Control	Experimental
Fill in the Blank	66	87	309	288
Matching	96	97	338	391
Short Answer	12	6	70	78
Total Correct Answers	174	190	717	757

Differences between the two conditions on the pretest and posttest were assessed by a t-Test. There were no significant differences found between the "Fill in the Blank" and the "Matching" sections. A significant difference was found for the "Short Answer" section.

Table 3 presents the means for the pretest and posttest.

Table 3

Cell Means, F-Ratios, P-Values, and Standard Deviations for Each of the Variables for Each of the Conditions

Factors	Control (N = 43)	Experimental (N = 52)	F-ratio	P-value
Pretest				
Fill in the Blank M ^a	1.53	1.67	-.316	.529
SD ^b	2.28	1.98		
Matching	2.23	1.87	.805	.300
	2.03	2.35		
Short Answer	.28	.12	1.84	.000*
	.50	.32		
Posttest				
Fill in the Blank	7.19	5.54	.772	.416
	2.22	2.62		
Matching	7.86	7.52	.772	.511
	2.09	2.19		
Short Answer	1.63	1.50	1.011	.185
	.58	.64		

^aMean

^bStandard Deviation

(* Significance level $P < 0.05$)

Differences between gender on the pretest were assessed by a t-Test. A significant difference was observed for the "Short Answer" section. Female respondents performed better than the males on the "Short Answer" section. No differences were observed for the other two sections.

Differences between gender on the posttest were assessed by a t-Test. A significant difference was observed for the "Short Answer" section. Female respondents performed better than the males on the "Short Answer" section. No differences were observed for the other two sections. Table 4 presents the means for the pretest and posttest.

Table 4

T-Test Analyses Between Respondent Means Grouped by Gender

Factors	Male (N = 49)	Female (N = 46)	t-value	P-value
Pretest				
Fill in the Blank M ^a	1.37	1.87	-1.161	.302
SD ^b	1.82	2.37		
Matching	1.94	2.13	-.421	.720
	2.31	2.11		
Short Answer	.12	.26	-1.599	.001*
	.33	.49		
Posttest				
Fill in the Blank	6.18	6.39	-.392	.922
	2.57	2.59		
Matching	7.67	7.67	-.001	.089
	2.32	1.96		
Short Answer	1.37	1.76	-3.314	.000*
	.67	.48		

^aMean * Significance level P<0.05)

^bStandard Deviation

A paired t-Test was conducted between respondent pre and posttest scores. There were significant differences found in all three areas of the test. Table 5 presents the means.

Table 5

Paired T-Test (t-Test) Analyses Between Respondent Pre and Post Scores

Test Section	(M) Mean	Standard Deviation	t-value	P-value
Fill in the Blank				
Pre	1.61	2.11	-15.08	.000*
Post	6.28	2.57		
Matching	2.03	2.21	-19.39	.000*
	7.67	2.14		
Short Answer	.19	.42	-20.42	.000*
	1.56	.61		

(* Significance level P<0.05)

Discussion

Dissection by high school students has long been a rite of passage in biology classes. It has been the standard instructional techniques for teaching the anatomy of organisms. However, are there alternative methods, which can serve as substitutes for dissection with equal or better student achievement? Computer simulation of dissection has the ability to put learning experiences which were, previous to the use of this technology, too expensive, dangerous, remote, or time consuming at the beck and call of the science instructor. Simulations ability to present realistic visuals and diagrams combined with the computer's capability to create a branching learning path makes it one of the most adaptable technologies used up to this point. This comparison study investigated student learning from a standard Fill in the Blank, Matching and Short Answers paper and pencil test, both before and after the treatments, and their attitudes on the experience.

The results of this research study supported the theory that prior use of a simulation before dissection can improve learning. This present study assessed a combination of both lower and procedural order of learning using computer simulation of an earthworm dissection. The experimental condition that completed the simulation activities before the actual hands-on dissection performed significantly better on Short Answers posttest performance than control condition. See table 2. Comparing the total number of correct responses revealed that Experimental Group had more correct responses than the Control Group on both the Pretest and Posttest. When individual pretest sections were compared, the Experimental Group had 11 more correct answers for the "Fill in the Blank section", 1 more correct answer for the "Matching section", but the Control Group had 6 more correct answers for the "Short Answer section".

The Posttest scores revealed the Control Group had 21 more correct answers for the "Fill in the Blank section", while the Experimental Group had 53 more correct answers for the "Matching section" and 8 more correct answers for the "Short Answers section". Table 2 presents the number of correct responses for pre and posttest results. The results of this research study supported the findings of Akpan and Andre, (2000, 2001; Hooper, and Sugrue 1991), that the effectiveness of simulations is dependent upon the sequence of presentation of learning activities to students. The treatment group that completed the simulation activities before the actual traditional practical hands-on dissection performed significantly better on the achievement posttest and dissection performance test than either of the other groups. This result is consistent with those obtained by Brant et al, (1991), who found that presenting a genetic simulation before lecture enhanced learning more than the same simulation presented after lecture. The results are also consistent with those of Kinzie et al, (1993) who compared the achievement of students who conducted a frog dissection with and without the use of an interactive video-based simulation used as a preparatory experience for the actual frog dissection. As in the present study, their results indicated that students in the interactive video simulation preparation group scored significantly higher on the posttest achievement measures than did other three conditions.

The results of this study revealed slight differences in the post-treatment scores between males and females. Differences between gender on the posttest were assessed by a T-Test (t-Test). A significant difference was observed for the “Short Answers” section only than the other two sections. Females respondents performed better than the males on the “Short Answers” section than the males participants. These results support the findings of Castleberry, Culp, and Lagowski (1973), Grandy (1971), Castleberry and Culp (1971), and Castleberry and Montague (1970), in which computer instruction used as a supplement to the traditional method, served to enhance achievement more than when the computer was used as a total replacement for the traditional method.

The most intriguing result of the present study was that a simulation used before dissection led to better achievement performance than a simulation used after dissection.

Although, Critics of computer simulation note that it is difficult to assess just what truly has been learned. Simulations represent opportunities to learn about structures and processes. The flexibility of these kinds of environments makes learning right and wrong answers less important than learning to solve problems and make decisions. Simulations promote learning about what-ifs and possibilities, not about certainties. Although some would agree that these learning potentials are valuable aspects of a student’s education, educators are not as skilled at assessing the depth of this kind of student learning as they are in assessing fact and skill knowledge. Until educators become more capable of assessing this type of learning, much of what is learned in a computer simulation will not be visible (Maddux et al, (1997). The finding in this study suggests that computer-based simulations can offer a suitable cognitive and constructive learning environment in which students search for meaning, appreciate uncertainty, and acquire responsibility for their own learning.

Implications

The national effort to modernize education in the science has as one of its goals a valid interpretation of contemporary science and its practice. If American students are to meet the national goal of “best in the world by the year 2006”, one dimension should be that they have the best understanding of how scientific knowledge is currently being produced. To achieve this purpose will require that a science concept be taught in a coactive context by integrating computer simulations into science curriculum that blurs distinction between science and technology. It should also be noted that there are only rare times in which technology does not play a part in generating a new theory, for example, the insights of Watson and Crick in developing the double helix model of heredity, Darwin’s conceptual scheme of organic evolution, and Einstein’s theory of relativity. It is time that schools consider virtual dissection as a viable substitute for using specimens or models or use in combination to help foster students achievement in science education. Calls by animal rights proponents to remove dissection from the high school biology curriculum have prompted instructors to investigate alternatives to dissection. This alternative is computer simulation of dissection. Simulation has the ability to put learning experiences which were, previous to the use of this technology, too expensive, dangerous, remote, or time intensive at the beck and call of the science instructor. Simulations of dissection as alternative to traditional hands-on dissection can be the right

alternative for students or parents with moral ethical objections to animal dissection. Several organizations will provide schools with models and resources free of charge to prevent cruelty to animals in the name of dissection.

References

- Akpan, J. P. (2001). Issues associated with inserting computer simulations into biology instruction: A Review of the Literature. *Electronic Journal of Science Education*, 5(3). Available: <http://unr.edu/homepage/crowther/ejse/ejsev5n3.html>
- Akpan, J. P., & Andre, T., (2000). Using a computer simulation before dissection to help student learn anatomy. *Journal of Computers in Mathematics and Science Teaching*, 19(3), 297-313.
- Akpan, J. P. (1999). The effect of a prior dissection simulation on middle school students' dissection performance and understanding of the anatomy and morphology of the frog. *Journal of Science Education and Technology*, 8(2), 107-121.
- Andre, T. (1986). *Problem solving and education*. In G.D. Phye and T. Andre (Eds.) *Cognitive Classroom Learning*. An Diego: Academic Press, Inc.
- Andre, T., & Haselhuhn, C. (1995). *Mission Newton! Using a computer game that simulates motion in Newtonian space before or after formal instruction in mechanics*. Paper presented at the American Educational Research Association Annual Meeting, (April 1995).
- Brant, G., Hooper, E., & Sugrue, B. (1991). Which comes first the simulation or the lecture? *Journal of Educational Computing Research*, 7(4), 469-481.
- Bourquin, S.D. (1999). The relationship among math anxiety, math self-efficacy, gender, and math achievement among college students at an open admissions commuter institution. (Doctoral dissertation, Ohio University, 1999.) *Dissertation Abstracts International*, 60, 679.
- Bruder, I. (1993). Redefining science. *Electronic Learning*, 12(12), 20-29.
- Bruner, J. (1966). *Toward a theory of instruction*. Cambridge, MA: Harvard University Press.
- Castleberry, S. J., Culp, G. H., & Lagowski, J. J. (1973). The impact of computer-based instruction methods in general chemistry. *Journal of Chemical Education*, 50, 469-476.
- Castleberry, S. J., Montague, E. J. (1970). Computer-based teaching techniques in general chemistry. *Journal of Research in Science Teaching*, 7, 197-208

- Castleberry, S. J., Culp, G. H. (1971). Computer-assisted instruction in undergraduate organic chemistry: An evaluation of selected programs. *Science Education*, 55, 423-430.
- Chambers, J. A., & Sprecher, J. W. (1983). *Computer-Assisted Instruction: Its Use in the Classroom*. Prentice Hall: Englewood Cliffs, New Jersey.
- Chambers, S., & Andre, T. (1992, April). *The relationship of conceptual change text to learning about electricity*. Paper presented at Annual Meeting of the National Consortium for Instruction and Cognition, Chicago, (April 1992).
- Coleman, F. (1998). Using the body electronic: Students use computer simulations to enhance their understanding of human physiology. *Learning and Leading with Technology*, 25(8), 18-21.
- DeVitt, T. (1997). Six reasons to infuse science with technology. *Electronic Learning*, 16(5), 41-46.
- Dresel, M., Ziegler, A. Broome, P. Heller, Kurt, A. (1998). Gender differences in science education: The double-edged role of prior knowledge in physics. *Roeper Review*, 2(2), pp. 101-106.
- Gardner, H. (1993). *Multiple intelligences*. New York: BasicBooks.
- Gatto, D. (1993). The use of interactive computer simulations in training. *Australian Journal of Educational Technology*, 9(2), 144-154.
- Gokhale, A. A. (1996). Effectiveness of computer simulation for enhancing higher order thinking. *Journal of Industrial Teacher Education*, 33(4), 36-45.
- Gorsky, P. & Finegold, M. (1992). Using computer simulations to restructure students' conceptions of force. *Journal of Computers in Mathematics and Science Teaching*, 11, 163-173.
- Hogle, J.G. (1996). Considering games as cognitive tools: In search of effective "Edutainment." (Information Resources Report No. IR019225). (ERIC Document Reproduction Service No. ED425737).
- Kahle, J. B. & Meece, J. (1994). *Research on gender issues in the classroom*. In D. L. Gabel (Ed.), *Handbook of Research on Science Teaching and Learning*, pp. 542-557. New York: Macmillan.
- Klausmeier, H. J., & Allen, P. S. (1978). *Cognitive Development of Children and Youth*. New York: Academic Press.

- Kinzie, M. B., Foss, M. J., & Powers, S. M. (1993). Use of dissection-related courseware by low-ability high school students: A qualitative inquiry. *Educational Technology Research and Development*, 4(3), 87-101.
- Kinzie, M. B., Strauss, R., & Foss, M. J. (1993). The effects of an interactive dissection simulation on the performance and achievement of high school biology students. *Journal of Research in Science Teaching*, 30(8), 989-1000.
- Maddux, C. D., Johnson, D. L., & Willis, J. W. (1997). *Educational computing: Learning with tomorrow's technologies*. Boston: Allyn & Bacon.
- Magnusson, S. J., & Palincsar, A. (1995). The learning environment as a site of science education reform. *Theory into Practice*, 34(1), 43-50.
- Mintz, R. (1993). Computerized simulation as an inquiry tool. *School Science and Mathematics*, 93(2), 76-80.
- McKinney, W. J. (1997). The educational use of computer based science simulations: Some lessons from the philosophy of science. *Science and Education*, 6(6), 591-603.
- Miller, L. M. & Castellano, J. (1996). Use of technology for science and mathematics collaborative learning. *School Science and Mathematics*, 96(2), 58-62.
- Naglier, Jack, A., Rojahn, J. (2001). Gender differences in planning, attention, simultaneous, and successive (PASS) cognitive processes and achievement. *Journal of Educational Psychology*, 93(2), pp. 430-437.
- Norton, P., & Wiburg, K. (1998). *Teaching with technology*. Fort Worth, TX: Harcourt Brace College Publishers.
- Miller, L. M. & Castellano, J. (1996). Use of technology for science and mathematics collaborative learning. *School Science and Mathematics*, 96(2), 58-62.
- Piaget, J. (1954). *The Construction of Reality in the Child*. New York: Basic Books. (Original French education, 1937).
- Pintrich, P. R., Marx, R. W., & Boyle, R. W. (1993). Beyond cold conceptual change: The role of motivational beliefs and classroom contextual factors in the process of conceptual change. *Review of Educational Research*, 63(2), 167-199.
- Queen, J.A. (1984). Simulations in the classroom. *Improving College and University Teaching*. 32(3); 144-145.

- Quinn, C. N. (1993). Cognitive skills and computers: "Framing" the link. Proceedings of the Fifth International Conference on Thinking. Townsville, Australia.
- Rivers, R. H., & Vockell, E. (1997). Computer simulations to stimulate scientific problem solving. *Journal of Research in Science Teaching*, 24(5), 403-415.
- Roblyer, M. D., Edwards, J., & Havriluk, M. A. (1997). *Integrating educational technology into teaching*. Upper Saddle River, NJ: Prentice-Hall.
- Schacter, J. (1999). *The impact of educational technology on student achievement: What the most current research has to say*. Milken Exchange on Education Technology, Santa Monica, CA. (BBB35521).
- Schommer, M. (1993b). Epistemological development and academic performance among secondary students. *Journal of Educational Psychology*, 85(3), 406-410.
- Strauss, R. & Kinzie, M. B., (1994). Student achievement and attitudes in a pilot study comparing an interactive videodisc simulation to conventional dissection. *American Biology Teacher*, 56(7), 398-402.
- Tennyson, R. (1989). *Cognitive science and instructional technology: Improvements in higher order thinking strategies*. Papers presented at the annual meeting of the association for educational communications and technology (Dallas, TX, February 1-5, 1989).
- Thomas, R. & Hooper, E. (1991). Simulation: An opportunity we are missing. *Journal of Research on Computing in Education*, 23(4), 497-513.
- Tylinski, J.D. (1995). The effect of a computer simulation on junior high students' understanding of the physiological systems of an Earthworm Dissection. (Doctoral dissertation, Indiana University of Pennsylvania, 1990)
- Von Glasersfeld, E. (1981). The concepts of adaptation and viability in a radical constructivist theory of knowledge. Siegel, I, Golinkoff, R., & Brodzinsky, D. (Eds.). *New Directions in Piagetian Theory and Their Applications in Education*, (pp 89-95). Hillsdale, NJ: Erlbaum.
- Wolf, B., & Hall, W. (1995). Multimedia pedagogues: Interactive systems for teaching and learning. *IEE Multimedia*, 2(3), 74-80.
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About the author...

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Appendix

Example Test questions :

Short Answers : Answer the following in complete sentences.

1. Describe why earthworms die when their skin becomes dry.
2. Describe how the earthworm perform the function of locomotion and how that differs from that of a frog?
3. Draw and describe the three parts of the earthworm's circulatory system. Compare and contrast these three parts to that of a frog.
4. What is typhlosole? What organ (s) in a human can perform the same function?
5. Draw and describe the two main components of the nervous system in your earthworm?
Compare their functions to that of a frog.

Parts To Identify:

1. somites
2. circular muscles
3. clitellum
4. septa
5. anal pore
6. aortic arches
7. longitudinal muscles
8. setae
9. mouth
10. dorsal blood vessel
11. nerve collar
12. typhlosole
13. What side of the body is this (ventral)
14. What carries the food from the parynx to the crop?

Function:

15. What is the function of the cuticle?
16. what is the function of the typhlosole?
17. what is the function of the parietal vessels?
18. what is the function of seminal receptacles?
19. what is the function of nephridia?

Fill in the Blanks:

20. The earthworm has ----- aortic arches which are sometimes referred to What?-----
21. The inner tube of the earthworm is called what?-----
22. An animal which has both male and female reproductive organs is said to be ?_____
23. ----- symmetry is characteristic of all earthworm
24. ----- are repeating longitudinal segments.

Matching: Write and describe in your own words terms/functions that matches with the following words.

1. litellum
2. seminal receptacle
3. pharynx
4. ventral nerve cord
5. setae
6. gizzard
7. dorsal vessel
8. nephridia
9. closed system
10. crop