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Use of the Digital Camera to Increase Student Interest and Learning in High School Biology

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Technology can be thought of in two ways: as a set of tools that amplify or extend what we currently do (make it better, faster, stronger), or as something with the potential to radically change what we do or how we do it (Pea, R. D., Beyond amplification: Using the computer to reorganize mental functioning. *Educational Psychologist* 20: 167–182, 1985). As technological tools, e.g. the digital camera, become more common, teachers and students have increasingly integrated them into their work. This research attempts to answer two research questions about the digital camera as a technological tool in the science lab. Does the use of the digital camera in laboratory activities increase student learning? Does the use of the digital camera motivate students to take a greater interest in laboratory work? Two high school biology classes in an urban high school of 1300 students were used to carry out the study. One, the control group, did not use the digital camera during two lab activities, and the other, the experimental group did use the digital camera during the same lab activities. The results of the study indicated that the digital camera did increase student learning of process skills in the two biology lab activities. The results of unpaired t tests for independent data indicated the differences were statistically significant for the process questions, while the differences in responses to the content questions were not significantly different. Anecdotal evidence also indicated that the experimental group took more interest in setting up the apparatus and made fewer mistakes in the lab procedure than did the control group.

KEY WORDS: technology; digital camera; high school; biology.

INTRODUCTION

One of the major challenges in education is to ensure that all students are prepared for today's more technologically advanced world. The implication of this challenge is that all students should be able to access and use technology in school. Unfortunately, there have been several conceptual articles, personal accounts, studies, and reviews of research that have found that technology is not equitably distributed in schools and across all types of students (Atwater, 2000; Brown, 2001; Damarin, 2000; Owens and Waxman, 1998; Stuhlmann and Taylor, 1999).

Meanwhile, many educators find this focus on educational technology and technology education frustrating when they struggle with students lacking the most basic cognitive skills. Most teachers would agree that the ability to solve problems and apply strong study skills provides the foundation for student success. Yet these basic issues continue to be overlooked, as an emphasis on technology becomes increasingly dominant. In many cases educators find themselves teaching apathetic students in classrooms surrounded with expensive, yet ignored, technology that promised to motivate and increase student performance, often without results.

O'Sullivan and Weiss (1999) report that between fourth and eighth grades the achievement and understanding of complex science declines in the

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United States relative to their peers internationally. The National Association for Educational Progress (2000), also known as "the Nation's Report Card," concluded in a recent study that most students can recall simple facts but serious deficiencies occur at the higher levels of scientific and technological thinking. With all these resources available, schools need to consider how technology can be used to strengthen these basic skills needed for student success in the classroom. Then, only with these foundations in place can educators begin to focus on technological literacy for these students.

With this in mind, educators need to determine how using more technology might be one way to increase student interest and motivation with the goal that they will learn more science through the increased interest. It is important to distinguish that technology education is different from educational technology, also called instructional technology. Dugger (1999) defines technology education as a school subject designed to develop technological literacy, while educational technology is used as a tool to enhance the process of teaching and learning. In science education it is important to consider the term "technology" much more broadly. Learning about, with, and through computers can help students to better understand how science, technology, and society interact (Trowbridge *et al.*, 2000).

As there continues to be an increasing emphasis on the implementation of electronic resources and while the inclusion of digital experiences is welcome, it also represents the growing divide between traditional teaching strategies and the expectations of a generation born into digital culture (Mills, 2000). A central theme resonating across cognitive science literature that is applicable to technology education is, when instruction and materials are designed, they should be designed to help students acquire and integrate the cognitive and metacognitive strategies for using, managing, assessing, reorganizing, and discovering knowledge. This suggests that students using technology must be active, collaborative participants in framing technology-related questions, designing and participating in data collection and analysis procedures, and free to predict and inquire about outcomes (De Miranda and Folkestad, 2000). Technology for technology's sake has little use.

This idea is mirrored in the constructivist learning theory that currently dominates science education and strongly recommends that teachers view themselves as facilitators in the educational process. Medina *et al.* (2001) predict that in one fell swoop, the technology revolution may accomplish what 10 years of education reform could not. The teacher preparation that has traditionally been provided no longer allows teachers to maintain the status of credible expert since they can never know as much as the Internet makes available to their students. As a result, teachers have been encouraged to become a "guide on the side" rather than the traditional "sage on the stage."

Technology can be thought of in two ways: as a set of tools that amplify or extend what we currently do (make it better, faster, stronger), or as something with the potential to radically change what we do or how we do it (Pea, 1985). Many educators use technology solely to amplify what is currently done (Girod and Cavanaugh, 2001). Yet any application of technology that may increase student motivation or increase retention needs to be considered as a possible learning tool to help every student. This is becoming even more true as the amount of funds directed towards technology and away from other instructional support increases.

As technological tools, e.g., the digital camera, become more common, teachers and students are increasingly integrating them into their work. The use of the digital camera in the classroom has increased greatly as the applications for its use in student reports and presentations and as a supplement to teachers' lectures have become more obvious. In the current research, the digital camera as a technology has remained a tool that can amplify or extend what the students and teachers currently do. As teachers, we need to begin to focus on how the digital camera and other technological tools can be used to change what we do or how we do it. In this paper, this will be done with a focus on how the digital camera can be used to increase science learning and improve motivation for laboratory work. This research will explain the potential for using it, as well as other technological tools, to build technology into the curriculum with the aim of increasing student learning during laboratory work.

Statement of Problem

Using technology to enhance student learning and motivation is a continuing concern demanding attention at the local, state, and national levels. This problem is substantial in scope and impact on the future. Educators must use to their advantage the resources available to them through the increased emphasis on the use of technology in the classroom. This includes developing lessons that allow students to interact with technology in such a way as to increase motivation, heighten problem-solving skills, and focus on the scientific process.

Specifically, this research attempts to answer the following questions:

Research Question 1: Does the use of the digital camera in laboratory activities increase student learning?

Research Question 2: Does the use of the digital camera motivate students to take a greater interest in laboratory work?

REVIEW OF RELATED LITERATURE

Teachers and students alike are finding innovative uses for digital cameras. The most common applications include enhancing school websites and incorporation of images into class assignments. Teachers can use digital cameras to keep student databases and make handouts more interesting (Knuttle, 1998). In many cases, students are using computers to create multimedia projects at a level of sophistication unheard of just a few years ago (O'Donovan, 2000). Physical education teachers may use the digital camera to photograph body movement in dance and sports (LaMaster, 2002). Art teachers use them to make pictures of still life from a variety of angles. Students can compare the digital images to their own drawings and use them as an aid to understanding the science and art of visual images (Klomp, 2002). Examples of digital camera use in science classes are sparse. One science article discussed the use of digital cameras in physics to challenge students' scientific creativity and provide experience in scientific research (Thompson, 2002).

In response to the emphasis on technological literacy, teachers have been encouraged to develop lesson plans on the basis of state and national standards that incorporate technology into the curriculum. According to Setters (1999) gathering data, analyzing data, communicating results, and using appropriate technology are all included in the state and national standards. Still and video photography have several applications in the classroom that fit with these aspects of the standards. Weiser (1997) suggests that students can use digital cameras to bring to life abstract concepts such as math, science, and grammar, specifically helping visual learners. According to O'Donovan (1996), the immediate results provided by digital cameras, as well as desktop video cameras, are great ways to motivate students.

METHODOLOGY

Subjects

Research was conducted at a high school serving a low socioeconomic urban area in the Western United States. The high school has a culturally diverse student population of approximately 1300 students. This study involved two biology classes of 31 students. Each of the two classes included students from each of the four high school grade levels: freshman, sophomores, juniors, and seniors. Students enrolled in the biology classes in this school are generally considered to be "upper level" students and they are more likely to take upper division science courses and pursue further education after graduating from high school. The majority of the other students in the high school are enrolled in general science classes.

Instrument

Data were collected with a postlab quiz that was distributed to students' in both classes three days after their involvement in each of the two laboratory exercises. Questions were designed to elicit responses concerning the content covered in the lab and the process followed during the lab to reinforce content (see Tables I and II). These questions were similar to the questions the students answered in the data analysis and conclusion sections of the lab. The criteria used when assessing student responses were on the basis of the responses generated to the questions students answered during and immediately following the lab in their lab reports.

Table I. Postlab Analysis Questions for Lab 1

Relationship between photosynthesis and cellular respiration
1. What is the chemical equation for cellular respiration?
2. What is the chemical equation for photosynthesis?
3. Describe the step-by-step process involved in your experimental design
4. How was the bromothymol blue solution used in your experiment?
5. How was the solution helpful when collecting data from *Elodea*?
6. How was the solution used in the section of the experiment focusing on respiration?
7. How did the data collected during your experiment show the relationship between respiration and photosynthesis?

Table II. Postlab Analysis Questions for Lab 2

Chromatography lab

1. Describe the step-by-step procedure followed during this lab
2. Describe the role of pigments during photosynthesis
3. What is chromatography?
4. Explain why some pigments moved farther up the filter paper than others did
5. Identify the two plants used during this lab and list the pigments separated from each plant

Data Analysis

The first question the research attempted to answer was if the integration of the digital camera into lab activities would increase student learning. Data were collected following the two different laboratory exercises in each of the two biology classes. During each lab, one class, the experimental group, was asked to incorporate the use of a digital camera into their lab procedure. None of the students in the experimental group had had previous experience with a digital camera; therefore one class session was devoted to the use of the camera and the processing of the images on the classroom computer. Students were required to document each step in the lab procedure with a digital image. Students were also required to process these images on the classroom computer and include them in their lab reports. The other class, the control group, did the labs without the digital camera.

The second question the research attempted to answer was whether the use of the digital camera would increase student motivation and interest. This was carried out by monitoring changes in the student interaction and discussion with peers, anticipation and level of participation. Other factors such as an increase in the number of student questions and a reduction in the number of procedural errors during the labs were also considered.

The postlab analyses were both quantitative and qualitative. The quantitative portion was administered to students in the two groups three days following each of the two lab exercises. All data were analyzed to determine the percentage of correct responses in the control group (the group not using the camera) and the experimental group (the group using the camera). Finally, responses were analyzed in the context of the type of question asked: *content* based or *process* based. *Content-based questions* focused on the material being studied in the class. For the content-based questions, the purpose of the labs was to extend the curriculum through the use of problem-based, hands-on activities. The *process-based questions* focused on the step-by-step procedure followed by the students and the characteristics of the lab materials used to make observations and collect data.

Table III. Percent Correct Responses According to Question Type

Question #	Question type	Control group ($n = 19$)	Experimental group ($n = 10$)
Lab 1: Relationship between photosynthesis and cellular respiration			
1	Content	37	40
2	Content	42	50
3	Process	63	100
4	Process	79	70
5	Process	74	50
6	Process	53	30
7	Content	47	30
Average percent correct response by question type			
Process questions		67	62
Content questions		42	40

RESULTS

Quantitative

Data from the two postlab analyses were analyzed independently to determine if any patterns were evident in the percentage of correct responses in content- and process-based questions in the control group or the experimental group (see Tables III and IV).

Results from Lab One showed that the control group answered a higher average percentage of process-based questions correctly (67%) than did the experimental group (62%). Results from Lab Two showed that students in the control group responded correctly to 48% of these questions while the experimental group responded correctly to 69% of the questions.

Table IV. Percent Correct Responses According to Question Type

Question #	Question type	Control group ($n = 17$)	Experimental group ($n = 14$)
Lab 2: Chromatography			
1	Process	82	100
2	Content	29	21
3	Process	35	71
4	Content	29	71
5	Process	29	36
Average percent correct response by question type			
Process		48	69
Content		46	29

Table V. Comparison of Results of Process Questions

Group	*N*	*M*	SD	*T*	df	*p* (two-tailed)
Control	17	4.24	1.25	−2.47	16	0.0103
Experimental	10	5.30	0.67		9	

Analysis of the content-based questions for Lab One showed that the control group answered 42% of these questions correctly while those in the experimental group responded correctly to 40% of these questions. The second lab results showed a 46% correct response by the control group and 29% by the experimental group.

Unpaired *t* tests for independent data were used to compare the number of correct responses by the control and the experimental groups to the process and content-based questions. Responses from students that were absent for one or both labs were eliminated. Results indicated the differences were statistically significant for the process questions, while the differences in responses to the content questions were not statistically significant (see Tables V and VI).

Question 3 of Lab One and question 1 of Lab Two asked students to provide a step-by-step summary of the process used during the exercise. In each case 100% the digital camera group provided accurate and detailed accounts of the method used during the experiments. This compared to a 63% for the first lab and 82% for the second lab with the control group. Results from an unpaired *t* test indicated the difference was statistically significant (see Table VII).

Qualitative

Certain anecdotal observations need to be considered in this study. The increased motivation in the students involved with the cameras was obvious. It must be noted that many of the students involved in this study had limited access to computers. Only one half of the students in the experimental group had access to a computer at home, and none of the students had worked with a digital camera prior to this study. Students often arrived to class early to practice using the cameras and the authors became increasingly concerned during the study that the students were more focused on the artistic quality of their images than on documenting the lab process.

Table VI. Comparison of Results of Content Questions

Group	*N*	*M*	SD	*T*	df	*p* (two-tailed)
Control	17	1.94	0.66	−0.63	16	0.2655
Experimental	10	2.10	0.56		9	

Table VII. Comparison of Correct Responses to Step-by-Step Summary Questions

Group	*N*	*M*	SD	*T*	df	*p* (two-tailed)
Control	34	0.71	0.46	2.76	33	0.0040
Experimental	20	1.00	0.00		19	

At the same time it was also noted that more mistakes were made in the lab procedure of the control group students than in the group using the camera. The extra attention paid to "setting up a shot" eliminated mistakes entirely from the digital camera group, while four students in the control group needed to start the labs over again because of errors in procedure. Students in the experimental groups also used their pictures as an aid in writing up the lab report after the lab materials had been torn down and put away.

During the final examination, one month after the two labs, the students who used the digital cameras still retained more of the process information in the two labs but it was not statistically significant.

DISCUSSION AND CONCLUSIONS

Any discussion involving the application of technology in the classroom needs to include an explanation of purpose and desired outcome. *Project 2061: Benchmarks for Science Literacy* (American Association for the Advancement of Science, 1993) provides a list of 10 questions that need to be asked concerning science education in every school. All these questions focus on the ability of the curriculum to increase science literacy for all students; including those with different interests and talents as well as those traditionally underrepresented in science and math courses. The solution can be found in schools where continuity of learning is important, and meaningful links among scientific ideas are made through active learning. The authors challenge educators attempting to successfully incorporate technology into the science classroom to build technology education into the curriculum as they use technology tools to promote learning.

Whether the technology is intended to be used as a tool to extend what is currently done, or as a tool to change what we do or how we do it, will ultimately determine how we measure its success. In this study, as in many instances where something new is tried, both intentions were evident. The digital camera was used to extend the lab process while at the same time it introduced the students involved with the digital cameras to a new form of technology that ultimately changed the way they communicated about their work.

Although the biology content data measured during this study is inconclusive, the responses to two of the biology process questions suggest that the use of the digital camera did strengthen one important aspect of both lab exercises; understanding scientific process. It is often obvious that students tend to go through the motions of a lab exercise focusing on obtaining the results they need to collect and analyze data. This habit is most likely the result of the written procedure or lab design which is often replication, a format that does little to promote the understanding of the scientific method or to support the goal of inquiry in the *National Science Education Standards* (NRC, 1996). Asking the students to include the camera in the lab process required them to consider each step of the scientific process being used to produce the desired results. The fact that the students were willing to come in without being asked, on their own free time, was certainly evidence of the increased interest in the science laboratories that the digital camera provided. Moreover, the evidence provided by the pictures in the laboratory report clearly indicated whether they had followed proper procedure in setting up the equipment. Perhaps, as a result, they were willing to take the time and make the extra effort to do it right when they knew their setup would be preserved for posterity in the resulting pictures. The digital camera also allowed them to immediately see their picture, delete it, and take another one if it did not conform to the appropriate setup.

Although the data indicate little change in retention of content knowledge, the increase in student retention of lab procedure as well as increased motivation and accuracy provides ample incentive to continue incorporating the digital camera into science labs. As this research indicates, and many teachers and students already know firsthand, in most cases technology alone is not the answer. Lectures, discussions, demonstrations, reading and writing and student-designed problem-solving activities, as well as other teaching and learning strategies, need to be emphasized in association with technology if students are to develop a complete understanding of the concepts and processes being considered.

This was a pilot study with limited lab work and further research is needed to determine how the integration of the digital camera will affect student interest and learning over an extended period of time. It would also be interesting to determine if the camera further increases the amount of time students retain the concepts covered during the lab exercises, beyond the 6 weeks measured in this study. It appears in this study that as a result of the pictures in their laboratory books, they also had better study cues to refer to when they studied for the final examination. Some students even commented that the pictures were useful in helping them recall the information learned in the lab work. The old adage of a picture being worth a thousand words may have applied in this situation.

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