Laptop Computers and Multimedia and Presentation Software: Their Effects on Student Achievement in Anatomy and Physiology

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Abstract

Two groups of high school students alternately used laptop computers with multimedia and presentation software to study anatomy and physiology content over the course of one school year. Each group used computers for two quarters and traditional paper-based materials for two quarters. Both groups were taught the same curriculum by the same teacher. The course grades of the two groups were compared each quarter. Analysis indicated that the students benefited from creating PowerPoint (1986–2000) presentations and reviewing course material with the A.D.A.M. (Animated Dissection of Anatomy for Medicine)—The Inside Story (1997) software. (Keywords: anatomy and physiology, laptop computers, multimedia software, presentation software.)

Many students and teachers believe technology may enhance learning (Mehlinger, 1996); as a result, computers are becoming a mainstay in elementary and secondary classrooms (Grimm, 1995). Laptop computers and multimedia and presentation software are two educational technology trends that have drawn recent attention. As these emerging technologies are introduced to the classroom, research is needed to investigate their effect on student achievement. Beasley and Waugh (1996) warned that research is lagging far behind advances in the capabilities of the multimedia technology. The purpose of this study was to investigate whether exposure to multimedia and presentation software on laptop computers influenced student achievement in a high school anatomy and physiology science course.

BACKGROUND OF THE STUDY

Software Use in Biology

Multimedia and presentation software are popular in education. They offer a unique blend of formats for displaying and organizing information. Both applications display information in many different formats that can be arranged in a variety of helpful combinations. Multimedia attributes (e.g., animation, recorded speech, graphics, video, music) accommodate a variety of learning styles (Ayersman, 1996; Provenzo, Brett, & McCloskey, 1999).

Multimedia and presentation applications promote a constructivist approach to learning by encouraging complex interactions between learners and content. *Constructivism* involves learning in context, whereby learners construct much of

what they learn and understand as a function of their experiences (Schunk, 2000). Use of presentation software such as PowerPoint (1996–2000) or HyperStudio (1989–2000) can transform students from being mere recipients of knowledge to active learners who make decisions about how to direct their learning (Thorsen, 1998). Presentation applications also facilitate the development of research skills and encourage cooperative learning and problem solving (Sharp, 1996). Jonassen, Peck, and Wilson (1999) proposed that "students-as-producers-of-technologies engage in much more meaningful learning than students-as-receivers-from-instructional-technologies" (p. 112).

Previous research indicates that using multimedia in biology curricula improved student achievement. Ritt and Stewart (1996) reported that students who used anatomy and physiology multimedia software scored 10 points higher on lab practical exams than those who did not. Ninety percent of the computer users in the Ritt and Stewart study indicated that the multimedia software used greatly enhanced their understanding of the subject matter.

A meta-analysis by Christmann, Badgett, and Lucking (1997) indicated that computer-assisted instruction (CAI) had a small positive effect on achievement scores in some of the subject areas. They did find a positive effect for high school biology. Meta-analyses by Fletcher-Flinn and Gravatt (1995) and Liao (1992) showed similar findings, with a moderate effect size favoring CAI. Lu, Voss, and Kleinsmith (1997) also reported positive effects of using CAI in high school biology classes. Other studies report a positive effect when using CAI for high school biology when compared to traditional instruction (Lazarowitz & Huppert, 1993). Hounshell and Hill (1989) used computer simulations as a supplement to a biology course to cover topics such as genetics and population studies. They reported significantly higher student achievement scores with the computer-assisted approach over the traditional classroom approach.

A.D.A.M.—The Inside Story (1997) is a common multimedia application for anatomy classes. Matray (1996) reported that A.D.A.M. provides learners with an opportunity to review systems that could not be viewed in a "real-life" environment. Learners are able to control their learning environment as they view the systems of the human body.

Jonassen et al. (1999) noted that despite multimedia's popularity, the research supporting positive effects of multimedia on learning is limited. Provenzo et al. (1999) predicted that the promise for multimedia and hypermedia has just begun. Provenzo et al. suggested that "when combined with other computer-based technologies such as the Internet ... multimedia and hypermedia have the potential to transform learning and instruction" (p. 187).

Laptop Computers

Laptops are becoming familiar learning tools for students. The portability of laptops is attractive to many educators who have limited equipment and who desire greater mobility and access for students. This technology has been shown to improve teacher and student technology literacy, student responsibility and independence, and the quality of student products (Fouts & Stuen, 1997; Gardner, Morrison, Jarman, Reilly, & McNally, 1994).

Gardner et al. (1994) explored the effects of providing portable computers for one year to 235 students from nine schools (one special education, one primary, and seven secondary). Their findings were mixed. The portable computers did not have a positive effect on achievement for mathematics and English, but did have a positive effect on science achievement. Gardner also reported that students with laptop computers were more motivated and acquired information technology literacy more quickly.

In other research (McMillan & Honey, 1993), teachers indicated that laptop technology increased their ability to undertake more inquiry-oriented activities, project-based activities, and long-term assignments. They found that students improved markedly in their ability to communicate persuasively, organize their ideas effectively, and accurately use a broad vocabulary. Researchers from the Copernicus Project in Washington State (Fouts & Stuen, 1997) noted that writing skills were most directly affected by the use of laptops, followed by communication and presentation skills.

It may be that the simple use of laptops in the classroom is less important than how they are used. As Clark (1991) proposed, "Learning is influenced more by the content and instructional strategy than the type of medium" (p. 34). Constructivist-based learning activities appear to be more beneficial. Bradshaw and Massey (1996) noted that laptops level the playing field because all students use the same tools and have similar access to information.

DESIGN OF THE STUDY

Methodology

This quasi-experiment used a control group/experimental group counterbalanced design. Two classes (Group A and Group B) of anatomy and physiology students served as a sample of convenience (Gall, Borg, & Gall, 1996). Group A used laptop computers with A.D.A.M. multimedia software (1997) and PowerPoint (1996–2000) presentation software during the first and second quarter of the 1997–1998 school year. Group A students received the laptop computers during the fifth week of the first quarter. Each of the students in Group A was given full-time possession of a laptop computer, including permission to take it home. Group B served as a control group and did not have access to the laptop computers, although MedWORKS (1995) software and the Internet were available on five workstation computers in their science classroom. Access to the technology was then reversed for the second half of the year; Group B students used the laptop computers while Group A served as a control. Group B received the laptops during the second week of the third quarter.

Both groups of students were taught the same curriculum by the same teacher. Instruction centered on lectures, lab activities, and open-ended projects. The students with the laptops reviewed the course material with the A.D.A.M. software (1997). They also used PowerPoint (1996–2000) to create a presentation on one body system covered in the curriculum. The median number of slides students created for their presentations was 12. Although some of the students created graphics to illustrate their topics, others inserted graphics from the Internet or the A.D.A.M. software. Generally, the students used the

A.D.A.M. software to review the systems and to reinforce the concepts taught in class. Therefore, the treatment involved full-time possession of a laptop computer, interaction with the A.D.A.M. software, and opportunities to create multimedia presentations with PowerPoint.

Participants

Participants were first-year anatomy and physiology students from a small rural high school in Idaho. The anatomy and physiology course was an elective course that was usually taken in the junior or senior year. Approximately one-third of the students were Hispanic. The rest were White. The participants were assigned to one of two groups based on class schedule. Group A (n =11) consisted of 9 high school juniors and 2 seniors. Group B (n =16) consisted of 1 sophomore, 14 juniors, and 1 senior. Before the study, the two groups did not differ on overall cumulative GPA, $t(25) = .93$, $p = .36$, $d = .49$, or previous biology grades, $t(12.26^{1}) = 1.89$, $p = .08$, $d = .89$. (See Table 1 for group means and standard deviations.) The difference in previous biology grades was approaching statistical significance.

Table 1. Prior Biology Grades and Grade Point Averages

Area	Group A		Group B	
	M	*SD*	*M*	*SD*
Biology grades	2.94	1.27	3.70	.51
Previous cumulative GPA	3.44	.65	3.65	.51

Instrument

Student achievement in the anatomy and physiology class was compared each quarter. Over the course of the school year, student achievement was based on 12 teacher-created exams. Each exam contained an average of 40 multiple-choice questions and two essay questions. The majority of the exam questions were taken from the instructor's guide that accompanied the classroom text. Both groups completed the same exams.

RESULTS

A repeated-measures ANOVA was used to analyze the data. The between variable was group membership. The repeated measures were the students' grades for each of the four quarters of the school year. There was no difference in the overall achievement of Groups A and B for the year, $F(1, 25) = 4.06$, $p = .06$ (Table 2). This result would be expected, because each group served as the experimental group and the control group for part of the study. The previous slight academic advantage of Group B is reflected in the probability approaching statistical significance.

[1] *unequal variance independent t-test*

Table 2. Analysis of Variance of Repeated Measures

Source	SS	*df*	*MS*	*F*	*p*	η^2
Between subjects						
Group	1,072.46	1	1,072.46	4.06	.06	.14
Error	6,604.71	25	264.19			
Within subjects						
Quarters	3,780.46	3	1,260.15	37.43	.001	.60
Quarters × Groups	355.57	3	118.52	3.52	.02	.12
Errors (Quarters)	2,524.75	75	33.66			

There was a significant difference in the overall achievement of the groups across the four quarters of the school year, $F(3,75) = 37.43$, $p = .001$. As the school year progressed, the content of the course became more difficult, and the students' grades dropped.

There was also an interaction between the groups across time, $F(3,75) = 3.52$, $p = .02$. The difference between the groups at each of the four quarters was investigated with separate *t*-tests. There were significant differences between the two groups at the first and fourth quarters (Figures 1 and 2). As noted earlier, we were approaching a significant difference in biology grades from the previous school year that favored Group B students. Group A students were given

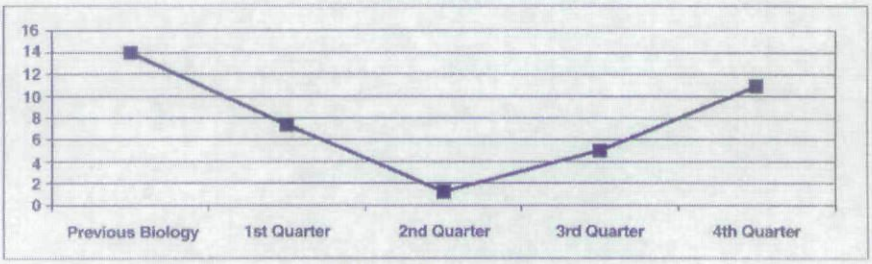

Figure 1. Grade advantage for Group B.

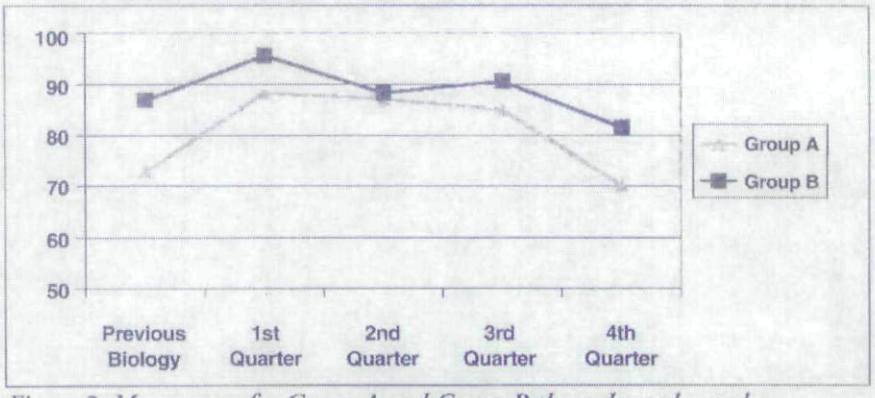

Figure 2. Mean scores for Group A and Group B throughout the study.

the laptop computers five weeks into the 1997–1998 school year. At the end of the first quarter, Group B students scored higher in the anatomy and physiology class than Group A students, $t(11.13^{1}) = 2.16$, $p = .05$, $d = .67$. This result was expected, because the previous biology grades for Group B were higher, and Group A had access to the laptops for only the last four weeks of the quarter. At midyear, there was no difference between the achievement of Group A and Group B, $t(25) = .38$, $p = .71$, $d = .11$. Group A, who had laptops for the entire quarter, were now achieving at the same level as Group B.

Two weeks into the third quarter, the laptops were transferred from the Group A students to the Group B students. There was no difference in the achievement of the two groups at the end of the third quarter; however, Group B was beginning to outperform Group A, $t(25) = 1.89$, $p = .07$, $d = .70$. This is evident by the group difference approaching statistical significance. The difference between the groups was surfacing after Group B students began using the laptop computers. By the end of the year, Group B students, who had used the laptops for the full quarter, were scoring a full letter grade higher in the class than Group A students who were not using them, $t(25) = 2.15$, $p = .04$, $d = 1.11$.

DISCUSSION

This study demonstrated that students in a high school anatomy and physiology class benefited from full-time access to laptop computers, exposure to multimedia software, and creation of projects with presentation software. Meta-analyses of computer-assisted learning by Christmann et al. (1997), Fletcher-Flinn and Gravatt (1995), and Liao (1992) support the findings of this study. Studies specific to computer use in biology classes (Hounshell & Hill, 1989; Lazarowitz & Huppert, 1993) also support the findings of this study. This research demonstrated that laptop computers with accompanying software had a favorable effect on students' course grades.

It is difficult to determine whether the positive outcomes are the results of possession of the laptops, the use of multimedia software, or the creation of presentation slides. Because each student focused on only one aspect of the anatomy and physiology curriculum in his or her PowerPoint (1996–2000) presentation, it is unlikely that creating a single PowerPoint presentation had a strong effect on the individual's knowledge acquisition. However, as one student commented about creating the PowerPoint presentations, "You have to review the information so frequently that it is implanted in your memory." Before beginning their PowerPoint presentations, some students created storyboards. One student reported that first creating the storyboard resulted in "putting more time into [the presentation]."

The students used the laptops and A.D.A.M. (1997) throughout the semester to review information, complete worksheets, and study for exams. This interaction with the multimedia software probably contributed to their increased understanding of the body systems. Two typical student comments were "I really like the idea of seeing the body ... I learned things I can't learn orally," and

[1] *unequal variance independent t-test*

"Laptops for this class make the visual parts of the anatomy and the written notes come together to clear up any misunderstanding."

Student use of laptops also may be superior to the traditional computer lab or bank of classroom computers approach. When students use a computer center or a computer lab, computing often becomes a separate activity. This may decrease opportunities to use technology as an authentic integral part of learning. Compatibility issues often complicate student's access to computing. There may be a difference between the hardware and software available to students at home and at school. Laptop computers can bridge this gap by allowing students the same access to technology both at school and at home. Some of the students did worry about their laptops. Two concerns were "I was afraid I might damage it," and "I worried where it was." With extended exposure, these concerns dissipated. Because students with laptops are able to learn at any place and any time, laptops hold the potential to change the dynamics of teaching. When every student has access to computing power and similar software, instructors can develop more learning opportunities that seamlessly incorporate technology into their curriculums. This flexibility adds another powerful tool to the arsenal for acquiring and processing information.

The small sample in this study is a limitation. Obtaining statistical significance with a small sample is difficult. The effect sizes reveal that, given more power, the two groups probably did differ in their previous GPA and biology grades. Given the limited statistical power, the differences that were reported in this article are significant. Further research with a larger sample is necessary. The effect sizes may have been more dramatic if the instructor had made a concerted effort to integrate the technology into his instruction, rather than allow it to be a supplementary add-on. The generalizability of these results is also limited. This study occurred in a rural farming community. The school and the students are not representative of urban or suburban students and schools.

It is also recommended that further research be conducted:

1. on the individual variables in this study: laptop computers, A.D.A.M.—The Inside Story (1997), and PowerPoint (1996–2000).
2. to distinguish their individual effects on learning as well as how effectively they work under various classroom conditions.
3. to investigate the effects of laptop computers and multimedia software on specific content areas.

Laptop computers and multimedia software provide a strong learning tool for educators. Additional research into new ways of thinking and teaching with these tools is warranted. ■

Contributors

Del Siegle earned his PhD in educational psychology in 1995. He is an assistant professor in residence at the University of Connecticut where he teaches Principles and Methods in Educational Research, Problem-Based Learning in an Information Age, and Telecommunications in Teaching. Dr. Siegle lectures

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