Learning Strategies and Performance In a Technology Integrated Classroom

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Abstract

This study examines students' use of technology for learning (accessing the course Web site to download PowerPoint slides for note taking and exam preparation) relative to more traditional learning methods (reading the textbook and taking notes in class and from the textbook) and the effect of their learning strategies on exam performance and class attendance. Students who were categorized as high on use of technology and low on traditional learning methods or low on technology and high on traditional learning methods exhibited higher attendance and performance than those students categorized as high or low on both technology and traditional learning methods. Results suggest that there is more than one path for optimal exam performance. (Keywords: learning, performance, technology, multimedia.)

INTRODUCTION

Since the turn of the 20th century, educators have used various types of technology aids to help them teach and to improve their students' learning (Heinich, Molenda, Russell, & Smaldino, 2001). During the last decade, the use of computer-based technology in college education has dramatically increased to include emerging technology for visual presentation, simulation, accessing course materials and World Wide Web resources, and interactivity. Our students have grown up in a "high technology" environment and are adept at the use of computers and the Internet for information exchange. Students frequently ask professors to prepare their lecture notes using PowerPoint, have a course Web site, and use multimedia to illustrate key themes. These new technologies also offer new learning strategies for students who do not perform as well using traditional methods. With computer-assisted instruction, instructors can provide different ways of learning besides traditional learning methods. For example, if a student is weak in verbal and linguistic ability or is lacking in motivation, the instructor may use visual cues in PowerPoint to help students grasp and conceptualize information and generate interest in the subject matter.

Many instructors use multimedia embedded in PowerPoint slides to help them present information in multiple formats, such as text, images, sound clips, and video clips (Karakaya, Ainscough, & Chopoorian, 2001; Schär & Krueger, 2000). It allows instructors to introduce alternative types of information to facilitate varied learning styles in the classrooms. In addition, PowerPoint presentations can also be used to provide a structure for lectures and discussions that help students gain focus and organization of course material (Debevec & Shih, 2005). Many researchers on multimedia instruction have also found that using

different modes of instruction helps students process information and better comprehend the content (Lambert & McCombs, 1998). It is believed that when used wisely, multimedia instruction will be able to foster deeper learning among students and benefit students with different learning preferences by presenting materials in more inclusive rather than exclusive ways (Mayer, 2003).

In their study, Frey and Birnbaum (2002) found that the majority of students agreed that computer-assisted instruction in class had a positive effect on lectures, especially in helping them take notes and study for exams. In addition, research suggests that those using a multimedia approach in instruction are perceived favorably by students and that this approach yields some significant improvements in student learning as evidenced by both student self-report and objective outcome testing (Smith & Woody, 2000). The term "multimedia" generally means using some combination of text, graphics, animation, video, music, voice, and sound effects to communicate (Gaytan & Slate, 2002).

Besides using multimedia in and outside of the classroom to enhance student learning, the World Wide Web has also created an information-rich teaching and learning environment that facilitates social interaction and exchange among students and instructors. It allows instructors and students to access a wealth of multimedia information, tutorials, live data, and assessment tools that replicate and expand the traditional classroom. It has also been proven effective for storing, disseminating, and retrieving information that is relevant to the course, and it is available to students anytime and anywhere (Aggarwal & Bento, 2000).

Although some studies indicate that technology-assisted instruction benefits students, other studies have shown no significant differences in student learning between the technology-assisted classroom and traditional classes (Butler & Mautz, 1996; Clark, 1983; Kozma, 1991). Some students performed better when they were exposed to computer-assisted learning tools, whereas others had better exam scores under the lecture format without computer-aided instruction (Ott, Mann, & Moores, 1990).

Given these varied results and the fact that an increasing number of instructors are using technology-assisted instruction in their classes, this research was undertaken to provide a better understanding of students' use of technology offered by the instructor relative to their standard and more traditional methods of learning and preparing for class and exams. It is also important to understand the effect of students' use of technology compared to standard learning methods in terms of their attendance and performance on exams. Instructors have questioned whether technology tools such as PowerPoint deter students from attending class and if technology use is valuable in enhancing their performance. Past research has not yet addressed how students integrate their use of technology with traditional learning methods or the extent to which technology use and preferences influences their performance.

STATEMENT OF PROBLEM

Many college instructors are struggling to learn new technologies and to see how they might be useful to them as teachers. They invest their efforts in incorporating computer-assisted presentation in instruction, creating course Web

sites and using the sites to provide students access to the lecture notes, PowerPoint slides, and practice quizzes. Given the investment of time and resources in developing multimedia presentations and maintaining course Web sites, it would be useful for instructors to know the extent to which students access and utilize the resources in and outside of classes in preparing for class and exams. Also of interest is whether students' preference for using technology to prepare for class and exams is superior to traditional learning methods in maximizing their exam performance. Lastly, instructors have questioned if the availability and use of technology outside the classroom inhibits class attendance and whether students view technology as an effective substitute for attendance in terms of maximizing their performance in the class.

RESEARCH QUESTIONS

The following research questions were addressed in this study:

1. To what extent do students take advantage of the technology provided by an instructor (accessing a course Web site and downloading PowerPoint slides) to prepare for class and exams compared to standard learning methods (effort reading the text, taking notes in class and from the book, etc.)?
2. Are students who access PowerPoint slides on a course Web site less likely to attend class?
3. Are students who utilize the technology (accessing the Web site and downloading PowerPoint slides) more likely to have enhanced exam performance than students who don't utilize the technology?
4. To what extent does students' use of technology (accessing the Web site and downloading PowerPoint slides) correlate with standard/traditional learning methods and their performance?

METHOD

Participants

A total of 79 undergraduate students enrolled in one of two sections of a Promotional Strategy course participated in the study. These participants represented 95% of students enrolled in the classes. Students were juniors (53%) and seniors (47%) and 55% of students participating were male (45% female). The majority of students had majors within the School of Management (72%). The other 28% of students could be classified as Arts & Science students, and come from a variety of areas, such as economics, bachelor's degree with independent concentration, English, exchange students, biology, etc.

Procedure

Data were collected online from students at the end of the semester. Students had one week to complete the online survey and were awarded extra credit for their participation. Throughout the semester, the instructor kept a record of students' attendance for later analysis. Students' average score on three exams was also computed at the end of the semester for use in the analysis. Exams were comprised of multiple choice and essay questions drawn from material in

the text and discussed in class, including concepts illustrated by the video clips used in class (but not particular questions about the video clips themselves). All material presented in class was also highlighted on the PowerPoint slides.

During the semester, the instructor integrated technology into the course in a variety of ways. First, class sessions were conducted using computer-assisted presentations (PowerPoint) that incorporated multimedia such as video clips, print ads, and live Web links used as examples. All students who attended class each day were exposed to the video clips embedded in the PowerPoint slides. Those clips were selected from videotapes provided by the author and publisher of the text and used as a springboard for discussion of the concept they reinforced. Second, a course Web site was developed to allow students to download the PowerPoint slides used in class, access the syllabus, semester schedule, assignments, their exam grades, and online practice quizzes. Video clips embedded in the PowerPoint slides in class were not available for viewing on the Web site as a precaution to avoid potential copyright issues. The PowerPoint slides for the entire semester were available on the Web site at the beginning of the course.

Research Design

Students had options on their exposure and access to the technology provided by the instructor as well as their engagement in standard learning methods as they attempted to learn the course material and maximize their performance in the course. Thus, the extent to which technology and standard learning methods affected their performance was assessed in a variety of ways.

First, usage of the various technology-driven and standard/traditional learning methods for students as a whole was examined. This allowed a comparison of strategies for using one method versus another method. In addition, students were classified as high or low on each of these two learning dimensions (use of technology and standard/traditional learning methods), recognizing that some students will actively utilize both technological and standard learning methods while others may prefer the use of technology over standard methods of preparation and vice versa. When students were classified in this manner, the two dimensions were treated as independent/blocking variables in an ANOVA with students' exam performance (exam average) and attendance as the dependent variables of interest. This design allowed an assessment of how students' learning choices (use of technology and standard/traditional learning strategies) affected their performance on exams and their class attendance. In addition to performance, attendance was considered an important dependent measure relative to the availability and use of technology by students. Finally, the relationship between performance, attendance, technology use, and standard learning methods was examined in a correlation analysis to assess the relative relationship of students' technology-driven learning methods versus standard learning methods relative to exam performance.

Students responded to several items designed to assess their use of technology and standard learning methods in preparing for class and exams. The items designed to assess students' use of technology included: (a) downloading PowerPoint slides from the Web site before class, (b) taking notes using PowerPoint

slides downloaded, (c) taking practice quizzes on the Web site before the tests, and (d) reviewing PowerPoint slides before the test. Items considered to reflect standard or traditional learning methods included: (a) paying attention and taking notes in class, (b) reading relevant chapters in the book before coming to class, (c) taking special note of things discussed in class as they read the book, (d) reviewing for a test more than one day before it is given, (e) reading chapters in the text throughout the semester and reviewing them before the test, and (f) reviewing class notes before the test. These items were all measured on a five point Likert scale that included "always," "usually," "sometimes," "rarely," and "never."

A 2 x 2 between-subjects ANOVA was planned with standard/traditional preparation and use of technology as the independent (blocking) variables and attendance and performance as the dependent variables. Given the sample size, care was taken to classify all students on each dimension while maintaining a sufficient distinction between those scoring high and low.

RESULTS

Student Learning Preference (Research Question 1)

The first research question addressed the extent to which students used technology to prepare for class and exams relative to standard preparation methods. Results suggest that students are taking advantage of the technology provided by the instructor. As indicated in Table 1, many students are downloading the PowerPoint slides from the Web site before class (M = 3.37, SD = 1.52) and using them to take notes in class (M = 3.67, SD = 1.38). In examining the frequency of response, it was found that approximately 54% of students always or usually downloaded PowerPoint slides from the Web site before coming to class, while 62% always or usually took notes using the PowerPoint slides they downloaded. (See Table 2, page 300.)

Table 1: Students' Preference for Technology versus Traditional Preparation Methods

	Mean	Std. Dev.
I pay attention in class.	4.18	.66
I take notes in class	3.82	.87
I take notes using the PowerPoint slides I downloaded.	3.67	1.38
I download PowerPoint slides from the Web site before class.	3.37	1.52
I read the relevant chapters in the book before I come to class.	2.86	1.23
As I am reading the book, I take special note of things discussed in class.	3.17	1.52
I review for a test more than one day before it is given.	4.03	.97
I read chapters in the book as we go along and review them again before the test.	3.41	1.36
I review my class notes before the test.	4.51	.86
I download PowerPoint slides from the Web site right before a test.	2.77	1.57
I take practice quizzes on the Web site before the test.	3.87	1.17
I review PowerPoint slides before the test.	4.42	1.04

Table 2: Response Frequencies of Students' Use of Technology And Standard Learning Methods

	Always	Usually	Sometimes	Rarely	Never
I pay attention in class.	29.1	62.0	6.3	2.5	0
I take notes in class	21.9	46.6	23.3	8.2	0
I take notes using the PowerPoint slides I downloaded.	38.4	23.3	17.8	8.2	12.3
I download PowerPoint slides from the Web site before class.	33.3	20.5	15.4	11.5	19.2
I read the relevant chapters in the book before I come to class.	9.0	24.4	28.2	20.5	17.9
As I am reading the book, I take special note of things discussed in class.	19.7	23.7	26.3	14.5	15.8
I review for a test more than one day before it is given.	39.2	31.6	22.8	5.1	1.3
I read chapters in the book as we go along and review them again before the test.	28.2	23.1	23.1	12.8	12.8
I review my class notes before the test.	69.2	17.9	9.0	2.6	1.3
I download PowerPoint slides from the Web site right before a test.	21.8	16.7	9.0	21.8	30.8
I take practice quizzes on the Web site before the test.	39.7	25.6	20.5	10.3	3.8
I review PowerPoint slides before the test.	69.2	15.4	6.4	6.4	2.6

Students were somewhat more reliant on PowerPoint slides in preparing for class (M = 3.37, SD =1.52) than reading the relevant chapters in the book (M = 2.86, SD = 1.23) and taking notes from the book (M = 3.17, SD = 1.34). In preparing for exams, students took advantage of the online practice quizzes (M = 3.87, SD = 1.17) and similarly reviewed both their PowerPoint slides before the test (M = 4.42, SD = 1.04) and their class notes (M = 4.51, SD = .86). Approximately 65% of students always or usually took practice quizzes on the Web site before the tests while 84% of students always or usually reviewed their PowerPoint slides before the test. Students were less likely, however, to review the chapters in the book again before the test (only 51% always or usually did, M = 3.41, SD = 1.36), perhaps suggesting that they are more reliant on their notes and slides.

Effect of Technology and Standard Learning Methods on Attendance And Performance

In order to understand the effect of technology on students' attendance and performance, students were categorized into one of four groups based on their use of technology and standard learning methods (whether they were considered high or low on each of the two dimensions). The items loading on the two dimensions (technology and standard learning methods) were determined by a principal component analysis with varimax rotation. Two components emerged with eigenvalues greater than 1 from the rotated component matrix of all items, a standard/traditional preparation component and a technology component.

The traditional preparation component included three measures: "I read the relevant chapters in the book before I come to class," "As I am reading the book, I take special note of things discussed in class," and "I read chapters in the book as we go along and review them again before the test." These three items had a reliability of .81. The technology component was also comprised of three measures, "I take notes using the PowerPoint slides I downloaded," "I download PowerPoint slides off the Web site before class," and "I review PowerPoint slides before the test." The reliability of these items was .77.

Students were classified as high or low on each of these two dimensions based on their mean score on each dimension and where they fell on the overall distribution for each dimension. If a student scored above (below) the mid-point in the distribution, they were classified as high (low) on the dimension. Thus, students classified as high on the traditional preparation component had a mean composite score on this dimension greater than or equal to 3.33 (while those scoring low on the dimension had a mean composite score less than or equal to 3.0). Students classified as high on the technology component had a mean composite score greater than or equal to 4.0 (while those scoring low on this dimension had a mean composite score less than or equal to 3.67). This dichotomous classification of the two independent variables is supported by studies in psychology and marketing (MacCallum, Zhang, Preacher, & Rucker, 2002). It is a commonly used method in behavioral research and the social sciences (MacCallum et al., 2002). Dichotomization offers a conservative test of the relationship between the use of technology and traditional learning methods and performance. It results in some loss of information, effect size, and power, but finding a significant relationship is indicative of a stronger relationship between the variables in the research.

Access of PowerPoint Slides and Attendance (Research Question 2)

In order to determine whether students' use of technology had a significant effect on their attendance, a 2 x 2 ANOVA (Technology x Standard Learning Methods) was run with attendance as the dependent measure. The lack of a significant main effect for the technology variable ($F(1,68) = .139$, $p = .71$) suggests that students who tended to use technology for in-class learning and preparing for the exams were not less likely to attend class than students who didn't tend to use the technology. (See Table 3, page 302.) However, a significant interaction between the technology dimension and standard/traditional preparation dimension (T x S) did emerge ($F(1,68) = 6.54$, $p = .013$) and suggests that attendance was highest among students who were categorized as high on the technology dimension and low on the standard/traditional preparation dimension ($M = 84.89$, $SD = 14.83$) and those students categorized as high on the standard/traditional preparation dimension and low on the technology dimension ($M = 84.29$, $SD = 14.32$). Conversely, the lowest attendance percentage ($M = 74.07$, $SD = 18.10$ and $M = 76.23$, $SD = 15.01$, respectively) appeared among those students who were classified as low on both the traditional and technology dimensions and high on both the traditional and technology dimensions. (See Figure 1, page 302.)

Table 3: Effect of Technology Use and Standard Preparation On Attendance

Source	*df*	*F*	*p*
Technology (T)	1	.139	.710
Standard (S)	1	.044	.834
T x S	1	6.545	.013 **

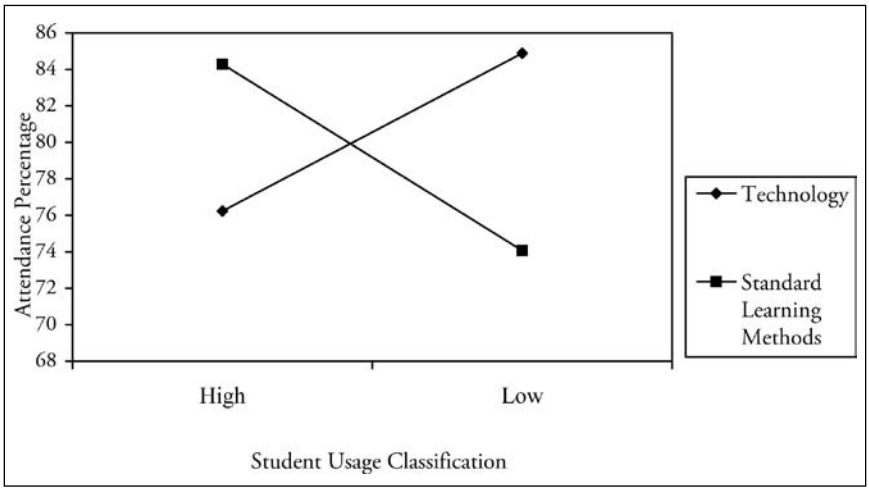

Figure 1. Interaction of Technology Use and Standard Preparation On Attendance.

Table 4: Mean of Attendance Percentage By Student Classification (Research Question 2)

Group	1	2	3	4
	Low Tech Low Std/Trd (n = 14)	Low Tech High Std/Trd (n = 17)	High Tech Low Std/Trd (n = 19)	High Tech High Std/Trd (n = 22)
Attendance %	74.07	84.29	84.89	76.23

Groups	T	df	Sign. (1 tailed)
1 vs 2	1.83	68	.035
1 vs 3	1.99	68	.026
1 vs 4	.41	68	.342
2 vs 3	-.12	68	.454
2 vs 4	-1.62	68	.055
3 vs 4	-1.79	68	.039

In addition, t-tests revealed that students low on both technology and standard/traditional learning methods had a significantly lower attendance rate than students who were low on technology and high on standard/traditional learning methods, $t(68) = 1.83$, $p = .054$ (one-tailed) and students who were high on technology and low on standard/traditional learning methods, $t(68) = 1.99$, $p = .026$ (one-tailed). Similarly, students who were high on both technology and standard/traditional learning methods had a significantly lower attendance rate

than students who were low on technology and high on standard/traditional learning methods, $t(68) = -1.62$, $p = .055$ (one-tailed) and students who were high on technology and low on standard/traditional learning methods, $t(68) = -1.79$, $p = .039$ (one-tailed). The results suggest that students who were classified as high on both learning methods (high on using technology and standard learning methods) may have felt less of a need to attend class. Table 4 provides the mean attendance percentages of each group and the t-test results.

Use of Technology and Exam Performance (Research Question 3)

In determining whether students who were high on technology use were more likely to have enhanced performance relative to those who used technology less often, a 2 x 2 ANOVA (Technology x Standard Learning Methods) was run with students' exam average as the dependent measure. A main effect for technology did not results ($F(1,67) = .303$, $p = .58$) but a T x S interaction (Technology x Standard Learning Methods) did occur ($F(1,67) = 3.908$, $p = .05$). (See Table 5.) The results suggest that technology use alone didn't enhance students' performance, but that the combination of high (low) technology with low (high) traditional preparation methods did affect performance. Exam averages were highest among students who were classified as high on traditional preparation methods and low on technology use ($M = 86.02$, $SD = 10.84$) and students who were classified as high on technology use and low on traditional preparation methods ($M = 83.13$, $SD = 9.03$). Exam averages were lowest among students who were

Table 5: Effect of Technology Use and Standard Preparation On Performance (Exam Average)

Source	*df*	*F*	*p*
Technology (T)	1	.303	.584
Standard (S)	1	.223	.639
T x S	1	3.908	.052

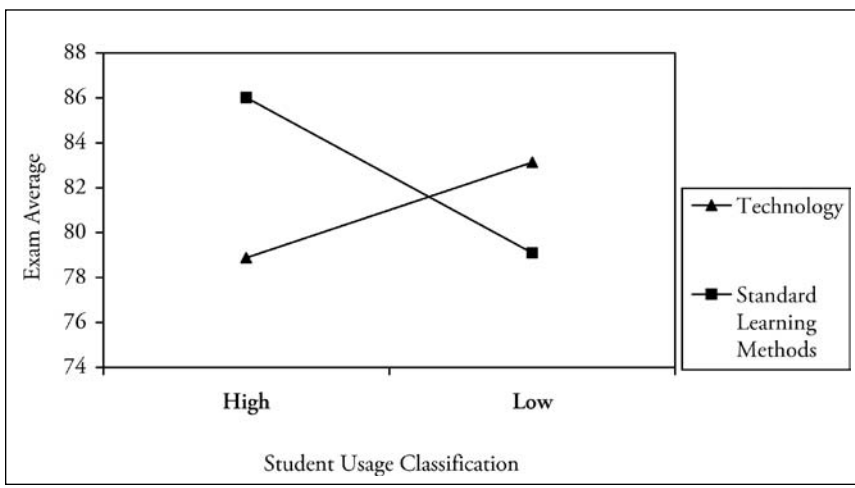

Figure 2. Interaction of Technology Use and Standard Preparation On Performance (Exam Average).

Table 6: Mean of Exam Average by Student Classification (Research Question 3)

Group	1	2	3	4
	Low Tech Low Std/Trd (n = 14)	Low Tech High Std/Trd (n = 17)	High Tech Low Std/Trd (n = 19)	High Tech High Std/Trd (n = 22)
Exam Average %	79.10	86.02	83.13	78.88

Groups	T	df	Sign. (1 tailed)
1 vs 2	1.63	67	.054
1 vs 3	.96	67	.169
1 vs 4	-.05	67	.478
2 vs 3	.73	67	.235
2 vs 4	-1.88	67	.032
3 vs 4	-1.14	67	.129

classified as high on both dimensions (M = 78.88, SD = 14.41) and low on both dimensions (M = 79.10, SD = 11.17). (See Figure 2, page 303.) The t-tests between these two groups also validated the same result; students classified as low on both dimensions and high on both dimensions had a significantly lower exam average than students classified as low on technology and high on standard/tradition methods, $t(67) = 1.63$, $p = .054$ (one-tailed) and $t(67) = -1.88$, $p = .032$ (one-tailed). Thus, as noted in Table 5 and Figure 2, a similar pattern of results emerged for performance (exam average) as that found when attendance was the dependent variable in the analysis. In addition, an analysis of covariance (ANCOVA) run with technology use and standard/traditional preparation methods as independent variables and attendance as a covariate revealed that attendance was a significant covariate for exam average ($F(1,66) = 4.996$, $p = .029$). (See Table 6.)

Relationship Between Use of Technology and Traditional Learning Methods (Research Question 4)

The final research question examines the extent to which the use of technology (e.g., PowerPoint and Web site access) correlates with the use of standard/traditional learning methods and performance. This allows an understanding of the relationship between students' use of technology and standard/traditional learning methods as well as how both learning methods relate to their performance.

Results suggest that students who prefer technology-driven learning methods (e.g., PowerPoint to take notes) are significantly more likely to make note of information discussed in class when reading the text ($R^2 = .28$, $p = .019$), a standard (traditional) learning method. Students who download PowerPoint slides before coming to class (technology-driven) are significantly more likely to read the relevant chapters before class ($R^2 = .25$, $p = .031$). Those who review PowerPoint slides before the exam are also more likely to use standard/traditional learning methods such as reading relevant chapters before class ($R^2 = .33$, $p = .003$), making note of information discussed in class while reading the text

Table 7: Intercorrelations between Technology-Driven and Standard Learning Methods, and Attendance, and Performance (Exam Average)

		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1.	Performance (Exam Average)	-	.29*	-.24*	-.13	-.09	-.01	.08	.19	-.03	-.10	.08	-.01	-.12	.09
2.	Attendance %		-	-.02	-.16	-.08	-.06	-.01	.01	.30*	-.16	-.11	.03	-.09	.08
Technology-driven Learning Methods															
3.	Take Notes using PP			-	.70**	.14	.19	.40**	.13	-.01	.23	.28*	.12	.13	-.06
4.	Download PP before Class				-	-.01	.22*	.51**	.11	-.07	.25*	.14	.22	.11	.06
5.	Download PP Right Before Test					-	.19	.21	-.08	.25*	.38**	.29*	.16	.43**	.18
6.	Practice Quizzes						-	.17	-.13	-.01	.20	.21	.23*	.33**	.02
7.	Review PP before Test							-	.05	.09	.34**	.40**	.55**	.27*	.35**
Standard (Traditional) Learning Methods															
8.	Pay Attention								-	.27*	.13	.22	.07	-.11	.06
9.	Take Notes in Class									-	.26*	.19	.15	.22	.26*
10.	Read Relevant Chs. Before Class										-	.59**	.50**	.65**	.16
11.	When Reading the Text, Make Note of Info Discussed In Class											-	.41**	.53**	.25*
12.	Review for Test More Than One Day Before Test												-	.47**	.23*
13.	Read Chapters as Discussed and Review Again Before Test													-	.19
14.	Review Class Notes Before Test														-

** Significance < .05; ** Significance <.01*

(R^2 = .40, p = .001), reviewing for a test more than one day before it is given (R^2 = .55, p = .001), reading chapters as discussed in class and reviewing them again before the test (R^2 = .27, p = .017), and reviewing their class notes before the test (R^2 = .35 p= .002). These students appear to have better preparation skills for class and exams. However, students who wait to download the PowerPoint slides until right before the exam are different from the previous group in that they aren't significantly more likely to review for a test more than one day before it is given or review class notes before the exam. They are significantly more likely to read chapters as discussed and review them again before the test (R^2 = .43, p = .001) and read relevant chapters before class (R^2 = .38, p= .001). These same students are more likely to take notes in class (R^2 = .25, p = .031) and when reading the text, make note of information discussed in class (R^2 = .29, p = .012). It appears that these students rely more on their standard/traditional learning methods and use PowerPoint more as a backup study strategy. Intercorrelations appear in Table 7.

The results also showed that students who take practice quizzes are significantly more likely to read chapters discussed and review them again before the test (R^2 = .33, p = .003) and review for a test more than one day before it is given (R^2 = .23, p = .043). These students appear to have a superior exam preparation strategy, as they utilize the technology to further enhance their performance.

An examination of the variables most highly correlated with performance (exam average) indicated that attendance was the most highly correlated variable (R^2 = .29, p = .016). No one preparation method was significantly correlated with performance. However, performance was negatively correlated with taking notes in class using PowerPoint slides (R^2 = -.24, p= .051).

DISCUSSION

We expected that technology would be a valuable learning tool but not a substitute for attendance and that many but not all students would take advantage of technology and use it to enhance their exam performance. In addition, it was expected that there would be more than one path to superior performance and those students who embraced more standard (traditional) learning methods could perform as well as those favoring more technology-driven learning methods.

This study showed that the majority of students appear to be integrating the technology offered by the instructor (Web site, PowerPoint slides, and online practice quizzes) into their course preparation and study routine. They are downloading the PowerPoint slides from the Web site before class and using them to take notes in class. They actually rely on the technology more in preparing for class (by downloading PowerPoint slides) than reading relevant chapters in the book before class. In preparing for the exams, students are as likely to review their PowerPoint slides as they are to review their class notes. Students also took advantage of the online practice quizzes in preparing for exams, although to a lesser degree than their review of PowerPoint slides and class notes. This study also showed that students were less likely to review the chapters in the book again in preparing for tests, perhaps suggesting that they are over reliant on their notes and PowerPoint slides.

Students who tended to use technology for in-class learning and preparing for the exams were not deterred from attending class compared to students who utilized the technology less often. However, an interaction between the technology and standard/traditional preparation methods suggested that attendance and exam performance was highest among students who were more reliant on either technology or standard learning methods for class preparation and exam preparation. Students categorized as low on both technology and standard/traditional learning methods or high on technology and standard/traditional learning methods had a significantly lower attendance rate and exam performance than students who were categorized as low on technology use and high on standard/traditional learning methods or high on technology and low on standard/traditional learning methods. The authors question whether students who were categorized as high on both learning methods were less motivated to attend class and thus sacrificed the learning that could have occurred in class discussion through the multimedia presentations including the digital video clips that reinforced important concepts. They also may have forfeited the benefits of class discussion relative to the concepts presented on the PowerPoint slides and related video clips. These students were actually similar in terms of class attendance and exam performance to students who were categorized as low on both learning methods. The latter group of students appear to be less prepared for class and exams overall.

Students integrated technology-driven learning methods with their standard/traditional learning methods. For example, those who reviewed PowerPoint slides and took practice quizzes before the exam were significantly more likely to read chapters as they were discussed and review them again before the exam. However, attendance was the variable most highly correlated with performance and students' use of a particular learning method alone was not a strong predic-

tor of their exam performance. Students' exposure to multimedia in class and related class discussions appeared to enhance their performance, although the present study does not experimentally test this.

Some students in this study chose a more technology-driven route while others chose a more traditional route and both were able to able to maximize their performance given that they attended class and gained the benefits of the multimedia presentation and discussion. Previous research has supported the importance of class attendance on performance (Chan & Shum, 1997; Devadoss & Foltz, 1996; Durden & Ellis, 1995; Launius, 1997; Romer, 1993) and the value of computer-assisted presentations and multimedia used in the classroom in terms of helping students remember what they were learning, enhancing their interest in learning the subject, and improving their understanding of course material (Debevec & Shih, 2005).

Future research should address the generalizability of the findings to courses outside of the business school and in other disciplines. For example, research could investigate whether students in other disciplines also rely more on technology in preparing for class and exams than traditional learning methods. The current research was limited to two classes in the School of Management. In addition, an even broader range of technology tools could be assessed relative to student attendance and performance such as the in-class personal response technology, Web-based readings, and links provided to guide student research and so on. The present study examined use of basic technology tools that instructors tend to adopt first, in addition to considering the potential effect of embedded digital video clips (to which students attending class were exposed), a multimedia tool requiring a significant investment of time for instructors. The latter was assumed to have an effect on students' class attendance, but the data did not support this. Future research could examine the effect of technology on attendance in an experimental context.

Our data suggest that there is more than one path to optimize student learning and performance. It is the instructors' challenge to adopt appropriate technology to support and create different types of learning environments that replicate and expand the traditional classroom to enhance students' learning experiences and maximize their performance.

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