Engaging college science students and changing academic achievement with technology: A quasi-experimental preliminary investigation

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A R T I C L E   I N F O
Article history:
Received 27 February 2008
Received in revised form 10 September 2008
Accepted 12 September 2008

Keywords:
Student engagement
Academic achievement
Technology
Science education
College students

A B S T R A C T
Can modern, computer-based technology engage college students and improve their academic achievement in college? Although numerous examples detail technology’s classroom uses, few studies empirically examine whether technologically oriented pedagogical changes factually lead to positive outcomes among college students. In this pilot study, we used a quasi-experimental design to examine whether a technology enhanced research methods classroom led to increased student engagement and academic achievement among college students. Two features generally characterized the technology enhanced classroom experience: specific feedback generated from recordings of small group discussions and podcasts of class recordings. Technology enhanced classroom students demonstrated statistically significant increases in student engagement and improved academic achievement. These findings support previous efforts to use technology to enhance engagement and achievement among college students and they encourage future efforts.

1. Introduction

Technology offers unimagined pedagogical opportunities to transform student learning (Jonassen, 1996; Resta & Laferrière, 2007), including students of science. Although technology can describe nearly any tool, here we define technology relatively narrowly to include computer-based hardware and software employed in the classroom. Multimedia presentations can enhance exposure to multifaceted, intricate problems across different representational forms (Pellegrino, 1995) and this can serve to increase learning (Halpern, 1998). Professors may also employ technological techniques to increase student engagement (Pemberton, Borrego, & Cohen, 2006). Increased engagement; broadly defined to include numerous aspects of class participation, class interest, number of completed assignments, informal and formal student collaborations, other required and optional student work and interactions, as well as student initiated attempts to incorporate the material into their life; correlates with increased academic achievement (Kuh et al., 2005; Newman, 1992), decreased absenteeism (Galichon & Friedman, 1985), and other general positive academic outcomes (Kuh et al., 2005; Newman, 1992). For traditionally disengaging and distancing subjects like research methods that examine the scientific method in detail, students frequently leave class hoping never to engage in science again (Newman, 1998). To address this, more professors could incorporate technology into their classrooms to engage students and foster achievement (Pellegrino, 1995).

Perhaps one reason professors do not utilize technology results from the relative paucity of studies examining its effectiveness. Although some studies have supported technology’s contributions (cf., Forsyth & Archer, 1997; Pemberton et al., 2006), surprisingly, little systematic, scientifically rigorous research evaluates the effectiveness of technological contributions, and even less examines the mechanisms by which these technologies foster (or fail to foster, cf., DeBord, Aruguete, & Muhlig, 2004) positive outcomes (Phipps & Merisotis, 1999). Despite repeated calls for evaluations, systematic, empirical research in this field remains lacking (Moore, 2007). Thus, while numerous applications of technology have been suggested and adopted (Jonassen, 1996; Resta & Laferrière, 2007), the determinants and predictors of success (and failure) go unaddressed. Moreover, professors may find themselves struggling to determine how they might evaluate the efficacy of changes in their specific classes. The current examination, a pilot study, sought to address these concerns by implementing a quasi-experimental design to evaluate whether a technology enhanced classroom (TEC) led to increased student engagement and achievement in a research methods in psychology class. This research gives an example of how one might use the TEC to increase engagement (described below), provides professors with an illustration of the quasi-experimental design to examine change generally, and systematically evaluates whether the TEC elevated student engagement or academic achievement.
Quasi-experimental designs make use of pre-existing groups to examine the effects of an experimental manipulation (Shadish, Cook, & Campbell, 2002). This method provides a particularly appropriate opportunity to professors who teach multiple sections of the same class, by introducing change to one class, e.g., the TEC, and holding other variables as constant as possible, e.g., teaching a separate section identically but without the technological enhancement, one can examine change associated with the pedagogical manipulation. This method lacks the strong causal attributions possible in experimental designs, but we can rarely assign students to classes and comparing a pedagogical manipulation across pre-existing classes provides a better method for evaluation than case studies and other less rigorous designs (Shadish, 2006). Professors may adopt the technique solely to decide whether to introduce a change in their own future classes, or, perhaps, as concerned us, one might use the practice as a pilot study to provide the basis for a more programmatic, institution-wide pedagogical investigation. Without initial pilot studies, larger scale research that requires substantial investments of time and money (e.g., additional costly technology) can rarely occur. A professor’s investment in their own future classes or an institution’s investment in programmatic research should not occur without some empirical and systematic demonstration of effectiveness. Quasi-experimental designs provide this opportunity.

We used this method to examine whether students learning the scientific method who experienced a TEC classroom (the experimental manipulation) that primarily used technology to provide students with superior feedback on group discussions (see description below) demonstrated increased engagement and improved academic achievement. Cognitive, social and evolutionary psychology all express numerous conduits by which feedback leads to learning and engagement (Bangert-Drowns, Kulik, Kulik, & Morgan, 1991; Butler & Winne, 1995; Halpern & Hakel, 2002; Pinker, 2002; Williams, Harkins, & Latané, 1981). As a result, we hypothesized that increasing the specificity and immediacy of feedback, as well as the professor’s presence (Garrison & Archer, 2000; Rourke, Anderson, Garrison, & Archer, 1999), through a TEC would lead to increased student engagement on a standardized measure of student engagement and lead to positive changes in students’ academic achievement.

2. Methods

2.1. Participants

Participants \( n = 25 \) included students enrolled in two sections of an undergraduate research methods in psychology class offered in the summer semester at a midsized, public, primarily undergraduate, comprehensive university in the Southeast US. At this university, a section refers to one of several offerings of a particular class. For the class studied here, research methods in psychology, the same professor taught both sections. Students in the TEC had a mean age of 25.24 (STD = 7.37; range: 20–52) and students in the control classroom had a mean age of 24.33 (STD = 7; range: 19–38). In both classes, participants were primarily female (72% and 67%, respectively) and predominately juniors and seniors.

2.2. Procedure

At this university, the Department of Psychology offers a research methods in psychology class. We randomly chose one of two available class sections to receive the experimental manipulation, i.e., the technology enhanced classroom, and the other served as the control class. The first author taught both.

2.2.1. General research methods classroom experience

Both class sections (control and TEC) met biweekly and a single instructor taught each. Both sections regularly experienced short lectures (identical in content) based in class-wide discussion (which differed to some extent given that students asked different questions across the sections). Both sections completed identical assignments at the same times across the entire semester. These included numerous individually authored chapter-based writings, frequent small group discussions that focused on developing collaborative communication and critical thinking skills, and short coauthored papers based on the small group discussions that focused on transferring discussion material to new topics and augmented written collaborative communication. Both sections received identical midterms and final exams given at the same points in the semester. Each section submitted assignments and received class-wide and individualized feedback via section specific Blackboard (Bb) sites. Formative feedback extended beyond simple “right/wrong” guidance, and instead used examples to model and highlight aspects of the process of scientific inquiry. With the exceptions noted below, the Bb experience delivered to students across the sections did not differ. The control group received the general research methods classroom experience.

2.2.2. Technology enhanced classroom (TEC) (experimental class)

The experimental pedagogical manipulation in the TEC consisted of two main features. First, the professor recorded all small group discussions for each group using portable audio devices, e.g., iPods. Widely available software, e.g., iTunes, allowed the professor to rapidly (within 1–2 days) transfer the recordings to a computer and listen to short, randomly selected pieces of the recordings to concretely augment group specific and individualized feedback with examples taken from the actual discussions. The recordings allowed students to feel the professor effectively participated in all of the groups all of the time. Additionally, we hoped that recording the sessions would allow the students to focus on the discussion itself and minimize their attention to a feeling that they must arrive at a concrete end. Finally, the software allowed the professor to easily manage and organize the set of recordings, as well as rapidly process the recordings. Second, the professor recorded all lectures and delivered them via Bb within 24 h as a download or as a podcast (students could subscribe to an RSS feed directly through Bb or publically via any available podcatching software, e.g., iTunes).

2.3. Measures

2.3.1. Achievement

Using academic records, we objectively examined students’ academic achievement in this class across several course components: average scores on regular, chapter-based individually authored papers; average scores on “other” assignments, e.g., collaborative papers based...
on in class group discussions; midterm exam scores; final exam scores; and a final course grade based on a weighted summary of the course components. For both TEC and control, Blackboard allowed the professor to download all assignments without students' names as identifiers. This allowed the professor to grade all assignments blind to students' class membership (TEC vs. control).

### 2.3.2. Engagement

Students anonymously self-reported their engagement at the end of the semester using the classroom survey of student engagement (CLASSE: Ouimet & Smallwood, 2005), a standardized measure of classroom engagement adapted with permission from the national survey of student engagement (NSSE: Kuh, 2001). On a four point Likert scale (e.g., “Never”, “1–2 Times”, “3–5 Times” and “More than 5 Times”), 30 items assess behaviors associated with student engagement inside and outside of the classroom, including but not limited to: asking questions in class, note taking in class, communicating with the professor outside of class, study time and behaviors (e.g., note reviewing) outside of class, discussing class ideas with family and friends, etc.

The NSSE collects institution level information, e.g., at your institution how often did you contribute to a class discussion. The CLASSE differs only in its class specific information collection, e.g., how often did you come to your research methods class without having completed the readings. No published data specifically address the psychometric properties of the CLASSE. However, psychometric data for the NSSE (Kuh, 2001) demonstrate appropriate validity and reliability, e.g., coefficient alphas of 0.85 and 0.90. Given minimal between survey differences we expect similar findings would result for the CLASSE, however some caution is warranted.

### 3. Results

Given the a priori directional nature of our hypotheses and the fact that the small sample size included in our pilot study limited power, we used one-tailed t-tests to examine change in engagement and achievement across the TEC and control students. Research (Clason & Dormody, 1994; Sisson & Stocker, 1989) supports the use of t-tests with the Likert type response options used on the CLASSE (e.g., options correspond to clearly defined frequencies). However, research does not support the use of t-tests with the more ordinal letter grades. Thus, we used the Wilcoxon–Mann–Whitney U-test to examine differences in final grades. TEC students endorsed elevated, statistically significant differences for several engagement items. Students in the TEC classroom reported that, on average, they more frequently contributed to class discussions ($t = 1.94, 23, p = 0.04, d = 0.74, CI_{95} = 0.95, 0.32$), took more notes in class on average ($t = 1.57, 23, p = 0.02, d = 0.58, CI_{95} = 0.69, 0.23$), and, on average, they more frequently reviewed their notes prior to class ($t = 2.00, 23, p = 0.03, d = 0.83, CI_{95} = 1.06, 0.35$). Moreover, across the entire set of CLASSE item differences, students in the TEC generally endorsed increased engagement. Effects sizes, as measured by Cohen’s $d$ (Cohen, 1988), ranged from 0.02 to 0.8, and averaged 0.12. However, power ranged from 0.05 to 0.057, averaged 0.08, and limited our ability to confidently ascribe these differences to non-chance factors. With regard to academic achievement, TEC students demonstrated greater and statistically significant average chapter-based writing scores ($t = 1.93, 23, p = 0.03, d = 0.56, CI_{95} = 1.16, 0.92$) and, similarly, greater and statistically significant average mid-term exam scores ($t = 1.57, 23, p = 0.02, d = 0.58, CI_{95} = 0.69, 0.23$). Moreover, across the entire set of CLASSE item differences, students in the TEC generally endorsed increased achievement. Effects sizes, as measured by Cohen’s $d$, ranged from 0.00 to 0.56, and averaged 0.15. Resultantly, power ranged from 0.05 to 0.34, averaged 0.09. Table 1 presents the means, standard deviations, effects sizes, $t$-values, and confidence intervals for the statistically significant differences among the CLASSE items and achievement measures across groups.

### 4. Discussion

This preliminary investigation used a quasi-experimental design to examine the effects of a technology enhanced classroom (TEC) on student engagement and achievement in a research methods class. Using a standardized measure of student engagement, results showed that TEC students endorsed statistically significant changes in their reported levels of engagement. Recording small group discussions, providing timely formative feedback explicitly tied to each group’s discussion using the recordings, and delivering recordings of each class as podcasts lead to increased engagement. With regard to grades, TEC students also showed statistically significant improvement in their academic achievement. These findings support previous efforts to use computer-based technology to enhance engagement and achievement among college students (Forsyth & Archer, 1997; Pemberton et al., 2006) and bolster arguments regarding the expediency of similar endeavors in the future.

Several explanations may jointly account for these outcomes. With regard to engagement, findings from social psychology demonstrate that social loafing occurs more frequently in unmonitored group situations (Pink, 2002; Williams et al., 1981). Students’ awareness that the professor would listen to their discussions through recordings, i.e., monitor their discussion, may have decreased social loafing and increased discussion engagement by increasing the professor’s presence (Garrison & Archer, 2000; Rourke & Archer, 1999). Additionally, increased individual engagement may have allowed a deepened discussion that incorporated greater heterogeneity in perspectives and topics. Increased heterogeneity may have then augmented engagement in a circular fashion. Diverse viewpoints and topics may have allowed students new intellectual and conversational entry points and eased their entry to the discussion and subsequent engagement with

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1. Due to incomplete data for one student in each section (i.e., one TEC and one control student), we could only include 23 students’ CLASSE responses in our CLASSE analyses.
2. The set is available upon request.
the task. Finally, improved engagement in one course activity (discussion) may have generalized to enhanced engagement in other aspects of the course, thereby increasing engagement within and without the course.

Research also demonstrates that failure to receive any group work feedback, formative, summative, specific, or general, often limits students' motivation to participate a priori (Bonwell & Eison, 1991). Recording devices visually supported the instructor's explicitly stated intent to provide feedback, and perhaps knowing that they would (and then did) receive timely and specific feedback reduced motivational barriers and increased students' discussion engagement odds. Additionally, recordings allowed the professor to provide specific individualized feedback that included positive reinforcement for engagement behaviors. Positive reinforcement that tied unambiguously to the group's and the individual's achievements may have helped students appreciate the value of their contribution, reinforced future contributions and generally increased engagement.

Feedback resulting from recordings likely contributed to changes in achievement as well. Cognitive psychologists have consistently described the importance of frequent, specific, formative feedback in learning (Bangert-Drowns et al., 1991; Butler & Winne, 1995; Halpern & Hakel, 2002). By recording group discussions and using the recordings as a guide, the professor provided formative feedback to a given group as a whole and individuals within each group. This feedback addressed the unique and subtle nuisances that arose for each group and/or individual. Thus, while common errors or accomplishment arose across groups and individuals, the feedback students received tied to the discussion they experienced and provided a more specific guide for students' attempts to correct their misunderstandings. Finally, TEC students may have used class discussion recordings available via Bb and/or iTunes to augment their notes, review material they missed, prepare for exams, etc., which also may have served to increase their academic achievement.

In sum, empirical evidence from numerous psychological theories converges to posit a reasonable explanation for the fact that a technology-enhanced classroom experience led to statistically significant increases in student engagement and academic achievement relative to an identical classroom that did not receive the technological enhancement. Nevertheless, some aspects of the study limit the extent of the conclusions.

4.1. Limitations

This pilot study represents a step forward in evaluating the effects of a technology-enhanced classroom and it offers an example of how professors and institutions might systematically examine technology's effectiveness within their own classrooms and institutions. Despite its value, some features constrain the study. First, our inability to randomly assign students to classrooms limits our capacity to make causal inferences. Given the quasi-experimental design, we cannot unambiguously attribute differences in student engagement to our classroom manipulation. Second, given the pilot nature of the study, small sample sizes limited the study's ability to powerfully detect even large effect sizes (Cohen, 1988). Effect sizes ranged from 0.02 to 0.8, and averaged 0.12. Subsequently, power ranged from 0.05 to 0.057, and averaged 0.08. Thus, although the majority of differences suggested enhanced engagement and achievement for TEC students, we could not reliably attribute these differences to our manipulation. Third, it remains unclear to what extent these findings would generalize to other classes, differently sized classes, other universities, etc. Future efforts to replicate these findings using larger sample sizes, across different classes and class sizes, will simultaneously address these concerns. Finally, differential levels of assessment effort (e.g., time spent assessing student work) across the TEC and control classes may have contributed to the differences described here. Although technology-based assessment time added no more than 5 h to the TEC class as compared to the control class, future work better disentangling assessment time and technology should address this issue.

5. Conclusion

Notwithstanding its limitations, this study represents an important effort to evaluate technology's capability to affect student engagement and achievement, especially in the college classroom. We found that a technology enhanced classroom can increase both student achievement and engagement. The extent to which students engage with a course can increase transfer and support higher order learning (Halpern, 1998) and engagement predicts a number of important markers of academic success (Kuh et al., 2005; Newman, 1992). Despite hopeful, almost default, assumptions that technology will enhance student outcomes, professors must systematically establish that changes in their teaching do lead to improved outcomes. Additionally, because technology certainly comes at a financial cost, universities and professors need to empirically and systematically assess the consequences of technological additions to the classroom. This pilot study did both using a quasi-experimental design. It provides an example of how professors might evaluate pedagogical changes, demonstrates the potential positive contribution that TEC offer science professors and others, and posits some interesting explanations for these positive changes in engagement. As we begin to examine the manner in which technology affects engagement and learning, we need to seek the psychological underpinnings that lead to change. We look forward to future studies that replicate these findings and elucidate their foundations.

Acknowledgements

We thank Tara J. Carle and Margaret Carle for their unending support and guidance. Additionally, we thank Dan Richard for his insightful comments on an early version of this manuscript. The University of North Florida's office of Academic Affairs graciously provided financial support for the technology used in this study.

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