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Abstract

There is minimal research which makes the connection between mobile technology and improved student achievement. This study addressed the gap in the literature and considered the dynamic and fluid engagement mobile technology brings to the teaching and learning environment to improve student essay scores in the composition classroom. Freshman composition essay scores were collected over the course of five semesters: two semesters where the instructor did not teach with mobile application technology, and three semesters after adoption of mobile technology. There was a statistically significant difference in mean writing project scores, with the mobile technology curriculum producing higher mean scores for all three writing projects. The purpose of this study was to expand current research to consider the effects of student achievement when using mobile application technology, and to inform current pedagogical practices across all disciplines.

Introduction

As a growing number of higher education institutions attempt to meet the demands of a new generation of digital learners, faculty adoption of teaching with technology becomes a priority and a challenge (Myers, Bennett, Brown & Henderson, 2004; Phan, Paul, & Zhu, 2021.) Higher education institutions have been funding teaching-with-technology initiatives for years, yet adoption of technology in the college curriculum has not met expectations (Weimer, 2013). In fact, this conversation has been in existence for over two decades (Spotts, 1999).

The literature supports the fact that innovative teaching with technology may take years for faculty to adopt and feel comfortable (Anderson, 1997; Hall & Hord, 2011). It can be difficult to convince faculty that the technology is worth the effort, as traditional discussions have focused more on the technology rather than student achievement (Uslu & Usluel, 2019). It is pertinent that faculty see the results of innovative teaching with technology as a catalyst for adoption. The purpose of this study is to analyze the progression of an innovative teaching practice and its role in improved student achievement. The research question for this study is how does a progressive effort of innovative teaching using mobile technology affect student achievement in a university writing course in the United States?

Defining Teaching with Technology

College instructors do not, as a requirement, hold teaching credentials and are not necessarily trained in classroom management skills; it is a knowledge-based profession (Ingersoll & Perda, 2008). Professors are scholars who enter the teaching profession as experts in their field of study. But being an expert in the field of nursing, for example, does not necessarily mean that you will be able to effectively teach students the most recent medical practices in a classroom environment. However, as with other professions, we expect teachers to use technology to increase their effectiveness (Ertmer & Ottenbreit-Leftwich, 2010). But what does it mean to teach with technology?

Technology's adoption in higher education is typically grounded in online learning or flipped-classroom pedagogy. Both online and flipped-classroom teaching models rely heavily on course content delivered through instructor-created videos and tutorials. The theory behind both teaching models is to engage students in course content outside of the classroom (Heyborne & Perrett, 2016). Today's access to Internet information is foundational for student learning engagement and critical thinking (Peled, Pundak & Weiser-Biton, 2020). Mobile technology teaching, or m-learning, is different from online and flipped teaching in that content is created and delivered more simultaneously (Alrasheedi & Capretz, 2015; Cook, Bradley, Lance, Smith & Haynes, 2007). Student engagement via a mobile device in class is more organic. While laptops allow students to explore content creation, the sheer portability of tablet devices with features allowing for instant transfer of information from one device to another offers a more spontaneous platform for assessment or discussion (El-Hussein & Cronje, 2010; Sarrab, Al Shiibli & Bardursha, 2016; Seipold & Pachler 2011).

Mobile technology in education (m-learning) is a recent and potentially dynamic teaching philosophy. Teaching and learning exist in real-time content delivery and content creation (El-Hussein & Cronje, 2010). Mobile learning requires a shift from pre-existing teaching and learning strategies and is not contextualized in finding answers to questions; rather, m-learning is contextualized in creating questions that curate knowledge (Kress & Pachler, 2007; Nyiri, 2002). The flexibility of mobile devices allows for the creation of knowledge in multiple contexts, often student-driven, thus student-centered (Sarrab et al., 2016). It is not just the physical mobility of m-learning that is effective but also the shared experience of being involved in the learning environment.

Students share in creating knowledge (Sarrab et al., 2016). The authors do not imply that course-content is supplied by students; rather, they introduce the existence of new ways to learn existing content and new ways to enrich an existing curriculum. M-learning engages knowledge sharing through interaction amongst students and instructors inside the classroom (Al Emran & Shaalan, 2014). When students and the instructor become simultaneously engaged with potentially new course content through mobile devices, a natural shift in instructional format occurs (Schaber et al., 2010).

Paradigm Shift: From Deliverer of Knowledge to Facilitator of Knowledge

In a traditional lecture-based classroom, teaching is often focused on what the teacher knows and on unilateral

transmission of content (Weimer, 2013). The instructor relays content in the classroom to students who passively absorb it; this lecture environment does not stimulate content retention and does not promote critical thinking (Pachler, Bachmair, Cook & Kress, 2010; Woods, Felder, Stice & Rugarcia, 2000). While students may be absorbing the lecture information, they are not being asked to engage and actively reflect on the lecture content until they leave the classroom environment (Weimer, 2013).

Through mobile technology engagement and self-assessment, students begin to navigate the learning environment more actively. Students are not passively absorbing knowledge; rather, they are becoming transactional with the content being delivered; they transact with the lecture content via a mobile device in real time. There is a need for faculty in higher education to become knowledge facilitators rather than content deliverers (Laxman, 2011). Laxman (2011) addressed the importance of adjusting a traditional passive learning environment to a knowledge-building environment with the use of advanced technology. With technology and the Internet available in today's classrooms, students can search and build content knowledge for instructor feedback; the teaching and learning process flips.

A more student-centered teaching approach focuses on students creating content and engaging in collaborative learning activities. Weimer (2013) defines five elements of student-centered learning: engages students in learning, active rather than passive learning, offers students more agency of learning, encourages collaboration, and promotes reflection. Giving students more agency over their learning creates a shift in the balance of power (Weimer, 2013). With the use of technology in the classroom, learning becomes transactional; the instructor acts as a catalyst for learning and engagement (Seipold & Pachler 2011). Embracing this shift in the teaching environment may naturally transition faculty toward a cycle of progressive innovative practices.

Theoretical Framework

The shift in the teaching environment is a process of adoption. The Concerns-Based Adoption Model (CBAM) is recognized as a valid and reliable theoretical model to assess implementation of innovative practices in teaching (Anderson, 1997; Hall & Hord, 2011; Min, 2017), and is the theoretical framework for this study. CBAM looks at the practices and behaviors necessary for educators to adopt change (Roach, Kratochwill, & Frank, 2009). CBAM is an attempt to help educators and professional development administrators understand the process of change experienced by teachers when trying to adopt innovative practices (Molla & Lee, 2012).

CBAM was founded within the context that a specific innovation will be adopted. The theoretical model considers the process of the adoption and its ultimate integration (Hall, Wallace, & Dossett, 1973). The change process for teachers adopting innovative practices initiates with a concern for one's self, and moves toward a concern of impact - what will be the impact on learning (Hall, Wallace, & Dossett, 1973)? The theory posits the importance of time when a change process begins. The innovation adoption process spans a three-year time frame for most educators (Loucks-Horsley et al., 2009).

CBAM consists of three instruments of measure: stage of concern (SoC), level of use (LoU), and innovation

configurations (IC) (Anderson, 1997). Christou, Eliophotou-Menon, & Philippou (2004) diagrammed the seven stages of CBAM's SoC: awareness, informational, personal concern, management, consequences, collaboration, and refocusing. The authors describe the change process from becoming aware of the innovative practice, to personal concern and challenges of the innovation, to student-centered concern, and eventual collaboration with other teachers and dissection of the change.

Molla and Lee (2012) diagrammed eight stages of CBAM's LoU: non-use, orientation, preparation, mechanical use, routine, refinement, integration, and renewal. The authors' LoU descriptions are transactional in nature - measuring engagement and modification. While this study did not entail a specific measurement of the CBAM scales, the change process from zero awareness of mobile technology to eventual implementation and course redesign is grounded in CBAM's theory of the change process. Adopting a mobile application pedagogy moves beyond the use of laptops in a classroom. Mobile technology creates a more transactional form of engagement with students (Seipold & Pachler 2011).

Methods

In the Spring semester of 2014, California State University, Fresno, launched a mobile technology program: DISCOVERe. Instructors selected into the program met twice a month for two-hour professional development during the semester, and spent one week at a summer institute of more intense training. Instructors were given iPad devices and offered stipends with the understanding that they would implement mobile technology into at least one course during the Fall 2014 semester. Students enrolled in DISCOVERe courses were given mobile devices as well. Students had a choice of selecting an iPad or a Chrome Book. The student devices were given to the students, and the university paid for insurance policies to cover loss or damage for students. Data plans were also included for students at no charge. DISCOVERe courses were scheduled into "smart" classrooms, equipped with Apple TVs for projection.

As mobile technology in education was fairly new at DISCOVERe's inception, professional development consisted of exploration and collaboration among faculty members; there were no specific deliverables or expectations. Faculty experimented with various mobile apps, and adopted what worked within their curriculum design.

Research Design

This study adopted a quantitative non-probability convenience sample of student writing scores. Quantitative research design in education allows for the variables involved in an activity to be quantifiably measured (Park & Park, 2016). It was expected that most of the essay scores would be from first-year freshmen; however, other grade levels would not affect the study.

Student demographics by percentage for first-time freshman fall semester enrollment for the four academic years are listed in Table 1.

Table 1. Institution Demographics for First-time Freshman Enrollment

Race/Ethnicity	Fall 2012	Fall 2013	Fall 2014	Fall 2017
African American	4%	3%	3%	4%
American Indian	.3%	.4%	.3%	.3%
Asian	18%	17%	16%	14%
Hispanic	49%	49%	52%	57%
Non-Resident Alien	2%	4%	4%	4%
Pacific Islander	.3%	.2%	.3%	.3%
Two or More	3%	4%	3%	3%
Unknown	3%	3%	3%	3%
White	20%	19%	18%	14%
Gender				
Female	59%	59%	60%	62%
Male	41%	41%	40%	38%

The data for this study consisted of five semesters of writing project grades from freshman composition courses taught by one instructor: pre-DISCOVERe training and post-DISCOVERe training. The classes were an English Composition course in a first-year-writing program. While other assignments were offered during these courses, the three major writing projects allowed for the most consistent and objective form of data assessment across all semesters. The format of other assignments also remained the same for each class of students; again, this was an attempt to control variance of instruction and content.

The total number of participants whose writing scores were analyzed for this study are listed in Table 2. For total participant calculations, the number of students completing the third writing project for each semester was selected; students may have dropped the course before completing all three writing assignments.

Table 2. Participants per Semester

Fall 2012	Fall 2013	Fall 2014	Spring 2017	Fall 2017	Total (N)
37	35	40	37	37	186

Fall 2012 (F12) and Fall 2013 (F13) courses were pre-DISCOVERe training, and Fall 2014 (F14), Spring 2017 (S17) and Fall 2017 (F17) were post DISCOVERe training. The project writing scores are listed in Table 3. The pre-DISCOVERe training courses consisted of two courses in the Fall 2012 and Fall 2013 semesters. The post-DISCOVERe training courses consisted of two courses in the Fall 2014, two courses in the Spring 2017, and two courses in the Fall 2017 semesters. The break in data collection for 2015 through 2016 was due to the instructor teaching other courses not included in this study.

The course curriculum and three major writing projects remained consistent throughout all of the semesters, including pre and post-DISCOVERe training. The writing prompts remained the same throughout the study. The data collected for this study consisted of writing-project grades from a single instructor. The intent was to

control for variance in teaching methods and grading policies. The writing project grades were exported from the campus Learning Management System (LMS), Blackboard.

Table 3. Project Writing Scores per Semester

	N	Minimum	Maximum	Mean	Std. Deviation
F17P1	39	60.00	100.00	84.5897	8.89032
F17P2	37	75.00	100.00	88.1081	6.73624
F17P3	37	50.00	98.00	86.5676	9.83062
F17Total	37	207.00	291.00	260.7429	20.19660
S17P1	40	65.00	94.00	86.1000	6.94595
S17P2	38	70.00	98.00	86.1579	7.17551
S17P3	37	70.00	98.00	85.8649	7.52832
S17Total	37	215.00	284.00	259.6875	14.92441
F14P1	45	60.00	95.00	82.9111	9.26337
F14P2	39	67.00	94.00	84.9487	6.19825
F14P3	40	60.00	96.00	82.0500	8.55735
F14Total	40	223.00	277.00	250.1765	14.75142
F13P1	44	60.00	95.00	79.9318	7.80101
F13P2	40	59.00	94.00	79.8000	8.38558
F13P3	35	60.00	93.00	80.8286	8.35776
F13Total	35	195.00	282.00	242.2121	19.32252
F12P1	45	70.00	95.00	80.4222	7.78836
F12P2	44	60.00	95.00	79.7045	11.45787
F12P3	37	59.00	95.00	81.8919	7.51954
F12Total	37	210.00	283.00	246.7568	20.36119

Teaching Method pre-Mobile Technology

Prior to DISCOVERe training, class lectures consisted of having students read generic sample essays for discussion, or use of a textbook reader of published essays and questions for discussion. The instructor would try to highlight specific passages or paragraphs using a document camera for projection. Writing projects were uploaded to the LMS and graded using digital comments for instructor feedback. The instructor would ask students to please review comments. There was no protocol in place to have students “reply” to instructor comments, thus there was no efficient way to confirm the students’ review and understanding of feedback.

Prior to final draft submission, students brought printed copies of their rough drafts to share in groups during class. At least two class sessions per writing project were dedicated to students reading each other’s essays and offering suggestions and comments for improvement; this form of peer review was very one way. In other words, students would write comments on a copy of an essay and return the essay to the author; there was no transactional engagement with the peer review comments by the author. It was hoped that students would read the peer reviews, but there was no process for students to illustrate their understanding of the feedback offered.

Not only were students required to purchase a textbook for the class, but the printing cost of multiple copies of essay rough drafts for each of the three writing projects was substantial.

Teaching Method Using Mobile Technology

Prior to the DISCOVERe program, the instructor had never used a tablet device, entering the awareness and informational stages of the CBAM SoC (Anderson, 1997). During the first semester following the DISCOVERe professional development, the instructor adopted two innovative practices: Google Community and digital peer reviews. It was helpful that all students were given a mobile device, as the instructor could rely on all students having equal access to technology and the expectation that all students would come to class with a mobile device. The Google Community offered students a comfortable digital community outside of the classroom, a student-centered awareness (Christou et al., 2004). Students began to communicate within the community regarding assignments and due dates; these would have been emails sent to the instructor prior to the community interaction. A university librarian also joined the community and provided additional insight for students with research and citations. Having the librarian in the community fostered a closer connection between freshman students and the university library.

The peer review process moved to a digital format where students “shared” electronic copies of their essays using Google Docs and the “commenting” feature. The instructor was included in shared peer review groups to monitor and join the peer review process: a management stage (Christou et al., 2004). All peer reviews were then conducted outside of the classroom, freeing up valuable teaching and learning time. Students were also able to electronically reply to comments for clarification as needed. The peer-to-peer communication was more transactional than previous written comments. Students had the opportunity to “reply” to digital comments for further clarification or explanation, and the original commenter had the option to respond.

Each semester, the instructor added additional innovative practices to the curriculum, confirming that the innovation adoption process does not occur all at once (Loucks-Horsley et al., 2009). Many of the innovations were somewhat organic in their adoption. For example, one student during a class lecture had a question regarding the instructor feedback she had received on a writing project. The instructor asked the student if she would mind sharing her essay and feedback with the class so all students would have the benefit of further understanding instructor feedback. The student air dropped her essay to the instructor’s device for projection via Apple TV. The instructor was able to dissect the essay and feedback of an actual student essay rather than a generic sample essay. As the class progressed, additional students requested their essays be displayed and the feedback clarified; this process became a standard course activity.

Not every student essay could receive an individual explanation of instructor comments; however, the digital commenting feature had an option for students to reply to each comment. The instructor began to require all students to electronically reply to essay comments. For example, if the instructor left a comment that the student had more than one topic in a single paragraph, the student had to post a corrected paragraph in the reply section. The instructor did not have to re-read an entire essay - only the student responses to comments; this process

assured the instructor that students were not only reading her feedback, but they were having to engage with the feedback.

By the third semester, the instructor had adopted the use of Socrative and Google Slides as formative assessment activities to gauge student understanding of lecture material. Student responses were projected via Apple TV for instructor feedback. The use of Socrative and Google Slides had the added benefit of allowing students to participate anonymously. All students in the class offered a digital response as to their understanding rather than only the few students who felt comfortable raising their hands and speaking up in class.

Lecture capture videos were added during the third semester following the DISCOVERe professional development. The instructor adopted a mobile app which allowed class lectures to be recorded in real time. The videos were then posted to the LMS for students to access outside of class. Students who may not have taken sufficient notes during the lecture were able to review the lecture video as often as needed. Students who may have missed class were able to gain a better understanding of what went on during their absence. Rather than the instructor having to reiterate what took place during class in an email, the instructor directed students to the lecture videos for review.

Findings

Scores for three writing projects each semester were collected and analyzed. Four independent sample t-tests were used to test for mean sample differences in writing project scores for courses taught prior to mobile technology implementation and courses taught using mobile technology (m-learning). The dependent variables were scores for Project 1, Project 2, Project 3, and a total of all three projects. It is assumed that student writing would improve over the course of a semester, so the total of all three projects was also analyzed for a better understanding of students' overall performance. The independent variable was non-DISCOVERe course or DISCOVERe course.

The mean, standard deviation, and sample size for Writing Project 1 are provided (see Table 2). There was a significant difference in the mean scores for non-DISCOVERe courses ($M=80.2$, $SD=7.75$) and DISCOVERe courses ($M=84.5$, $SD=8.50$); $t(df=211) = -3.77$, $p < .001$. The results suggest that instructor use of mobile application technology provided more robust learning options for students.

Table 2. Descriptive Statistics for Writing Project 1

	Group	N	Mean	Std. Deviation	Std. Error Mean
Project 1	Non-DISC	89	80.18	7.754	.822
	DISC	124	84.47	8.495	.763

The mean, standard deviation, and sample size for Writing Project 2 are provided (see Table 3). There was a significant difference in the mean scores for non-DISCOVERe courses ($M=79.8$, $SD=10.05$) and DISCOVERe courses ($M=86.38$, $SD=6.79$); $t(df=136.61) = -5.23$, $p < .001$.

Table 3. Descriptive Statistics for Writing Project 2

	Group	N	Mean	Std. Deviation	Std. Error Mean
Project 2	Non-DISC	84	79.75	10.05	1.097
	DISC	114	86.38	6.79	.635

The results suggest that instructor use of mobile technology provided more robust learning options for students. Of note is the difference in standard deviation, with the DISCOVERe scores grouped closer to the higher mean score of 86.38.

The mean, standard deviation, and sample size for Writing Project 3 are provided (see Table 4). There was a significant difference in the mean scores for non-DISCOVERe courses ($M=81.4$, $SD=7.9$) and DISCOVERe courses ($M=84.75$, $SD=8.84$); $t(df=163.5) = -2.71$, $p = .007$. The results suggest that instructor use of mobile technology provided more robust learning options for students.

Table 4. Descriptive Statistics for Writing Project 3

	Group	N	Mean	Std. Deviation	Std. Error Mean
Project 3	Non-DISC	72	81.38	7.900	.931
	DISC	114	84.75	8.842	.828

The mean, standard deviation, and sample size for the total of all three writing projects are provided (see Table 45). There was a significant difference in the mean scores for non-DISCOVERe courses ($M=244.61$, $SD=19.87$) and DISCOVERe courses ($M=256.85$, $SD=17.39$); $t(df=135.4) = -4.17$, $p < .001$. The results suggest that instructor use of mobile technology provided more robust learning options for students.

Table 5. Descriptive Statistics for Total Writing Projects

	Group	N	Mean	Std. Deviation	Std. Error Mean
Total Project	Non-DISC	70	244.61	19.87	2.37
	DISC	101	256.85	17.39	1.73

Discussion

The statistically significant analysis results illustrate an improvement in student essay scores when mobile technology is implemented into writing instruction pedagogy. While this study does not suggest a causal effect, it does propose that students are given more opportunities to assess and analyze their learning when instructors adopt innovative teaching with technology (Paul, Torgerson, Tracz, Coy, & Wahleithner, 2020). The students in the DISCOVERe courses were offered a more direct engagement with instructor feedback in order to improve their writing skills. With the use of formative assessment programs such as Socrative and Google Slides, students were able to display their understanding of the lecture material while remaining anonymous. Rather than the few students who typically raise their hands to respond to questions, the technology allowed an opportunity for all student voices to be recognized digitally. The engagement with and manipulation of content

using a digital device allows students to express their level of learning and understanding that may never be explored using traditional pedagogical practices.

The use of mobile devices provided real-time exchange of course content. The convenience of airdrop and Apple TV allowed the instructor to adjust the learning environment spontaneously. Students engaged with relevant essay samples rather than generic samples written by a stranger. The instructor was able to assess the students' understanding of grading feedback, and further explain as needed. Instructors always hope students read the comments and grading feedback offered for improvement; this study provided an example of an innovative practice to require students to actually engage with the comments and feedback.

The study offered innovative examples of how the use of technology may also improve faculty efficiency. Placing students into a digital community was a catalyst for students to begin to self-moderate their learning environment. Rather than emailing the instructor with questions, students began posting the questions in the digital community and receiving help from their peers. The innovative use of lecture capture to create lecture videos provided the instructor a tool to help students who may have missed class or added a class later in the semester. Rather than the instructor trying to organize course content for a second delivery to individual students, the lecture videos were a replica of what took place in the class. The lecture videos also offered students one more tool for success.

The instructor in this study did not attempt to adopt numerous innovative technologies from the onset; rather, implementation of teaching technologies was gradual over the course of multiple semesters. The students in the DISCOVERe courses appeared poised to experiment with the technology alongside the instructor, as was the example of the student who wanted to have her essay used as an artifact during the course lecture. The significant results of improved student essay grades offer motivation for instructors to continue to explore innovative teaching practices to support student success. The curriculum in this study was focused on leveraging mobile technology to improve the learning environment; it was not about the technology itself.

Conclusions and Recommendations

The literature supports the fact that innovative teaching with technology may take years for faculty to adopt and feel comfortable. It can be difficult to convince faculty that the technology is worth the effort, as traditional discussions have focused more on the technology rather than student achievement. This study connects innovative teaching with mobile technology to improved student achievement in the composition classroom. The instantaneous and transactional engagement between instructor and students offer an opportunity for a more authentic learning experience. Information Technology has altered the course of education and learning and how education is communicated within the classroom and outside of the classroom (Nordquist & Laing, 2015). Technology has enabled a less linear form of delivery. Rather than an instructor delivering course content and students receiving that content, a more dynamic and fluid distribution exists.

The theoretical framework for this study, CBAM, posits the levels of faculty adoption of teaching with new

technology from inception to implementation. The instructor in this study gradually experimented and adopted innovative teaching strategies as she moved from self-understanding to student-centered to reflection and dissection (Hall, Wallace, & Dossett, 1973). The course redesign involved a change process for the instructor, and this process was repeated each semester as new technology was added to the course content each semester. The instructor felt a level of comfort with innovative practices. The collaborative level of CBAM's SoC was not realized for this study and may have offered a broader impact to improve student achievement (Christou et al., 2004).

Instruction in higher education can be siloed. While the DISCOVERe program's professional development offered collaboration among faculty fellows initially, that collaborative platform did not extend beyond implementation. In other words, faculty who were perhaps struggling to adopt would have benefited from the mentorship of early adopters. Instructional designers were the program's initial point of contact for support, but the instructional designers did not teach in a classroom environment on a regular basis. The exploratory and collaborative engagement among faculty that began with the program's inception may have been a beneficial requirement post-adoption.

The purpose of this study was to expand current research to consider the effects of student achievement when using mobile technology, and to inform current pedagogical practices across all disciplines. Technology has a role in student success when instructors understand the change process involved in adoption of innovative practices. The statistically significant improvement in mean essay scores when teaching with mobile technology informs faculty and administrators of another high-impact practice for student success.

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