Frontiers in Education Technology
Vol. 1, No. 1, 2018
www.scholink.org/ojs/index.php/fet
ISSN 2576-1846 (Print) ISSN 2576-1854 (Online)

Original Paper

Students' Perceptions of Technology-Enhanced Pedagogy in Their Statistics Learning

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Received: April 21, 2018 Accepted: May 11, 2018 Online Published: May 25, 2018

doi:10.22158/fet.v1n1p70 URL: http://dx.doi.org/10.22158/fet.v1n1p70

Abstract

Statistical literacy, reasoning, and thinking are highly valued in various industries. However, many college students struggle in their required statistic course(s). The use of technology has the potential to bring about positive changes in content, pedagogy, and course format of statistics instruction. This study explores undergraduate business students' perceptions of the instructor's technology integration efforts in their statistics learning. The research results reveal that students mostly regarded their learning experience as positive, engaging, informative, and effective. They attributed their learning gain to the instructor's innovative teaching style, the availability of various learning resources on Moodle, and how the resources were presented.

Keywords

statistics learning, technology integration, technology-enhanced pedagogy, resource-based learning, performance support

1. Introduction

Statistical literacy, statistical reasoning, and statistical thinking are highly valued in various industries (Ben-Zvi & Garfield, 2004; Davenport & Harris, 2007; Franklin & Garfield, 2006; Lane, Mansour, & Harpell, 1993; Philip & Schultz, 1994). Statistics course is required by most college degree programs in the United States (Ramirez, Schau, & Emmioglu, 2012). However, many college students have not had a positive attitude or conducive learning experiences toward statistics, either due to their math-phobia and statistical anxiety, or due to their negative attitude towards statistics and pre-dispositions against statistics (Gal & Ginsburg, 1994; Garfield, 1995; Hogg, 1991; Rochelle & Dotterweich, 2007; Verhoeven, 2006). Surveys of graduating seniors at the first author's business college reveal that students

constantly rank the two statistics courses offered as the least valued and yet most difficult in their degree programs. Therefore, it remains an important task to develop more innovative teaching methods to improve the situation.

The significance of teaching statistics with a technology-enhanced pedagogy was endorsed by the Board of Directors of the American Statistical Association (Franklin & Garfield, 2006). Researchers contemplate that "traditional lecture-based teaching methods should be replaced or supplemented by new approaches" (Tishkovskaya & Lancaster, 2012, p. 11), and the use of technology has the potential to bring about positive changes in content, pedagogy, and course format of statistics instruction (Chance, Ben-Zvi, Garfield, & Medina, 2007). Higher education is heavily investing in technology to enhance teaching and learning activities (Kagima & Hausafus, 2000; Kozma, 2011; Massy & Zemsky, 1996; Stensaker, Maassen, Borgan, Oftebron, & Karseth, 2007). Researchers have called for the use of technology and multitude of online learning resources to enrich students' statistical learning experiences, and ultimately enhance their academic performance (Ben-Zvi, 2000; Chance et al., 2007; des Nicholls, 2001; Garfield, 1995; Mills & Raju, 2011). Meanwhile, researchers observe that pedagogy matters more in student learning than any particular technology adopted. They caution that "teaching and learning activities should be designed and implemented to take pedagogical principles of learning into account" (Tishkovskaya & Lancaster, 2012, p. 11).

The results of a previous quantitative research suggest that online video tutorials, when systematically provided as a supplement to traditional classroom instruction on course management system Moodle, were instrumental to some students (Lai, Zhu, & Williams, 2017). It seemed that the video tutorials benefited those students: (a) aspiring to earn a higher grade, (b) with average statistical capability, and (c) who struggled to understand the course materials during the limited class time. In statistics education literature, there is a lack of qualitative research exploring the effectiveness of such technology-enhanced pedagogy in students' learning experiences. To fill the gap, in this paper, we will explore students' perceptions of the effects of technology-enhanced pedagogy in their statistics learning process. The focus of the pedagogy in this study is the extensive use of course management system, Moodle, in traditional lecture-based instruction of an undergraduate statistics class. On Moodle, throughout the semester, the instructor makes available various online learning resources/materials to supplement students' statistics learning.

2. Literature Review

2.1 Multimedia Learning

Multimedia refers to combined use of multiple media including text, audio, music, graphics, animations, and videos. Multimedia has considerable promise for teaching statistics.

> Multimedia offers a highly interactive and individualized environment in which the learner is constantly invited to manipulate animations, asked to respond to questions, and encouraged to work independently to exercise newly learned concepts. The

> interactivity and continuous availability of automated calculations and graphics are ideal for data analysis. Animation and simulation can provide visualizations of concepts from probability and interference. Video, text, map, etc., vividly present real problem settings. The learner can control the pace of instruction, request review or enrichment, and emphasize the media that best suit her individual learning style (Velleman & Moore, 1996, p. 217).

Multimedia learning serves as an integral component of technology-enhanced pedagogy. Multimedia learning materials should add the potential in developing students' schemata of statistical problem solving, and ultimately increasing their interest in statistics learning. For example, Lai, Zhu, and Williams (2017) found that, online video tutorials, if systemically made available as a supplement to traditional classroom instruction, could enhance undergraduate business students' academic performance in a required introductory business statistics course. Aberson (2002) used an interactive Web-based tutorial to supplement instruction on statistical power. Students who used the tutorial achieved better performance. Students also rated the tutorial as clear, useful, and easy to use, and they reported increased comfort with the topic after the tutorial use. McDaniel and Green (2012) found that the use of an applet and audio-visual tutorials contributed to an increase in students' understanding of sampling variability concepts. Similarly, Chandrakantha (2014) found out that the use of simulation enabled by Microsoft Excel and Data Tables helped students visualize and comprehend statistics concepts such as sampling distribution, confidence intervals, and hypothesis testing. Neumann, D., Neumann, M., and Hood (2011) explored students' perceptions of integrating computer-based simulations, multimedia, and animations in their first year university level statistics course. The results showed that: (a) the use of technology increased connection between statistics and real concepts and showed examples of practical application; (b) enhanced their statistics comprehension; and (c) increased their interest, engagement, motivation, and enjoyment of statistics learning. Moreover, viewing video of statistics-in-action can positively affect students' attitudes towards statistics (Allredge, Johnson, & Sanchez, 2006). Boyle and colleagues (2014) conducted a narrative literature review of games, animations and simulations, and they identified the potential of a games-based approach to statistics learning. Specifically, the activities enabled by these multimedia venues provide active approaches to statistics learning. Meanwhile, these researchers caution that, to make the most effective use of digital resources such as games in statistics instruction, such resources should be pedagogically incorporated within the context of curricula.

2.2 Technology Adoption in Higher Education and Technology Adoption Barriers

Massy and Zemsky (1996) maintain that there are three levels of technology adoption in higher education: a) *personal productivity aids*, e.g., the use of Microsoft Excel and PowerPoint. Most faculty members in higher education are at this level. b) *Enrichment add-ins*, e.g., the application of web page, multimedia, and simulation to enhance traditional teaching. This level of technology adoption is very common. And c) and *paradigm shift* where faculty redesign teaching and learning activities to take full advantage of the potentials of the available technologies. This level of technology adoption is still in the emerging phase.

Numerous barriers might hinder faculty's technology integration into their classroom teaching. Leggett and Persichitte (1998) identify five categories of barriers including time, expertise, access, resources, and support. According to Fabry and Higgs (1997), key barriers to technology integration in the classroom include resistance to change, negative attitudes toward computers, constraints on training and support, costs, and a lack of access to the right types of technology in appropriate locations. Keengwe, Onchwari, and Wachira (2008) synthesize major technology integration barriers that include lack of computers and relevant quality software, lack of time, lack of funding, technical problems, teacher attitude toward computers, lack of teacher confidence, resistance to change, poor administrative support, poor training, and lack of vision to integrate technology into the curriculum. Su (2009) summarizes similar common technology integration barriers for teachers in kindergarten through grade 12. Most of these barriers are external to teachers, and thus more resource-related. Ertmer (2005) links external and internal technology integration barriers, and classifies them into first-order and second-order. First-order barriers refer to external obstacles including lack of equipment, unreliability of equipment, lack of technical support and other resource-related issues. Second-order barriers include both school level factors such as organizational culture, and individual teacher-level factors such as teacher's pedagogical beliefs, technology beliefs, and willingness to change. First-order barriers are easy to overcome, but not the second-order barriers. For Ertmer, many technology integration conditions have already existed; it is teachers' beliefs that hold them back. Tsai and Chai (2012) suggest a third-order barrier, because the removal of first-order and second-order barriers might be insufficient to enable technology integration in classroom. They posit that the removal of first-order barriers may facilitate teachers' technology usage; the elimination of second-order barriers may help them be committed to technology integration. Teachers still need to overcome third-order barriers, their lack of design thinking skills and disposition. Due to the dynamic nature of classroom context and students, teachers "should rely on some design-thinking to re-organise or create learning materials and activities, adapting to the instructional needs for different contexts or varying groups of learners" (Tsai & Chai, 2012, p. 1058). After third-order barriers are removed, teachers can undertake technology integration more actively and more fluently.

In summary, this section presents how multimedia learning resources can be leveraged to enrich students' statistics learning experiences and enhance their statistics performance. This section also identifies different technology adoption levels in higher education, and the various barriers that might hinder faculty's adoption and integration of technology in their teaching.

3. Method

The purpose of this study was to explore business college students' perceptions of the effects of technology-enhanced pedagogy in their statistics learning process. Qualitative methods were chosen to guide data gathering and data analysis. The following research questions guided the study:

1) What was the impact of the technology-enhanced pedagogy on students' learning experiences in the course?

2) Which aspects of course delivery enriched students' learning experiences and enhanced their academic performance?

3.1 Course Description and Participants

The research setting for the study is a business college of a state university in the southern United States. The first author taught two sections of a required undergraduate course, Advanced Business Statistics, in Spring 2015, delivered in a traditional classroom setting. The instructor took advantage of affordances of Moodle. On Moodle, the instructor provided students with multiple supplementary learning resources including PowerPoint slides, textbook examples presented in Microsoft Excel, video tutorials, quizzes, and discussion forums. Participants for the study were the students enrolled in the two sections. Altogether, 43 students completed the course.

3.2 Data Sources

Student reflection. Approaching the end of the semester, students completed a voluntary reflection and posted them on Moodle. They followed question prompts to reflect on their overall learning experiences, the aspects of course delivery they enjoyed the most, the aspects of course delivery where specific improvement might be needed, as well as any suggestions that they think might contribute to enhance their learning experiences and academic performance.

Student Evaluation of Instruction (SEI). University collected students' online voluntary evaluation of instruction at the end of each semester. The first author received SEI results after the university aggregated and analyzed the course evaluations.

Journal entries. Throughout the semester, the first author kept weekly journal entries of his observations and reflections of his technology-enhanced pedagogical practices. An entry typically describes the specific practice adopted for the class, the reactions, feedback, and recommendations for improvement from the class.

3.3 Data Analysis

Two researchers coded the data. They used Miles and Huberman's (1994) data analysis procedure to guide data analysis. First, in the data reduction step, they coded the reflections, SEI comments, and instructor notes and observations into conceptual chunks, and grouped them into categories. Next, in the data display step, they made sense of relationship among the categories. Finally, we wrote up answers to the research questions. Discrepancy in data analysis was reconciled through discussion between the two researchers until full agreement was reached.

4. Research Results

Question 1. What was the impact of the technology-enhanced pedagogy on students' learning experiences in the course?

Most students admitted that Advanced Business Statistics is quite a challenging course. Compared with the prerequisite statistic course, there is a sharp learning curve for students to overcome while being introduced to two-sample tests of hypothesis during the first couple of weeks of the semester. Students

not only needed to brush up their knowledge and skills of one-sample tests of hypothesis learned in the prerequisite statistic course, but also had to quickly become comfortable with various two-sample test statistics in a short time. It seemed that the availability of video tutorials related to one-sample hypothesis tests helped them close the learning gap. Eventually, many of them indicated their learning experiences in the course as positive, engaging, and effective. A few students considered the pedagogy exceptional, because they realized the instructor's technology integration efforts and acknowledged the learning benefits brought about by such efforts. As a result, some students expressed their gratitude on how the instructor effectively delivered the course. For example, one student stated that the instructor "REALLY made an effort to make sure we all understood the material". Another student commented,

> I feel that you truly wanted us to learn the material and gave us everything you possibly could to assure that. Posting the excel files and video instruction to refer to really went above and beyond any other professor I have had when it comes to the use of Moodle.

Another student concurred:

> I think you utilized Moodle more than any other professor I've had. That is a huge plus in the class. It was very well organized throughout the semester. The excel files that you used are very helpful and I can tell that you put a lot of work into this course with those and the videos.

Moreover, they showed their appreciation of such pedagogy by saying, for example, "you gave us other resources to help us understand the information and for that I was most grateful!" Students taking this class generally hope for a short-term learning goal, to pass the test(s). Some students realized that the way the class was delivered provided them with an avenue to long-term learning transfer. For example, one student reflected how the pedagogy helped transfer her learning in this class into a long-time memory:

> Surprisingly I have not only learned a lot but have also contained and remembered so much information from this course. Normally with a course like this, I don't remember much after a test day. But the way things are taught, I have a better time remembering the information.

Compared with students in his previous semesters when supplementary learning resources/materials were not as extensively and systemically provided, the instructor realized that students were more engaged in the classroom throughout the semester. They were more attentive to the instruction and asked less peripheral statistics questions for the instructor to clarify so that the instructor could spend more quality class time to go deep in the topics covered. Moreover, from the instructor's numerous discussions and conversations with his students, he found out that students experienced less statistics learning anxiety due to their self-proclaimed abhorrence of mathematics. It seems that the messages of difference between statistics and mathematics instructor constantly embedded in the video tutorials helped students increase their interest in their statistics learning.

Question 2. Which aspects of course delivery enriched students' learning experiences and enhanced their academic performance?

Overall, three aspects of course delivery stood out. First, students appreciated the comfortable learning/teaching environment the instructor created and maintained in classroom setting and on Moodle. They commented that such a learning environment was conducive to their statistics learning process. For example, only after a few classes into the semester, I had these threaded journal entries.

> After covering chapter 11 [Two-Sample Tests of Hypothesis], I told the class to take advantage of the ungraded practice multiple choice questions on Moodle. Upon their completion of the graded chapter quiz, I asked why some of them did not attempt more than once the practice quiz. Some of the students complained that, even if they tried twice or thrice, they would always get the same set of questions. They made a point here. I instantly told the class I would create more randomly selected questions for chapter 12 [Analysis of Variance].
>
> I created twenty-five more questions for chapter 12. It turned out their participation in this chapter increased a lot, so did their performance. A couple of students today in class showed their appreciation of such opportunity when asked about the instructor's new efforts.

Second, students appreciated the instructor's innovative teaching style in the course. Immersed in purposefully designed sequence of instruction and supplementary learning resources, students found themselves engaged in their learning process. For each chapter, the instruction sequence went like the following-PowerPoint slides and learning resources in Excel were made available on Moodle upfront to allow for student preparation ahead of the class. After instruction of statistical techniques, the instructor provided ample in-classroom practice and review of related problems. Supporting materials/resources such as PDF documents of the instructor's problem solving and video tutorials on the same problems were then made available on Moodle to allow students unlimited review to enhance their understanding. Meanwhile, unlimited chapter practice quiz with instant detailed feedback was made available on Moodle to provide students with opportunities to comprehend the statistical concepts and techniques introduced. After homework problems were assigned, collected for evaluation, and reviewed in class, video tutorials on the homework problems were made available on Moodle. The students were also encouraged to post their questions in asynchronous discussion forum on Moodle to cultivate a community of engaged statistics learning. Because of the way the course was structured and delivered, students perceived that student/instructor interaction, student/content interaction, and student/student interaction both in classroom and on Moodle were enhanced to the greatest extent.

Third, students enjoyed most the availability of various learning resources on Moodle. Such availability satisfied their learning needs, and eventually contributed to their success in the class. For example, one student commented how the availability of various learning resources on Moodle helped him succeed in the class:

> The Excel files are a huge help in understanding the problems. The videos help a lot too since they actually walk you through the problem all over again outside of class.

> The interaction on Moodle was great. It is much easier to keep track of a class when all of the information is available on Moodle. QMET is not my thing, but those three tools previously mentioned helped me get through this class.

Another student summarized the benefits of the resource-based learning he experienced in the class as below:

> Overall, I think that if everyone pays attention in your class and uses all the resources you give online that they cannot fail the class. I only used most of the resources provided and easily have an A, and that is definitely not because I am really smart but that your teaching style is extremely effective to those who put in the effort. I took this class after taking your QMET251 class because I knew that even though the material can be difficult, your teaching style and plentiful learning resources make it possible to get a good grade in the class, which is definitely my favorite aspect of your class.

5. Discussion

The purpose of the study was to explore undergraduate business students' perceptions of technology-enhanced pedagogy in their statistics learning process. Relatively little qualitative research has been conducted in this area. The findings of the study shed some insights on the significance of such pedagogy in enriching college students' statistics learning experiences and enhancing their statistics performance, as well as on how to promote and support technology-enhanced pedagogy in higher education.

The findings of the current study revealed that students' learning experiences with the statistics course enriched by technology-enhanced pedagogy were positive, engaging, and effective. The students appreciated the conducive learning environment created and maintained in both classroom setting and course management systems, Moodle. They also gave credit to the instructor's innovative teaching style, which not only enriched their statistics learning experiences, but also enhanced their academic performance. Most importantly, students enjoyed the availability of various learning resources/materials on Moodle to enable just-in-time supplementary support. Resources as performance support mechanism are integral to learning. Recent years have witnessed the resurgence of resource-based learning in various learning environments (Freeman, Patel, Routen, Ryan, & Scott, 2013; Hill & Hannafin, 2001). Educators in higher education are increasingly provided with various digital teaching materials/resources from textbook publishers. Students can also easily retrieve learning materials/resources from the Internet, for example, Wikipedia, Google and Youtube, which have been increasingly touted as elearning tools (Quinn, 2004). Moreover, with the exponential growth of computer technology, and development and easy access to various educational tools (for example, the university of the first author provides EduTools including Panopto, a lecture capture software; Screencast-O-Matic, a desktop application for computer screen activity capture; Animoto, a web-based video editing platform; Skype; VoiceThread, a web-based sharing and collaboration tool; and Zoom, a synchronous web conference tool), educators find

themselves better equipped to design and develop digital learning resources like the multimedia materials used in the study. In their statistical learning process, other than the routine in-class instruction, students in this study seemed to enjoy the availability of multitude of supplementary digital resources on Moodle; subsequently, students perceived that their course performance benefited from their easy access to such purposefully designed and developed resources.

However, easy access to learning materials/resources does not automatically translate into students' learning gain. Or as Tolmie (2001) put it, simply providing technology resources without effectively integrating them into instruction will not produce better learners. Other researchers concur. Dede (2000) posits that technology by itself will never help improve education, unless simultaneous innovations occur in pedagogy, assessment, and other primary areas of education reform. Similarly, according to Jacobsen, Clifford, and Friesen (2002), technology should only be regarded as means to improve learning. The challenge is to develop educators' fluency with pedagogically sound teaching repertoire with technology. Just like the first author's journal entries indicated, unless pedagogy with unlimited practice quiz on Moodle evolved, students would not benefit or appreciate such availability. It seems that how to leverage the rich amount of readily available resources for meaningful and purposeful learning presents a challenge to educators.

Technology-enhanced pedagogy seems to have potential in improving the teaching and learning of statistics. Neumann, Neumann, and Hood (2011) argue that, in statistics education, technologies need to be suitably integrated with lecture content, and make sure that technology should not be used merely for the sake of using it. According to the synthesis of Tishkovskaya and Lancaster (2012), one of the major directions of the statistics education reform movement implies that "integration of technology and computer-based methods into teaching statistics as an important tool for effective delivery of teaching and essential part of effective pedagogy" (p. 11). In addressing some students' yearning for abstract statistics knowledge construction, the first author is contemplating to provide them with such learning opportunity by infusing more statistical reasoning and thinking while he designs and develops video tutorials. As a result, it is viable to offset the restriction of limited class time to offer motivated learners a pathway for growth. Moreover, as the first author experienced, the embedded messages in the video tutorials can not only help address students' negative attitudes and misconceptions about statistics, but also increase their interest in being engaged in their statistics learning process. This seems to fit in another major direction of the statistics education reform movement which involves "pedagogical reforms toward development of conceptual understanding and teaching to statistical thinking and reasoning" (Tishkovskaya & Lancaster, 2012, p. 11).

In anonymous university-administered student evaluation of instructions, students never hesitated to disclose their gratitude or dislike toward the pedagogical principles the instructor adheres to. The findings of the study highlighted the effectiveness of technology-enhanced pedagogy in college students' statistics learning, and their appreciation of the instructor's technology integration efforts in their learning process. However, we have to accept the reality that technology integration paradigm shift is

still at the emerging phase in higher education (Rogers, 2000), and technology-enhanced pedagogy has not yet been widely embraced in higher education (Strauss, 2015). As human beings, we have a natural tendency to abhor change or be reluctant to change. Content with their comfort zone of teaching repertoire, educators might find various excuses to stay away from technology integration into their classroom teaching, as synthesized in the literature review section of this study. On one hand, the concept of "publish or perish" has been ingrained in tenure-track faculty members' mindset in higher education in the United States, especially in the universities categorized as research extensive or intensive. Subsequently, majority of faculty's merit evaluation comes from their research efforts/contribution, and not their teaching effectiveness per se. Literature reveals that it takes tremendous amount of time and efforts to effectively incorporate new technologies into instruction (Tsai & Chai, 2012). While addressing barriers and enablers of technology integration, Spector (2013) posits that politics and policies stand out as the greatest challenge. Therefore, how to engage and motivate faculty members in integrating technology into their classroom teaching remains a challenge to higher education administration.

On the other hand, Lai, Hill, and Ma (2015) find out, typically there exist three categories of challenges related to technology integration: technological, managerial, and pedagogical ones. Technological and managerial challenges are comparably easier to be alleviated than the pedagogical ones. Technological and managerial challenges can be easily overcome with sustained training and support. Pedagogical challenge is closely tied with one's pedagogical belief. Ertmer (2005) argues that the biggest barrier to effective technology integration in education is educator's pedagogical beliefs of what sound teaching practices are. Unlike K-12 teachers who are required to take methods courses and pass tests on pedagogical knowledge, higher education faculty typically had little training on pedagogy prior to becoming a faculty member, and they generally teach the way they had been taught (Mehlinger & Powers, 2002). To make matters even worse, most higher education institutions have limited resources for faculty development related to pedagogy, not even to mention technology-enhanced pedagogy. Therefore, to improve student learning with emerging technologies, we need to provide faculty with an easy access to technologies and in-depth training on technological know-how, and ongoing technical support. Other than that, it is imperative that knowledge and support be provided for them to try out new instructional strategies and reflect on them so that they can grow in their teaching repertoire and teaching effectiveness (Ertmer, 2005; Keengwe et al., 2008). Moreover, effective technology integration in education is not simply as a state of "technology", but a state of "art" (Tsai & Chai, 2012). To be proficient in the art of teaching, educators also need to be continuously cultivated with course design thinking skills and disposition to undertake technology integration.

6. Limitations of the Study and Future Research

The research findings were based on students' semester-long exposure to technology-enhanced pedagogy in their statistics class taught by one instructor. The external validity of the study may hence be limited. We would also like to point out that this study only examined students' reflections and their voluntary and anonymous evaluations of instruction, the generalizability of the study may also be limited. More research involving cross discipline or cross campuses needs to be done on the effects of such pedagogy, and how and why it works.

There are several directions in which we would like to approach our future research. We could conduct an explanatory mixed methods research by first collecting quantitative data to examine whether technology-enhanced pedagogy could enhance students' academic performance, then collecting qualitative data to help explain the quantitative results. We could also consider conducting student surveys or interviews, and interviews with university administrators to enrich the data sources.

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