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Teaching Plan Reading to Construction Students: The Effect of Using Tablet Computers

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With rapid changes in device technology and adoption rates in the industry, there is an increased need for the construction programs to introduce the use of current technology devices in their curriculum. One of these technologies is to utilize digital devices such as tablet computers replacing traditional printed copies of construction documents. A recent study undertaken at a major university compared the performances of the students on their ability to read and interpret construction documents using both the formats. The students were divided into two groups performing similar assignments- one group using the tablet computer to read the construction documents and the other using documents in paper format. A second study was performed with the construction document mediums reversed between groups. Data was collected during the studies and through post survey questionnaires. Results showed that both the groups took longer time to finish the assignments using the tablet computer. However, the overall time taken by the group that used paper format first followed by tablet was substantially lower than that of the other group. The authors concluded that introducing the tablet after the students have familiarized themselves with the documents in paper format will be beneficial for the students' learning.

Keywords: iPads, tablet computers, digital construction documents, plan reading

Introduction

The sustainability drive has provided the impetus to move towards electronic documentation to reduce printing across all the industries. In addition to being sustainable, electronic documents also have positive cost implications in the reduction of printing and storage expenses. This change in the mode of documentation has made the use of tablet computers more common in construction projects. A tablet computer or simply 'tablet' is a mobile computer that accommodates camera, microphone, touchscreen, and other hardware all in a single unit. While the light weight of the tablet and ease of updating the electronic documents are obvious benefits, the authors have been informed of the huge cost savings by several contractors during personal communications. It has also became apparent that the cost savings from using the tablets fall into two main categories: eliminating cost of reprographics that can amount to millions in big projects, and the cost of rework for not performing work based on the most up to date documents.

With the increase in the use of technologies in the construction industry (Shrestha et al., 2011), an increase in the use of tablets in construction projects is likely. This new technology is being integrated in construction program curricula but there is a difference in student perceptions of the uses of the technology as compared to those of industry practitioners. As observed by Smithwick et al. (2014), industry practitioners use technology to increase efficiency and accuracy of their work based on experience. Students, however, are limited by their lack of experience in the application of technologies to construction processes.

To investigate the efficacy of tablets among construction students, the authors conducted an experimental study using the students of a construction program at a major Midwestern university as participants. The objective of the study was to investigate the impact of using tablet on the students' accuracy and efficiency during document reading and quantity surveying. As using tablets to read construction documents on construction projects is fairly new, the authors did not find a study that has attempted to measure the impact of the tablet on the students' abilities. Some previous studies were located that dealt with the impact of software on student performance, but very few have presented any comparative data. The following section presents a brief review of the related literature.

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Literature Review

It can be safely assumed that all the construction documents are now prepared using computer assisted drafting and design (CADD). However, the documents are frequently issued for bidding and construction purpose in paper format. To realize the benefits of electronic documents, several companies led by Timberline Estimating created a hybrid system of quantity take-off and estimating that mixes electronic spreadsheets, digitizing tablets and paper drawings. It is worthwhile to mention here that the first application of information technology in construction was noticed with the use of electronic spreadsheet to automate repetitive mathematical calculation (Shrestha et al., 2011). Electronic bid documents have become available since the last decade throughout the construction industry. The precedence of distributing bid documents electronically was set by the Army Corps of Engineers in 1995 (Peters, 1996; Watson, 1998). Since then many nationwide plan rooms such as F. W. Dodge and regional plan rooms, in addition to state governments are offering electronic construction documents. Though the industry moved towards distributing the construction documents electronically, it is far away from using the documents completely in electronic format. The documents are printed and used for bidding and construction purposes. With the advent of tablets and realization of the prospective benefits of using electronic documents, the present situation can change.

Having students use tablets for construction document reading presents a new method of reading documents that students may not be familiar with. It is often the case that many students are learning to read construction documents for the first time and learning to do so on a device may be a challenge if they are not accustomed to using the device for document reading. One obstacle in implementing the use of tablet computers in the classroom is in line with general challenges with implementing any new technology.

Student Response to New Technology in the Classroom

With rapid changes in device technology and adoption rates, there is an increased need for educators to be aware of and engage in the use of current technology devices (Anderson & Blackwood, 2004). Millennial generation college students, or students born somewhere between the early 1980's to the early 2000's, grew up surrounded by new technologies (Oblinger & Oblinger, 2005). A large majority of these students were actively using computer technologies by the time they were 18 years old and are considered to be digitally literate, or able to use and understand a plethora of different IT devices without instruction (Jones, 2008). These Millennial's are comfortable with new technologies, more so than any other generation before them (Oblinger & Oblinger, 2005).

Conole et al. (2008) conducted an analysis of college students and their uses of technology in an academic setting. Their research revealed that students are learning effectively by engaging with many different types of technologies to support their learning. Their findings reiterate what has been found in other literature; today's college students are adept at using a variety of different technological tools to find and synthesize information in an effective manner (Conole et. al, 2008).

It may be easy to assume from these findings that the college students of today would heavily prefer their classrooms to be filled with new technologies, but this is not correct. In fact, students indicated in a student technology survey that they prefer a moderate amount of IT in their classroom because they also benefit from face-to-face interaction (Jones, 2008). So although it is important to integrate technology into the classroom, too much can be just as detrimental as none at all.

Technology use has been known to be effective in enriching learning, but recently tablet use specifically has started to show positive educational uses (Mock, 2004). The 2013 NMC Horizon Report discussed tablet use as a powerful learning tool in and outside of the classroom (Johnson, 2013) and much of the recent literature focuses on the positive outcomes of tablet use in the classroom. A study by Morris et al. (2012) analyzed student interviews and surveys to determine the effect of the tablet use on student study habits. Student interviews showed that students adapted the device into their everyday study behaviors, and some even claimed that it made them feel more prepared for class with the ability to bring up journal articles on their device instantly. Other researchers are finding that tablets may even be replacing other commonly used technology devices. Students of all disciplines are increasingly familiar with new devices and are eager to incorporate them into their education practices (Anderson & Blackwood,

2004). In fact, many undergraduate students already own or will own a tablet device or other mobile learning device to use during their college experience (Jones et al., 2010; Margaryan et al., 2011).

It is clear that technology and tablets are becoming more commonplace in higher education and that they bring with them many educational benefits, but it is important to keep in mind how the technology is implemented in the classroom. Researchers Drennan and Kennedy (2010) looked specifically at students' reaction to new technology implementation within a distance learning course. What the authors found to be most influential in students' positive attitudes and satisfaction of new technology was if the instructor provided autonomy with the use of technology and if the instructor demonstrated the usefulness of the technology. The technology itself will not elicit positive attitudes from students if it is not accompanied by proper instruction. If newer technology and devices are introduced into a classroom setting in an effective manner the educational benefits and outcomes will be vast.

Research Objective and Method

The objective of this study was to investigate the impact of using electronic construction document on students' performance in terms of accuracy and efficiency. In this context, 'accuracy' refers to the variance of the students' answer from the correct answer; 'efficiency' refers to the amount of time the student takes to find the answer. The authors adopted an experimental method for the study in which the stimulus variable was the type of document format (electronic or paper) used by the students and the outcome variables were accuracy and efficiency in orientation, extracting information, performing quantity takeoff, and identifying sequence of activities based on the documents.

The authors selected a sophomore level class in a construction program at their affiliated institute. The class had 24 students and they were divided in two groups, Group A and Group B. To increase the likelihood of comparable groups, the students were first divided into four groups based on classroom performance as of the day of the study. Each group of students was then randomly assigned to either Group A or Group B. This resulted in both groups having an equal number of students from each performance level. The study was approved by the Institutional Review Board of the institute and participation of the students were completely voluntary and the outcome of the study had no influence on their course grade. Each of the groups had to complete two assignments based on the same set of construction documents.

On day one, Group A completed Assignment I using electronic documents and Group B completed Assignment II using paper documents. On day two, the assignments were switched and both the groups used paper format of the documents to complete the assignments. Both the assignments were based on of same set of documents, and the study was conducted towards the middle of the semester to allow enough time to the students to get used to the documents. Apple iPads were used for the electronic documents using the iBooks application to view the pdf files. The students were also asked to record the time they finish their responses. Time required by each student was used by the authors to examine the efficiency of their performances. The students did not interact during the assignment completion (neither with the other group nor within their own group). The two assignments were carried out within the span of a week and students did not receive feedback on the first assignment so there was no opportunity for learning between the two assignments.

Assignments

Assignments I and II were prepared collectively by the authors based on the construction drawings and specification book of a 73,000 SF medical office building. The students had access to the complete set of drawings and the specification book. The students had been working with these documents in the document reading class for three months before the study was conducted. Each of the assignments had 12 questions with equal weightage on the four categories previously mentioned - orientation, extracting information, performing quantity takeoff, and identifying sequence of activities. Each question required students to write the correct answer and also indicate the sheet they found the answer from.

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The tablets used by the students to complete the assignments were supplied by the authors. The tablets were pre-loaded with the electronic format of the construction documents. All the students had varying levels of experience working with tablets. The authors allowed 15 minutes for the students to get themselves accustomed with the tablets before working on the assignments.

The students were also asked questions about their perceptions of the experience and their prior experiences. These questions were asked at the end of the assignments and were Likert-type items on a 7-point scale. With these questions, authors sought to measure the students' experiences with tablet computers, their level of experience in reading construction documents on a tablet, and how comfortable they felt using a tablet during the assignment exercises.

Findings

The breakdown of the groups, their assignments, and the results are detailed in Table 1. The group means were compared using a paired samples t-test with SPSS. There was no significant difference found between the mean scores. A statistically significant difference was found between the mean completion times of the two groups with a p-value less than 0.001. The group that did the assignment with the tablet first (Group A) took significantly longer to complete the assignments than did the group that did the assignment with a paper set on the first day and with a tablet the second day.

Table 1

Group and Assignment Breakdown

	Group A		Group B	
Avg. Time to Complete Assignment	Day 1 – Tablet *36.7 min*	Day 2 – Paper *23.58 min*	Day 1 – Paper *25.1 min*	Day 2 – Tablet *27.78 min*
	Avg. Total Time: ***60.28 min***		Avg. Total Time: ***52.88 min***	
Avg. Score on Assignment (out of 12)	Day 1 – Tablet *7.5*	Day 2 – Paper *8.83*	Day 1 – Paper *6.58*	Day 2 – Tablet *6.83*
	Avg. Score: ***8.17***		Avg. Score: ***6.71***	

The two groups did not differ significantly in their level of experience with tablets in general or how comfortable they felt using the tablets for reading construction documents. They were also similar in their reported level of prior experience using tablet for reading construction documents. It was noted that both groups had a fairly low level of prior experience using tablets to read construction documents. This is in alignment with the idea that using tablets for this purpose in the classroom constitutes an implementation of a new technology or at least a new use of an existing technology. The results of the seven-point Likert scores from the students are detailed in Table 2, with seven (7) representing very high and one (1) representing very low.

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Table 2

Student Prior Experiences and Perceptions

Survey Questions	**Group A Avg. Response (1 - low; 7 – high)**	**Group B Avg. Response (1 - low; 7 – high)**
Prior experience using tablet computers	5.67	4.25
Prior experience using tablet for reading construction documents	1.75	1.38
Comfort level using tablet for reading construction documents	5.33	4.75

Discussion

The results from the findings provides evidence that the students that had initial access to the paper construction documents became familiar with the test project quicker than the students that started with the tablets. This confirmed that there was a difference in performance related to speed within the two groups. It was observed that the students that had the opportunity to review the construction drawings through the document format in which they had previous experience allowed them the opportunity to familiarize themselves with the drawings before they had to familiarize themselves with operating the new technology. The students using the familiar technology first resulted in faster overall speed of assignment completion. The data provided no sufficient evidence of the technologies impact on the accuracy of the students' performance on the assignment. The personal abilities of the individuals within the groups presented a limitation for testing the accuracy of the performance between the two groups. Future research should identify optimal methods for testing performance accuracy.

In addition to the study, a post examination survey was conducted in which the authors observed an increase in confidence with tablets during the study with the group that was allowed the opportunity to familiarize themselves first with the construction drawings before learning how to operate the tablets. Group one, which started with the tablets and finished with the paper documents rated their past tablet experience at 5.67 (out of 7), but rated future confidence with using tablets for reading construction drawings lower at 5.33 (out of 7). Conversely, group two showed an increase in scores after the study between their previous table experience (4.25 out of 7) and their confidence moving forward (4.75 out of 7) with tablet computers in the construction field. This observation leads to the authors' recommendation of providing construction drawings in more familiar mediums to the students before introducing them to new technology formats for reading construction drawings.

Conclusion

Tablet computers have become more common in both the academic and industry settings in the construction industry, universities continue to introduce these new technologies within their curriculum. This study introduced tablets within a university classroom to explore the impact it had on students' performance with reading and interpreting construction drawings. The study measured the accuracy and speed of the students between two assignments using different construction drawing formats. Paper format and tablet format were used in the study to compare students' performance with the technology.

Data from the study suggests the benefits of introducing new technology such as tablets to students with assignments that include construction documents in which the students are already familiar with. Students that were familiar with

the plans experienced more positive experiences during the introduction of the new technology and performed the assignments faster. The implication for future instruction is the demonstration of the importance of using a medium with which students are familiar and comfortable when teaching a new skill such as the reading of construction documents. While students may be comfortable using tablets for other tasks, using them for construction documents is a novel activity. Separating the activities of learning how to read construction documents from learning how to navigate those documents on a tablet is likely to lead to increased understanding and performance by students.

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