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U.S. Construction Management Students Comfort Level With and Knowledge of Mobile Technologies

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Abstract

Mobile technologies are becoming increasingly common on U.S. construction sites as companies become aware of how they can simplify and automate the capturing of information in the field, and communicate that information back to company management systems. Field personnel are now being equipped with smart phones or tablets to check email, look at blueprints, take progress photos, or create punchlists, all with one device. These technologies are being used to make work efforts more efficient, raise productivity, reduce costs, and positively impact project profitability.

As the U.S. construction industry moves to these mobile technologies, so too should university construction management programs move to mobile education and learning applications to ensure that students are prepared for a mobile construction industry. This study uses university provided iPads in construction management classes to expose students to mobile technologies before they enter the workforce. Pre- and post-test surveys collected data about first-year and upper-level construction management students comfort with mobile technologies, their knowledge about mobile technologies in construction, and their views on whether they think they will use mobile technologies in the workplace and for what tasks.

While some students entered with a very low comfort level with mobile devices, there were gains in comfort level by nearly all students. Most, even first-year students, were able to envision how a mobile device could be used within the construction industry to perform various tasks, and their visions increased from the beginning of the semester to the end, even though no formal instruction was done in this area. The gains were primarily due to exposure to the device and general usage. By gaining a greater understanding of student comfort with and knowledge of emerging technologies, more effective educational and training methodologies can be developed to facilitate instruction and improve the effectiveness of students upon graduation.

Introduction

Mobile devices, including devices such as smartphones, tablets, personal digital assistants (PDAs), personal media players and wireless laptop PCs are increasingly being used by companies in the U.S. construction industry to assist in the management of construction projects[1]. Along with accompanying technologies such as wireless protocols and wireless applications (apps) that allow access to web portals and web sites[2], mobile devices are being used to access, create, modify, organize, store, and/or otherwise manipulate data in various forms without being bound to a static location[3]. Construction personnel, who until recently were limited to the office when performing coordination and communication functions, now have mobile devices and wireless networks that allow for nearly unlimited access to digital information, as well as input and output capabilities while on the construction site[4].

The Construction Site and Mobile Technologies

To do a project right you need the right tools. In the construction industry, those tools are not limited to tools in a toolbox. The construction team, both in management and in the field, need the right tools to maximize productivity and make work easier[5]. Companies must be cognizant of new and creative ways to apply technical solutions that allow for a competitive advantage, and the use of mobile technologies is that new and creative way. Mobile technologies are becoming increasingly more common on the construction site as companies become aware of how mobile technologies can reduce inefficiencies, raise productivity, reduce costs, and positively impact a company's "bottom line"[6]. Mobile technologies can reduce the gap in the information flow between the office and the construction site by simplifying and automating the capture of information in the field and communicating that information back to company management systems.

Mobile technologies allow site supervisors to more efficiently perform activities such as managing digital time cards for payroll and project cost coding, quickly developing RFIs to reduce construction delays, developing daily field reports in real time, as well as accessing project plans[7]. Field personnel equipped with handheld devices such as smart phones or tablet computers have access to information needed to perform their work more efficiently and effectively. Rather than having to carry stacks of papers, blueprints, and specs when performing functions at the job site, these workers now have access to everything they need on their mobile device[5].

Difficulty with Implementation

The rollout and implementation of a mobile technology can be difficult. Change is not always easy or easily accepted[8]. Management of change is the greatest factor in the success or failure of any technology implementation[9] including mobile technology. An advantage that the adoption of mobile technologies has over other changes lies in the popularity of the iPad. Being one of the most sought-after consumer electronic devices on the market, the iPad can help grease the change-management wheels, turning fear or skepticism into eager anticipation[10]. Another reason that the implementation of mobile technology is difficult is because historically the construction industry has long been a laggard in technology adoption[11] and technology spending, historically ranking 80th or higher among industries in the adoption of technology solutions. However, the downturn in the economy accelerated the acceptance of technology and investment in the deployment of mobile and wireless solutions. Costs of implementing mobile technologies have historically been problematic, but because of advances in wireless technologies including coverage, performance, and security, overall cost of ownership is becoming an issue of the past for construction operations[12].

At first, it appeared that the implementation of mobile technologies was an attempt by some to push (or even force) the construction industry to change its traditional ways of working[13]. However, more recently, many would argue that the reason the construction industry has been slow to adopt the use of mobile technologies is the slow development of applications that meet the needs of the construction industry. Thus the delay in implementation represents a strong demand pull which is yet to be satisfied[14]. A lack of support by Apple has also been a problem in the implementation of the use of mobile technologies in that Apple has notoriously shunned the enterprise in favor of the consumer for years, and there are not good enterprise management

tools for deployment, requiring each unit to be set-up individually, as opposed to configuring multiple mobile units at one time[10].

The move towards a mobilized jobsite comes with little to no implementation guidelines, and with little prior knowledge base from which information can be gleaned. To offset the lack of guidelines and knowledge, companies often look to their younger, newer employees to drive mobile technological change, assuming that university graduates own and use these mobile technologies and are familiar with the latest technological innovations[15]. In reality, currently only about three quarters of US college students own such devices[16] and many fewer incorporate them into their daily routine, especially in school where a majority of instructors ban or discourage the use of mobile devices[16]. University construction management programs should implement the use of mobile education and learning applications to intensify student awareness of how mobile technologies are being used in the construction industry, as well as help students to positively impact their academic productivity and performance[17].

Method

The research described in this paper was carried out with undergraduate students in two courses at Boise State University in the fall semester of 2012. One course was a 100-level construction management (CM) course entitled "Construction Materials and Methods" and the other course was a 300-level construction management course entitled "Mechanical and Electrical Installations." The 100-level course was about two-thirds freshman and sophomore students (31 of 48) and was largely CM majors and minors (40 of 48). Regardless of class standing, the CM majors in this course have a minimum of two more years to complete their degree. The 300-level course was predominantly seniors (26 of 32) and all were CM majors or minors (32 of 32). The two courses were similar with respect to age, gender, and other demographics.

Data was collected with an anonymous web-based survey instrument. Students in both the 100-level and 300-level courses were asked by email to participate. The overall response rate for the pretest was 45% (36 of 80). The 100-level course pretest response rate was 39.6% (19 of 48) and the 300-level course pretest response rate was 53.1% (17 of 32). The overall response rate for the posttest was 28.8% (23 of 80). The 100-level course posttest response rate was 25% (12 of 48) and the 300-level course posttest response rate was 34.4% (11 of 32). The survey asked a number of questions related to their ownership and comfort with different mobile technologies, as well as questions regarding the use of mobile technologies in the construction industry. Survey questions are included in the results section of the paper.

The pretest survey was given during the first week and a half of the semester. The posttest survey was available for three weeks beginning with the last week of classes for the semester. During the semester (between the two surveys), students were loaned university owned iPads free of charge. Students were given an orientation that included how to set up the device, how to connect to their university email account, and how to download an app. The students were encouraged to use the device as a personal device, to put their music on it, check their email with it, and otherwise use it as if it were their own. Only a few students were visibly nervous about learning how to use the new device. For class related purposes, the devices were only minimally

used for construction related applications; instead they were primarily used for educational purposes, such as electronic flashcards, creating videos, and in-class quizzes.

Results and Discussion

Students were asked in both the pretest and posttest surveys about their use, ownership, and comfort with mobile technologies, their knowledge about mobile technologies in construction, and their views on whether they think they will use mobile technologies in the workplace and for what tasks. Due to some students only responding to the pretest, some only to the posttest, and some responding to both, approximations and trends will be shown, but in most instances, numbers of responses and percentages will not be provided due to this.

Ownership and use of mobile devices

Students were asked in the survey which mobile devices they owned and which they had previously used. They were specifically asked about the following mobile devices:

- Regular cell phone (does not access internet)
- Smartphone (iPhone, Android, Blackberry, etc)
- Tablet (iPad, Android, etc)
- eReader (Nook, Kindle, etc)
- iPod Touch

Slightly less than half of the responding students owned a regular cell phone, though most had used one. Slightly more than half owned a smartphone and approximately the same number had used one. Fewer owned tablets (approximately one-third), but two-thirds had used one at some point. The iPod Touch was similar – about one quarter of the respondents owned this device and a little over half had used one. The eReaders had both the lowest ownership reported, as well as the lowest usage, with ownership by less than one quarter of respondents, and only about one third had used an eReader previously. All respondents owned at least one of the devices listed and all had used at least one device as well.

In a university setting, it is often assumed that most students own and use these mobile technologies daily and that no introduction to them is necessary, so the ownership and usage described above may seem very low. In reality, only about half of US college students owned internet capable handheld devices and less than one third of those used the internet capabilities in their daily routine in 2009[18]. This means that only about 15% of college students owned and used the internet on a mobile device on a daily basis then. The percentage of student users did increase when looking at 2012, when this survey was administered, but did not increase appreciably, as the data here show. Today, these numbers have again increased, with three quarters of students owning an internet capable handheld device[16], but as stated previously, many do not use them to access the internet on a daily basis. Cost continues to be a major reason why students do not own an internet capable device, or if they do own one, why they choose not to use the internet capabilities[16, 18].

Comfort level with mobile devices

Students' comfort level with mobile devices showed similar trends to their ownership and use of the devices. In the survey, they were asked to rate their comfort level using each of the types of

mobile devices (the same categories as in ownership and use) on a five point scale ranging from (1) 'very uncomfortable' to (5) 'very comfortable.' Regular cell phones and smartphones were rated with the highest comfort level, followed closely by tablets and the iPod Touch. There was a large drop in comfort level for eReaders compared to the other devices. Figure 1 shows the average comfort level ratings for each of the device types.

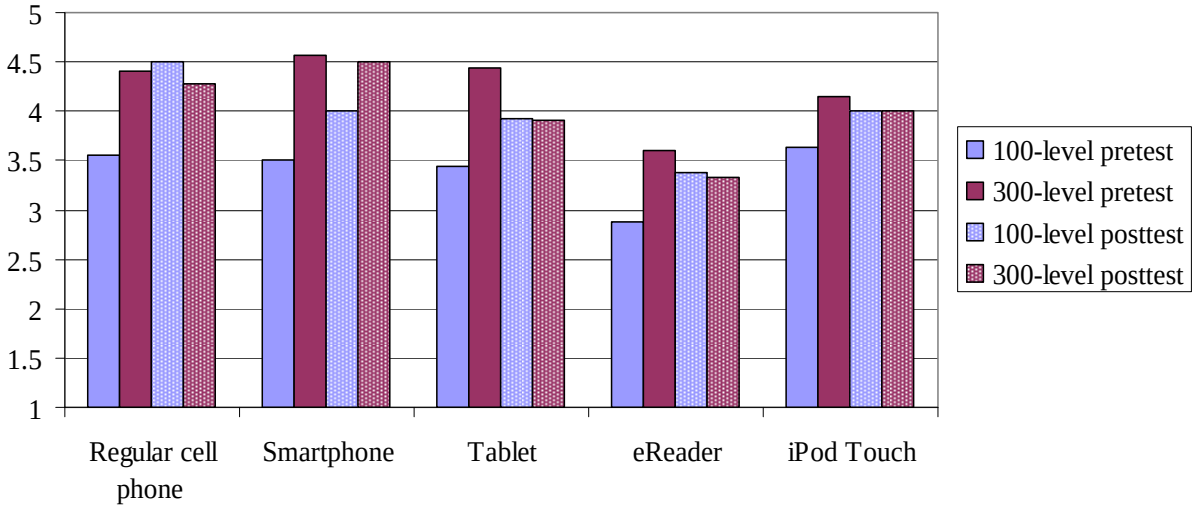

Figure 1: Average comfort level ratings with mobile devices

Looking at the ratings from the pretest, the 100-level students ranked their comfort level with all of the mobile devices much lower than the 300-level students. Ownership of the devices was similar for all types of devices except the smartphone, where the 300-level students owned at a slightly higher rate and the eReaders, where the 100-level students owned at a slightly higher rate. Given this, ownership level is unlikely to be the reason for the difference in comfort level between the two groups. The percentage of students who had used each type of device was also very similar for both groups and is also not likely to explain the difference in comfort. Some possible explanations for the 100-level students' lower comfort include: they may have owned the device(s) for a shorter period of time and/or they may have only used the device(s) for entertainment purposes and have no comfort with other possible reasons to use the device(s).

Comparing pretest ratings with posttest ratings, the 100-level student ratings increased in comfort rating for all devices. Increases in the comfort level with tablets was expected, as all students were loaned an iPad tablet for the semester. The increases in comfort level for the other mobile devices may be a result of longer ownership of the device(s) and/or the realization that skills and comfort with one device readily transfer to other devices. The increase may also be a result of different students completing the posttest versus the pretest.

With the 300-level students, the data indicates that their comfort levels with all devices went down somewhat over the course of the semester. One possible explanation for this is that some of the students completing the posttest were different from those completing the pretest. Another possible explanation is that their comfort level actually did go down. Perhaps they completed the pretest believing that they knew a lot about how to use mobile devices, but over the course of the semester, they discovered that there was much more to learn.

Knowledge of mobile devices in construction

When students were asked if they thought that mobile technologies such as these are used in the construction industry, only one person (from the 100-level course) thought they were not used. Even if they did not have much familiarity with some of the devices, they were aware that mobile technology is used in the U.S. construction industry.

This question was followed by two related survey questions: (1) For what tasks do you think mobile devices are **actually** used in the construction industry? and (2) For what tasks do you think mobile devices **could** be used in the construction industry? These questions were provided in a matrix format with a list of tasks on the side and each of the device types along the top. They were asked to mark the mobile device types that are (or could be) used in the construction industry for that task. They were also provided with 'none of these' and 'don't know' options for each task. The list of tasks they were to respond to included:

- Plan Reading
- Estimating
- Planning & Scheduling
- Contract Management
- Budget Management, Cost Control, Accounting
- Internal Communications (within company)
- External Communications (outside of company)
- Safety
- Equipment Management (small tools, like a hammer)
- Equipment Management (large equipment, like a bulldozer)
- Surveying & Project Layout
- Materials Selection & Construction Procedures
- Management of Changes
- 3D Modeling

In most instances, there was very little difference in the responses to the two questions (actually used versus could be used), so only the responses to the first question (actually used) will be reported in this paper. This similarity in responses implies that students believe that mobile devices are actually being used in all of the ways they could be used in the construction industry.

While the students were asked about many different types of mobile devices, since they were loaned iPad tablets for the semester, this paper will only look at the tasks they thought were being done with tablets, measured at the beginning of the semester and again at the end. Figure 2 shows the percentage of respondents that thought a tablet was actually being used in industry for the construction tasks listed. As can be seen in the figure, more than half of students at the beginning of the semester in both courses believed that tablets were being used in industry for all of the construction tasks listed, except for small tool management. In the pretest, the 100-level students were more optimistic in their thoughts of what was actually happening in the industry than the 300-level students were. The pessimism of the upper-level students may be due to them believing they have more knowledge of the industry through construction internships, while the lower-level students may be more naïve about the actual happenings in the industry. It is also possible that the 300-level students thought they had a better understanding of the capabilities and limitations of the device, due to their higher comfort level.

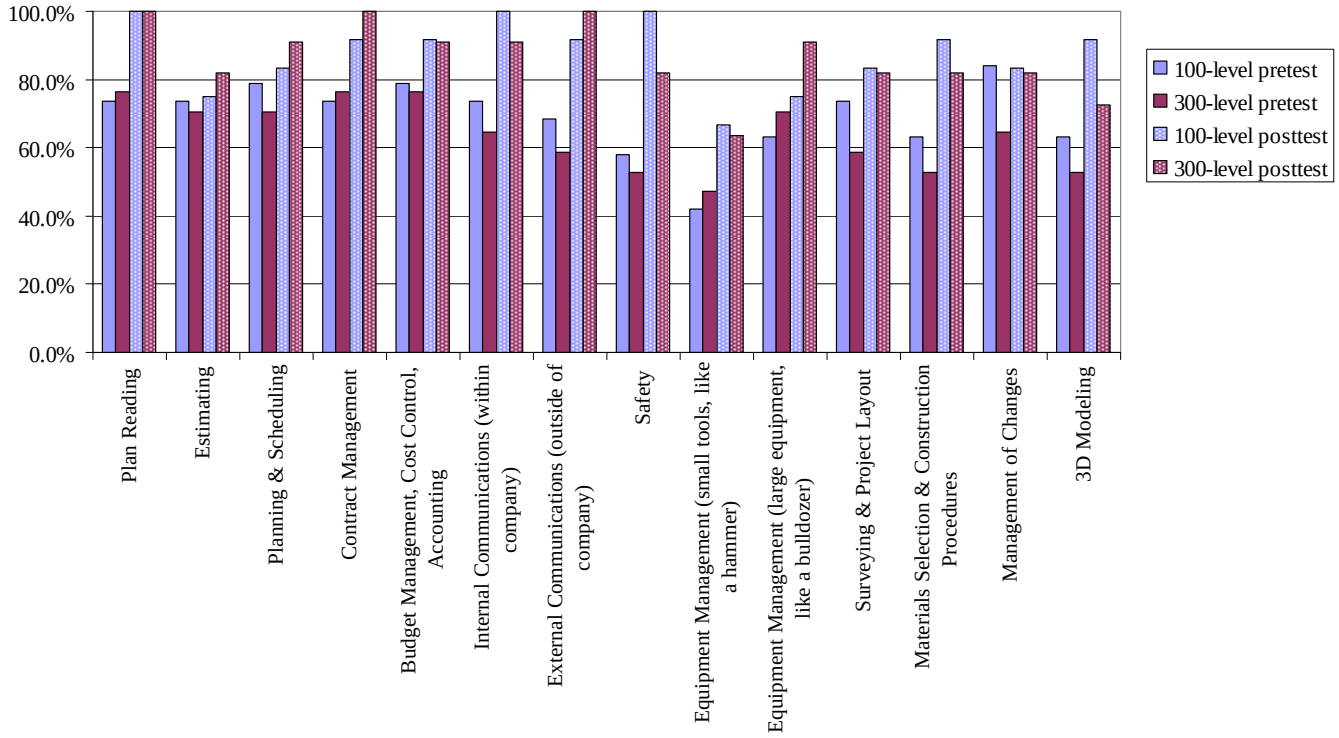

Figure 2: Percentage of respondents that thought a tablet was actually being used for the construction tasks listed

When comparing the pretest data with the posttest data, in all instances except one (100-level students in the management of change task), the percentage of students that thought a tablet was being used for construction tasks went up and in many instances, it increased significantly. Since there was no specific instruction provided regarding how tablets might be used in industry, the increases can be attributed to exposure to the device and general usage. In other words, ensuring that students have devices, as well as providing opportunities for them to use the devices and achieve a high level of comfort with them can improve their visions of how the devices can be used in the construction industry.

Students' vision of the future with mobile devices

Students were asked two final questions in the survey: (1) Assuming that you take a job in the construction industry upon graduation, do you think you will be **required** to use mobile technologies in the workplace? Why or why not? and (2) Again, assuming that you take a job in the construction industry upon graduation, do you think you will choose to use mobile technologies in the workplace? Why or why not?

All but one 100-level student felt that they would be required to use mobile technology in the workplace. That student commented that "Old people aren't that into technology." There was also one 100-level student that would not choose to use mobile technologies in the workplace, stating "I'm old school. I wouldn't choose to unless I had to." The remainder of the students felt

that mobile technologies would be required, but they would willingly choose to use them even if they were not required. Figure 3 shows a word cloud representing student responses to the survey questions. As can be seen in the figure, using mobile technology for communication was the most common theme throughout the student responses.

Figure 3: Word cloud showing why students think they will use mobile technologies in the construction workplace

Conclusion

When students graduate and enter the workforce, they are often expected to drive the construction industry into the future. As educators, it is our job to help prepare students for this role by providing them with opportunities to use mobile technologies in ways that allow them to envision the future. The department of construction management at Boise State University is trying to lead the way and, following this study, began incorporating mobile devices into seven different construction management courses. While it is a challenge for faculty to effectively use the devices for teaching and learning, both in and outside the classroom, this is an important step toward ensuring that our students are prepared to be technology leaders in the future construction industry.

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